EFFECTS OF REPLACEMENT OF SOYBEAN MEAL WITH PALM KERNEL CAKE IN DIETS SUPPLEMENTED WITH MULTI-ENZYME FOR BROILER CHICKENS

BY

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October, 2018

DECLARATION

I hereby declare that this Thesis was written by me and is a correct record of my own research work. It has not been presented in any previous application for any degree of this or any other university. All citations and sources of information are clearly acknowledged by means of references.

……

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Date ……

CERTIFICATION

We certify that this Thesis entitled "Effects of replacement of soybean meal with palm kernel cake in diets supplemented with multi-enzyme for broiler chickens" is the outcome of the research carried out by I. D. DADA in the Department of Livestock Science and Sustainable Environment Programme, Centre of Excellence in Agricultural Development and Sustainable Environment (CEADESE), Federal University of Agriculture, Abeokuta (FUNAAB).

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ABSTRACT

Palm Kernel Cake (PKC) is used for livestock production. However, its high fibre content limits its use in poultry feed. Two trials of 42 days each were conducted to investigate the effects of adding a multi-carbohydrase to PKC. A total of seven hundred and twenty (720) one-day old Marshall broiler chicks were used for experiment one (E1) in a 2x3 factorial arrangement with PKC replacing Soybean meal (SBM) in the diet at 0, 7.5 and 15% levels (weight for weight). The birds were alloted into six (6) dietary treatments having six (6) replicates of twenty (20) birds each. The diets were labeled D1-D6 (D1-D3 without enzyme and D4-D6 with enzyme). In experiment two (E2), four hundred (400) one-day old Marshall broiler chicks were allotted to ten (10) diets in a 2x5 factorial arrangement with PKC replacing SBM at 0, 25, 50, 75 and 100% levels (protein for protein). There were ten (10) dietary treatments of four (4) replicates containing ten (10) birds each. The diets were labeled D1-D10 (D1-D5 without enzyme and D6-D10 with enzyme) for experiment two (E2). Data on performance, carcass, digestibility, gut morphology, ileal digesta viscosity, serum and haematological indices and feed cost analysis were collected. Data were subjected to Analysis of Variance in a Completely Randomized Design. For E1, the birds on D6 had significant ($p<0.05$) final weight (FW) of 433.14 g at day 21 while D4 had FW of 1502.47 g and lowest cost per weight gain (CPWG) of ₦267.31/Kg at day 42. Gut morphology parameters were found to increase ($p<0.05$) when D5 was fed for ileum and duodenum and at D6 for jejunum. Birds fed D6 had the highest ($p<0.05$) total proteins (54.63 mg/dl), albumin (33.50 mg/dl), Uric acid (50.00 mg/dl) and alkaline phosphatase (166.67 µ/L). In E2, birds had ($p<0.05$) final weight (513.33 g) and weight gain (476.27 g) at D6, and D3 had ($p>0.05$) CPWG (₦261.34) for 0-21 days and birds on D1 had ($p<0.05$) values for performance parameters

but the lowest CPWG (₦319.35/Kg) was found with birds on D8. Birds on D8 and D9 had ($p<0.05$) villus height for ileum and jejunum. Birds consuming D10 had significantly ($p<0.05$) higher gizzard weight (3.59%). Enzyme addition caused a reduction in the viscosity of ileal digesta with ($p<0.05$) lowest values at D6 for 50, 60 and 100 rpm (revolution per minutes). Packed cell volume, haemoglobin and red blood cells were improved ($p<0.05$) for birds on D6 and the white blood cells differentials were not influenced ($p>0.05$) by dietary treatments. Birds on D6 had best values for crude protein (CP), crude fibre (CF) and ether extract (EE) digestibility for 0-21 days, but at 22-42 days, CP was highest at D8, CF at D5 and EE at D6. The nutrient in PKC can be adequately utilized by broiler chickens if supplemented with an exogenous enzyme to make the nutrient more available therefore, PKC can effectively replace 50% SBM (protein for protein) in diets supplemented with multi-carbohydrase.

DEDICATION

I dedicate this work to God Almighty, who has shown me Grace and Mercy and has enabled me finish this race I started. It could only have been possible with His help.

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CHAPTER ONE

1.0 INTRODUCTION

Broilers are chickens that have been specially selected and bred for rapid growth and high efficiency for converting feed to quality meat. Broiler strains are based on hybrid crosses between Cornish White, New Hampshire and White Plymouth Rock and these poultry birds are kept for the production of eggs and meat. They are kept in most areas of the world and provide an acceptable form of animal protein to most people throughout the world. During the last decade, many developing countries have adopted intensive poultry production in order to meet the demand for this form of animal protein.

It was observed that poultry makes a substantial contribution to household food security and this is achieved by providing income, quality food, fertilizer and assets in over 80% of rural communities in developing countries (Bebay, 2003). It is also said to contribute up to 40 percent of agricultural Gross Domestic Product (GDP) and employs 1.3 billion people, while supporting the livelihoods of one billion of the world's poor people (FAO, 2007).

Intensively kept poultry is seen as a way of rapidly increasing animal protein supplies to meet the need of rapidly growing urban populations. Poultry are able to adapt to most areas of the world, they are relatively low priced and have a high rate of productivity. Poultry and other livestock feeding take up to about 65 – 75% of the total cost of production (Tewe and Kasali, 1986), and this is so because of the high cost of conventional feed resources like maize, soybean, and groundnut used in producing animal feed (Amaefule and Obioha, 2005). Maize most often, constitutes the highest proportion of ingredient in diet formulation of any poultry ration (Agbede *et al*., 2002). This high

inclusion rate translates into high cost of feed because of seasonality of maize production and competition for it by man and livestock (Agbede *et al*., 2002). Preston (1995) reported that one of the major challenges to researchers in the humid tropics was providing alternative feed resources for monogastrics.

Poultry production in Nigeria is affected by high cost of feedstuffs (Okoye, 2002), although some alternative feed resources have been discovered to be useful but that there was a need to have adequate knowledge of them and their composition (Shittu *et al.*, 2004). Palm Kernel Cake (PKC) is one of the abundant agricultural by-products that is cheap and readily available. It is aflatoxin free, palatable and has considerable potential as carbohydrate and protein sources. However, due to its low nutritive value, grittiness and potential for deterioration in unhygienic conditions, large amounts of PKC is often discarded and often create environmental concerns in the future (Sundu *et al.*,2005).

PKC or Palm Kernel Meal (PKM) is an agro-industrial by-product that is produced locally and within the West African sub-region in sizeable quantities and when used as livestock feedstuff can help curb the problem of environmental pollution that accompanies its disposal (Boateng *et al.,* 2008). Also, PKC has been used both as protein and energy sources in laying hens (Olorede and Longe, 2000; Perez *et al.*, 2000; Odunsi *et al.*, 2002) and broilers (Okon and Ogunmodede, 1996; Ezieshi and Olomu, 2004)

There has been a dramatic increase in global production of PKC, with annual growth rate of 15% over the last two decades (FAO, 2002). Moreover, the move towards the use of diets devoid of ingredients of animal origin will exacerbate the effects of anti-nutrients on bird performance and nutrient excretion in the environment. One of the key technologies that can help address this challenge is the use of appropriate enzymes. The enzyme

technology had progressed tremendously over the past twenty years with respect to efficacy and matching activities with their target substrates. For example, Nikam *et al*. (2016) found that the use of β-glucanases and xylanases for degradation of the β-glucans and arabinoxylans in barley, oats, wheat, rye and triticale have proven efficient in enhancing the nutritive value of these grains for poultry (broilers in particular). The inclusion of microbial phytase to improve the utilization of organic phosphorus is another good example. The benefits of using enzymes in diets for monogastrics gives enhanced growth performance and feed conversion, causes reduced environmental problems due to reduced output of nitrogen excretion, increases accuracy and flexibility in least-cost feed formulations and improved well being of animals (Nikam *et al*., 2016). As more and more knowledge is gathered on the detailed chemical structures and the physiological activities of non starch polysaccharides (NSPs) in various ingredients, highly sophisticated enzymes are being developed to target these polymers in a more precise manner. Therefore, an exogenous enzyme that is capable of degrading the individual NSPs contained in PKC to adequatly release its nutrients (Energy, crude protein, crude fibre etc) is necessary for its efficient utilization by monogastrics that cannot degrade them adequately because of lack or low production of appropriate endogenous enzymes, especially broiler birds.

Few studies (Dusterhoft *et al*., 1993; Daud *et al*.,1997) have shown that enzymes with mannanase activity could break down the non-starch polysaccharides (mannans) of PKC, hence improving its nutritive quality. Multi-enzyme complexes produced from fungi could also therefore be used as an agent to improve the nutrient contents of PKC. Such enzyme extracts may have the potential to breakdown the NSPs in PKC thereby enhancing its nutritive values, especially for broiler feeding. Therefore, the multi-enzyme

used in this study was purposely selected and has the following components Xylanase, β-glucanase, β-mannnanase, α-galactosidase, amylase and protease, to improve the nutrient availability of the test ingredient for the proper growth and development of the experimental animals.

1.1 JUSTIFICATION

PKC is aflatoxin free, palatable and has considerable potential as carbohydrate and protein source (Sundu *et al*., 2006). The inclusion of PKC in the diets was less practiced in monogastric animals, particularly in poultry due to their poor response to the feedstuff, and this was due to its high fibre content and low metabolizable energy content (Atteh *et al.*, 1993). However, the nutritive value of PKC may be improved through exogenous supplementation of enzymes to breakdown the non-starch polysaccharides and the use of enzymes in animal feed rations targets the specific undigestible parts of the dietary components in which several studies in poultry have reported the benefits of using enzymes in the diets on growth performance of poultry (Ao *et al*., 2011). In poultry diets, PKC is included as a partial replacement for soybean meal (SBM) due to its fluctuations in price as the season changes. Apart from using PKC as a partial replacement for SBM, it could also be used to substitute certain amount of corn in poultry feed as it contains moderate amount of energy together with protein.

The use of PKC in all types of livestock feed makes it one of the most flexible feed ingredients and with increased interest in research on PKC, the prospect of PKC becoming more important is bright. According to Alimon (2004), engaging in research to improve the nutritive value of PKC for poultry, especially through treatment with enzymes and solid state fermentation, will bring about new strategies in using PKC. This will lead to a brighter future for both oil palm and the livestock sectors. Since few studies have been carried out on the degradation of the Non Starch Polysaccharides (NSPs) contained in PKC, this study therefore evaluated the effects of a multi-enzyme of fungal origin on the efficiency of utilization of this non-conventional feedstuff by broiler birds.

1.2 BROAD OBJECTIVE

To determine the effects of the replacement of soybean meal with palm kernel cake in diets supplemented with multi-enzyme for broiler chickens.

1.3 SPECIFIC OBJECTIVES

- To evaluate the relationship between the chemical components of PKC and SBM.
- To determine the growth performance of broiler chickens fed PKC diets with or without multi enzyme supplementation.
- To determine the nutrient digestibility of broiler chickens fed PKC diets with or without multi enzyme supplementation.
- To determine the carcass quality of broiler chickens fed PKC diets with or without multi enzyme supplementation..
- To determine the heamatological indices and serum biochemistry of broiler chickens fed PKC diets with or without multi enzyme supplementation.
- To evaluate the gut morphology of broiler chickens fed PKC diets with or without multi enzyme supplementation.
- To evaluate the gut microbiology of broiler chickens fed PKC diets with or without multi enzyme supplementation.
- To evaluate the ileal digesta viscosity of experimental broiler chickens fed PKC diets with or without multi enzyme supplementation.
- To carry out the feed cost analysis of raising broiler chickens on the enzyme supplemented diets.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Chicken

The classification of Chicken has been done and it is found to belong to the Kingdom: Animalia; Phylum: Chordata; Class: Aves; Order: Galliformes; Family: Phasianidae; Genus: Gallus; Specie: *G. gallus;* Binomial name: *Gallus gallus*. Chicken is said to be one of the most common and widespread domestic animals with a population of more than 24 billion in 2003. According to literatures, there are more chickens in the world than any other bird and humans keep them primarily as a source of food, to consume both their meat and their eggs. The primary value in poultry keeping was majorly for egg production, meat was considered a secondary product. However,the supply for these products was less than the demand which made them expensive.

Farm flocks tended to be small because the hens largely fed themselves through foraging with some supplementation of grain, scraps, and waste products from other farm ventures. Such feedstuffs were limited in supply, especially in the dry season thereby regulating the size of the farm flocks. Later on, poultry keeping gained attention of agricultural researchers. Improvements in nutrition and management made poultry keeping more profitable and business-oriented (Christopher, 2003).

2.2 Nutrient requirements of broilers

Nutrient requirement is defined as the minimum amount of nutrient that must be incorporated into the ration to meet the needs of the normal healthy birds (Scott *et al.*, 1982). Poultry birds obtain all they need for growth, tissue synthesis and maintenance from their feeds. In terms of quality, all chickens have the same nutritional requirement but quantitatively, the requirement differs. There are at least 40 specific nutrients

(chemical elements) that need to be in the diet to support life, growth and optimum reproduction. These consists of 13 important amino acids, 13 vitamins and 13 essential minerals and fatty acid known as linoleic acid and sufficient non-essential amino acids and enough metabolisable energy, to meet the energy needs for maintenance and production (Olomu, 1995).

Nutrient requirement vary according to both the physiological condition and health status of the animal. It also differs among breeds, strains and birds of different ages of poultry. Highly productive animals require more nutrients in terms of quantity and quality than the non-productive ones, which are considered to be at maintenance stage of growth. Broilers like other classes of chicken have a simple digestive system and their nutrient requirement change significantly as they approach market age. Their requirement for protein, amino acids, minerals and vitamins reduce in relation to energy. Male birds are said to require higher quantity of nutrients than female birds. However, the difference seems to be little when the requirement is expressed as a percentage of the diet.

2.2.1 Energy requirements of broiler chickens

Good growth in broilers is achieved with a wide range of energy levels (Olomu, 1995). It has been shown that the determinant of feed intake is the energy concentration of the diet. High energy diets significantly depressed feed intake (Olomu and Effiong, 1983). The energy intake of chickens varies with the metabolic body weight, the rate and composition of body gains. Aduku (1993) recommended energy levels of 2800 and 3000 Kcal/kg ME for the broiler starter and finisher phases respectively. Olomu (1995) recommended 3000

Kcal/kg metabolisable energy (ME) at both broiler starter and finisher phases. These recommendations were lower than the requirement in the temperate zones.

2.2.2 Vitamin and mineral requirements of broiler chickens

Vitamins and minerals play critical roles in the nutrition of broilers, particularly at the early age of their life. Vitamin D3 requirement of broiler chickens was reported to be 100 ICU/100kg of feed. Vitamin E requirement of broiler was put at 200, 80 and 80mg/kg for starter, grower and finisher diets respectively. Dietary biotin of 120mg/kg is required for the prevention of dermatitis, mortality to fatty-like kidney syndrome and leg deformation in broiler chicken.

The principal minerals required in broiler diet are calcium and phosphorus. Calcium and Phosphorus deficiency has been linked with weak or brittle bones. The requirements for some minerals have been identified to be affected by level of other minerals for example, calcium and phosphorus, sodium and potassium. Apart from these four which must be supplied from other sources than normal ingredients, all other micro-minerals are provided in ample amount by the usual natural ingredients used in formulating poultry feeds. The micro-elements are often included in most commercial premixes (Olomu, 1995).

2.2.3 Protein and Amino acid requirements of broiler chickens

Dietary protein is used by broilers for many functions, the most important being accumulation as broiler meat. The supply of dietary protein and essential amino acids can be considered as one of the most important determinants of growth of chicken. Broilers, being birds raised for meat require high protein level than layers and cockerels; this is to

ensure rapid tissue synthesis, resulting in fast growth. A review by NRC (1994) on nutrient requirement of poultry indicated that protein requirement decreased with increase in the age of birds. It thus recommend 23% crude protein for broiler starter of 0-3 weeks of age, 20% for 3-6 weeks of age and 18% for broilers between 6-8 weeks of age. Aduku (1993) reported similar values of 23% and 20% crude protein for starter (0-4 weeks) and finisher (5-8 weeks) broilers respectively with the addition that protein supplied to birds should be both of plant and animal origin to ensure balanced amino acids in the diets. The most limiting amino acids in broiler ration are lysine and methionine, thus, the supplementation of broiler rations with synthetic forms of these amino acids is necessary.

Table 1: Nutrient Requirement of Broiler Chickens

Nutrient	0-4 weeks	5-8 weeks
Energy (kcal/kg)	2,800	3,000
Crude Protein (%)	23	20
Calcium (%)	1.0	1.0
Phosphorus (%)	0.7	0.7
Lysine (%)	1.25	1.1
Methionine (%)	0.86	0.75
Methionine + Cystine (%)	0.86	0.75

Aduku, 1993

2.3 Palm Kernel Cake

Palm kernel cake is an agro industrial by-product obtained after extraction of oil from palm kernels and it is abundantly available in the tropical areas of the world. Tropical Agriculturist (1998) reported that oil palm (plant) has the highest oil yield per unit area and it is in this context that oil palm assumes significance to satisfy the increasing demand for edible oils, and palm kernel cake availability also increases at the same time. (Shakila *et al*., 2012).

Palm kernel cake is a major by product of palm kernel oil production and there is a wealth of literature on its potential as a source of protein and energy for livestock (Alimon and Hair-Bejo, 1995). It generally contains 17-21% protein, 10-17% crude fibre, 4-5% ash and ether extract values of 0.7-0.9% depending on the efficiency of oil extraction from the kernel (Nwokolo *et al*., 1977; Onwudike, 1986). Although, large quantities of PKC are available for feed, the use of PKC in the feed industry is mainly limited to the ruminant sector because palm kernel cake is not widely used in the poultry industry due to its high fibre and low energy contents (Sundu *et al*., 2005). Generally, PKC is obtained from two stages of oil extraction from the palm fruit; the first stage is the primary extraction of palm oil from the pericarp portion of the fruit which also produces the kernel and by-products of palm oil sludge (POS) and palm press fiber (PPF), then the extraction of oil from crushed kernels that also results in the production of PKC and palm kernel shell as by-products (Chin, 2008). The kernel of oil palm fruit consists of tiny cellulosic sack containing fat embedded with proteins and carbohydrates; where the insolubilization of PKC protein may be partly due to the entrapment or binding of proteins or polysaccharides under the influence of the heat and pressure of oil-extraction processes (Aghazu *et al*., 1979).

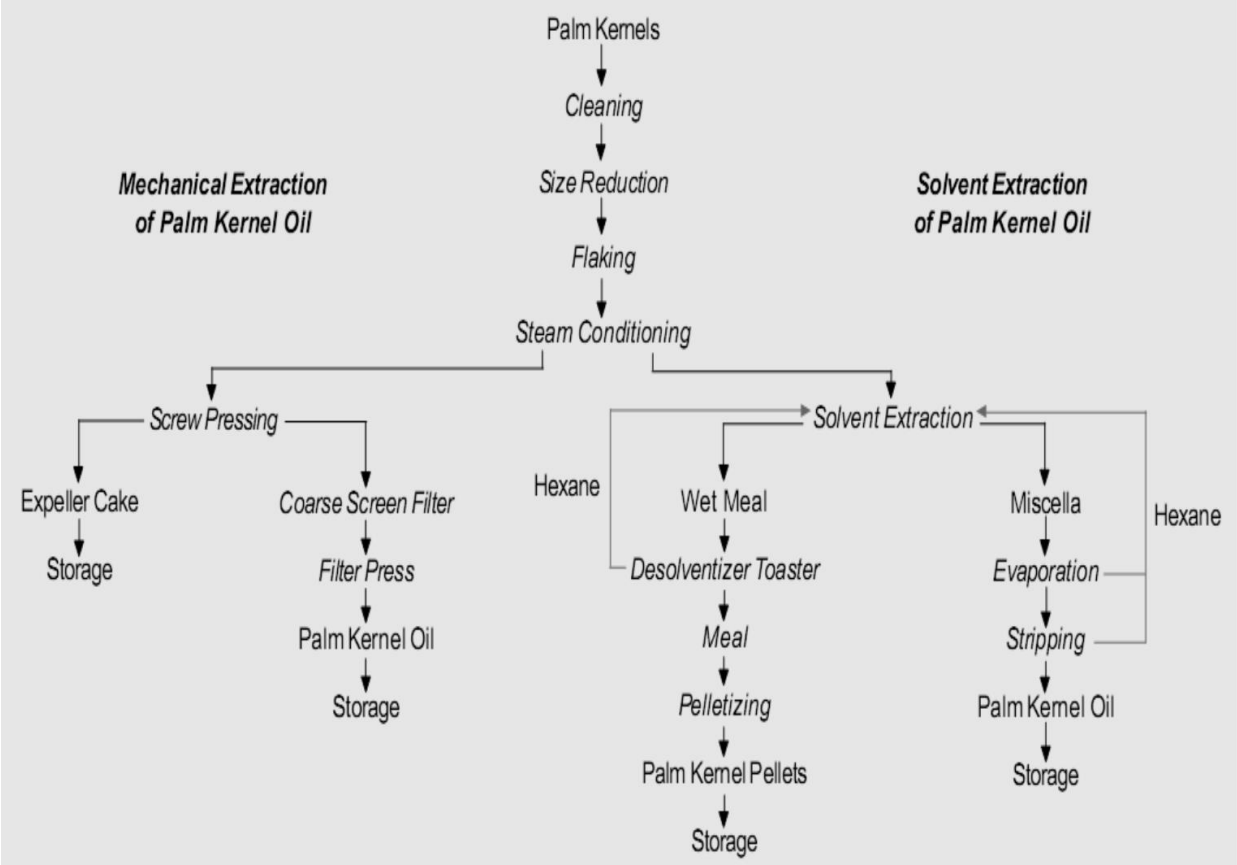

Figure 1: Extraction of palm kernel oil. (Hishamuddin, 2001)

According to Saw *et* al. (2012), there are three methods of palm kernel oil extraction and they are mechanical extraction (screw-pressing), solvent extraction and pre-pressing followed by solvent extraction and the production of PKC from mechanical extraction and solvent extraction is shown in Figure 1 above. Alimon (2004) reported that most of the PKC produced in Malaysia were from mechanical extraction because the production cost was lower than solvent extraction. The PKC produced from screw-pressing contains higher oil content than those produced from solvent extraction and pre-pressing solvent extraction; however other composition, such as protein, crude fiber, and carbohydrate are almost similar (Tang and Teoh, 1985; Saw *et al*., 2012).The mechanical extraction process leads to the production of PKC while the solvent extraction method leads to the production of Palm Kernel Meal (PKM). The difference in the quality of expeller PKC and solvent extracted is small, although in general expeller PKC contains more oil (4%-8%) than solvent extracted PKC (1%-2%). (Alimon, 2004)

2.4 Nutritional Composition of Palm Kernel Cake

Palm kernel cake varies considerably in chemical composition (protein, fibre or lipids), depending on the sources (Rhule, 1996), the methodology of oil removal, the proportion of endocarp remaining (Adesehinwa, 2007) and the efficiency of oil extraction from the kernel (Onwudike, 1986; Onuh *et al*., 2010).The nutrient values of PKC have been extensively studied and described by several authors and some are presented in the table below:

Table 2: Nutrient composition of Palm Kernel Cake (Reported)

Parameters	A	B	C	D	E
Dry matter (%)	88.0-94.5	91.8	94.0	93.6	-
Crude protein (%)	14.5-19.6	20.0	14-21	14.8	17-21
Crude fiber (%)	13.0-20.0	-	21-23	16.7	10-17
Ether extract (%)	5.0-8.0	15.47	-	-	0.7-0.9
Nitrogen Free Extract (%)	46.7-58.8	-	-	50.3	-
Ash (%)	3.0-12.0	8.6	3.0-6.0	-	-
Calcium (%)	0.2-0.3	-	-	-	4-5
Phosphorus (%)	0.48-0.7	-	-	-	-
Metabolizable energy, MJ/Kg					
Poultry	6.50-7.50	-	6.2-9.49	-	-
Ruminant	10.5-11.5	-	-	-	-
Swine	10.0-10.5	-	-	-	-
Amino acid, g/16 g N					
Lysine	2.68	-	-	-	-
Methionine	1.75	-	-	-	-

Sources: **A**- Alimon (2004), **B**- Dairo and Fasuyi (2007), **C**- Sundu *et al.* (2005), **D**- Nuzul Amri (2013), **E**-Nwokolo *et al*. (1976);Onwudike (1986).

2.4.1 Metabolizable Energy of PKC

Metabolizable energy (ME) of PKC has been reported previously by several researchers with Alimon (2004) reporting that the ME was between 1553 to 1792 kcal/kg, Sundu *et al*. (2005) reported it contained 1479 and 2260 kcal/kg. PKC produced through mechanical processing result in higher ME value compared to solvent extracted PKC as observed by Ezieshi and Olomu (2007) where they found that the PKC obtained through mechanical extraction contained higher residual oil of almost 8% compared to the palm kernel cake produced via solvent extraction which had residual oil of 1% while Marini *et al*. (2005) found that the oil content in the solvent-extracted PKC was around 0.5 to 3%, whereas the expeller-pressed PKC contained between 5 to 12% oil. The oil content is a major determinant of the energy available in the end-product of each of the processing method.

2.4.2 Protein and amino acid of PKC

The protein content of PKC has poor amino acid balance, with methionine and lysine (Rhule, 1996), histidine and threonine content (Ezieshi and Olomu, 2007) being the major limiting amino acids. Nwokolo *et al.* (1976) reported that the average availability of amino acid for poultry ranged from 63.3% for glycine to 93.2% for arginine. The low level of valine and methionine in palm kernel cake coupled with the low availability of valine implies that supplementary valine and methionine from other sources are needed when using it as a basal diet. (Sundu, 2006). However, palm kernel cake is regarded as an excellent source of arginine because of its high content (2.68%) and availability (93.2%) (Nwokolo *et al.,* 1976).It has been reported by Chamruspollert *et al.* (2001) that the nutritional requirements for arginine, methionine and lysine are interrelated. Since the

ratio of arginine to lysine is very high (1.03), the inclusion of palm kernel cake in diets should be supplemented with either synthetic lysine or a high lysine feedstuff to balance these two amino acids. Failure to provide the correct balance can impair the performance of poultry. Balnave *et al.* (1999) found that arginine: lysine ratio of 1.03 gave better results for birds kept from three to seven weeks under a temperature of 32^{o}C. The requirement for methionine increased as levels of arginine increased (Chamruspollert *et al.*, 2001).

TABLE 3: Amino Acid Contents of Palm Kernel Cake (g/16 g N)

Amino Acid	**1**	**2**	**3**	**4**	NRC Requirement (Broiler) 0-3weeks
Alanine	3.83	-	-	-	
Arginine	11.56	2.18	2.68	2.40	1.25
Aspartic acid	3.63	-	-	-	
Cystine	1.13	0.20	-	-	(Cys + Meth) 0.90
Glycine	4.17	0.82	0.91	0.84	(Glycine + Serine) 1.25
Glutamic acid	16.80	-	-	-	
Histidine	1.91	0.29	0.41	0.34	0.35
Isoleucine	3.22	0.62	0.60	0.61	0.80
Leucine	6.07	1.11	1.23	1.14	1.20
Lysine	2.68	0.59	0.69	0.61	1.10
Methionine	1.75	0.30	0.47	0.34	(Cys + Meth) 0.90
Phenylalanine	3.96	0.73	0.82	0.74	(Phenyl + Tyrosine) 1.34
Proline	3.31	-	-	-	
Serine	4.11	0.69	0.90	0.77	(Glycine + Serine) 1.25
Threonine	2.75	0.55	0.66	0.60	0.80
Tryptophan		0.17	-	0.19	0.20
Tyrosine	2.60	0.38	0.58	0.47	(Phenyl + Tyrosine) 1.34
Valine	5.05	0.93	0.43	0.80	0.90

1-Alimon 2004 ,**2**- Yeong, 1983; **3**- Nwokolo *et al.,* 1976;**4**- Hutagalung, 1980, **5**-NRC 1994

2.4.3 Crude fibre content of PKC

The fiber content of PKC is about 13-20% which is responsible for the grittiness and poor digestibility of PKC (Onuora and King, 1985; Alimon, 2004). The principal neutral sugar content in the cell wall of PKC fiber is mainly contributed by 56.4% of mannose, followed by 11.6% of glucose, 3.7% of xylose and 1.4% of galactose (Marini *et al*., 2005). In a study conducted by Ezieshi and Olomu (2007), they found that the composition of crude fiber (CF) of solvent extracted PKC was higher compared to mechanically extracted PKC due to the degree of oil extraction, whereas solvent extraction method provides a better oil removal efficiency, leaving PKC with higher CF content. Also, the use of different varieties of oil palm, different methods of separating the shell from kernel and different processing methods employed before extraction of the oil is carried out may also affect the crude fibre values of PKC.

2.4.4 Mineral content of PKC

The ratio of calcium to phosphorus is low and diets based on PKC need to be supplemented with calcium to meet the requirements of most animals. Its copper content of 21-28 ppm is higher than that required by ruminants. In fact, sheep fed diets containing PKC above 50% may suffer high accumulation of copper in the liver if fed for too long and may develop copper toxicity symptoms. Studies on the relationship between copper toxicity and the feeding of PKC to sheep have been conducted by some researchers (Hair-Bejo *et al*.,1995; Alimon and Hair-Bejo,1995). Malaysian indigenous sheep and their crosses were found to be more susceptible to copper toxicity than exotic breeds. Al-Kirshi (2004) showed that Santa Innes hair sheep were more tolerant of copper than Malaysian indigenous sheep. In their studies, Santa Innes sheep fed PKC-based diets did not show physical symptoms of copper toxicity in spite of being fed for more than six months. The

study also showed that both molybdenum and sulphur are effective in reducing the copper levels in the liver and kidneys of sheep fed PKC-based diets. Earlier, Hair-Bejo *et al*. (1995) showed that zinc sulphate can be used instead of molybdenum and sulphur. The iron content of PKC is also high but does not adversely affect the animal performance as most ruminants are able to regulate their iron absorption. The mineral contents of PKC are shown in table 4 below.

TABLE 4: Mineral Contents of Palm Kernel Cake

Mineral	Quantity
Calcium (%)	0.21 – 0.34
Phosphorus (%)	0.48 – 0.71
Magnesium (%)	0.16 – 0.33
Potassium (%)	0.76 – 0.93
Sulphur (%)	0.19 – 0.23
Copper (ppm)	20.5 – 28.9
Zinc (ppm)	40.5 – 50.0
Iron (ppm)	835 – 6130
Manganese (ppm)	132 – 340
Molybdenum (ppm)	0.70 – 0.79
Selenium (ppm)	0.23 – 0.30

Source: Alimon, 2004

2.5 Utilization of PKC as livestock feed

PKC which is a solid by-product or a high protein residue (Daud and Jarvis, 1992; Hair-Bejo and Alimon, 1995) have been used for feed application to ruminants (Wong and Wan Zahari, 2011), poultry (Ao *et al*., 2011), swine (Adesehinwa, 2007) and fish (Ng *et al*., 2004) since it does not contain aflatoxin but has edible oil that contains considerable amount of nutrients comprising of 50.3% carbohydrate, 19.8% protein, and 16.7% crude fiber and 8% ether extract. (Nuzul Amri, 2013). It is abundantly produced in the three main areas of the equatorial tropic of South East Asia, Africa and South America. Attempts have been made to feed it to livestock (Rhule, 1996) practically and widely used most in ruminant diets compared to non-ruminant diets.

PKC supplies both protein and energy, but it is looked upon more as a source of protein. The CP content of PKC varies between 10.0 to 19.8% (Yeong and Mukherjee, 1983; Ramin *et al*., 2010; Nuzul Amri, 2013). Also, PKC contains high amount of CF ranging between 13 to 20% (Alimon, 2004) and this high amount of CF contributes to the low digestibility in non-ruminants, especially poultry. There are many treatments available to breakdown the cellulose chain in PKC to make it more digestible and the chemical and biological treatments of PKC appeared to improve the nutritive values of PKC, but in contrast, the physical methods did not. The solid-state fermentation of PKC appeared to increase the protein value and bioavailability of nutrients (Marini *et al*., 2005; A'dilah *et al*., 2011), however the most suitable microorganisms for treatment of PKC using this approach are yet to be identified (Ramin *et al*., 2010).

2.5.1 Palm kernel cake in poultry nutrition

The subject of using PKC in poultry diets has been studied by some researchers (Onwudike, 1986; Zulkifli *et al*., 2003; Mustafa *et al*., 2004), but the recommended levels of inclusion seem to vary from one study to another. Longe (1984) noted poorer egg production for layers fed 20% PKC, while other authors found that 20% PKC could be used in layer diets without detrimental effects on performance (Yeong and Mukherjee, 1983; Ngoupayou, 1984).

Onwudike (1988) reported that levels as high as 40% for laying hens could be used without reducing performance. Due to its high fibre content, the use of palm kernel cake in poultry rations is very limited. Osei and Amo (1987) evaluated palm kernel cake as a broiler feed ingredient. Palm kernel cake partially replaced maize at levels of 0, 5, 7.5, 10, 12.5 and 15%. The addition of palm kernel cake to the diet had no significant effect on feed consumption and body weight up to 8 weeks of age. However, feed conversion efficiency significantly declined as palm kernel cake levels reached 12.5% and above.

Owing to its high fibre content, the use of PKC in poultry rations is very limited. There exist wide variations in the optimum inclusion level of PKC in poultry rations. The main reasons are due to the origin and variations in the oil and shell content of the PKC used. Broilers can tolerate up to 20% PKC in their diets without affecting their growth performance and feed efficiency (Yeong, 1980). A feed conversion ratio of 1:0.48 was reported for broilers fed palm kernel expeller (PKE) at 35 days of age (Onifade and Babatunde, 1998). In layer rations, PKC can be included up to 25% without any deleterious effects on egg production and quality (Radim *et al.,* 2000). Inclusion of PKC at levels greater than 20% was reported to reduce egg production and egg quality (Yeong *et al., 1*981) but in another study, reduced egg production was observed only at levels

greater than 40% (Onwudike, 1988). Muscovy ducks can be fed PKC at 30% level without any deleterious effects on their performance (Mustafa, 2002).

2.5.2 Palm Kernel Cake in Swine Nutrition

Palm kernel cake has been found to reduce the cost of swine diets. In a study on growing pigs, Okai and Opoku-Mensah (1988) assessed the performance of the pigs on palm kernel cake at 0, 10 and 20% inclusion levels. At the end of the 28-day trial, all the growth performance criteria were found to be higher for the palm kernel cake diets except for feed intake which was similar for all the three treatments. Back fat thickness was however higher ($P< 0.05$) for the palm kernel cake-based diets. There was a decrease in the cost of a kilogram feed with increasing levels of dietary palm kernel cake.

Rhule 1996 also fed the palm kernel cake at 0, 20, 30 and 40% inclusion levels to grower pigs from 25 to 90 kg live weight without any adverse effect on performance. The average daily weight gains (ADG) by the pigs for the grower stage were 0.46, 0.46, 0.43 and 0.41kg respectively on the 0, 20, 30 and 40% palm kernel cake diets. These values for 0% palm kernel cake and 20% palm kernel cake inclusions were similar and significantly higher ($P< 0.05$) than with the 30% palm kernel cake diet, which were in turn similar to those with the 40% palm kernel cake diet. But at the finisher phase, there was no significant difference between the ADGs, though that of the 40% palm kernel cake was lower.

In another study, Rhule 1998 evaluated the effect of two diets containing palm kernel cake from two oil mills (A and B), incorporated into the diets at 300 g/kg level. The average daily gains of the pigs were 0.57, 0.46, and 0.49 kg/day for those on the control diet, palm kernel cake A and palm kernel cake B diets respectively, during the grower period. The

corresponding values were 0.60, 0.63, and 0.65 kg/day during the finisher period, and 0.60, 0.54, and 0.55 kg/day during the entire grower-finisher period. It was also reported that the palm kernel cake with high level of residual fat led to a higher average daily weight gain and better feed conversion efficiency but there was increased carcass fatness and reduced leanness in pigs. Studies by Okai *et al.* (2006) under the AgSSIP Non-ruminant Programme indicated that when a 34.5% palm kernel cake diet was fed to pigs, there was no deleterious effect on carcass characteristics. However, pigs on a control, maize-based diet reached market weight earlier than those on the palm kernel meal diet.

PKC was also found to be suitable for swine at 20%–25% inclusion for growers and finishers. In some areas in Peninsular Malaysia, PKC is used at lower levels (about 5%-10%). In Nigeria, PKC is fed to swine at from 15%-40% without any negative effects on performance (Codjo *et al.*,1995). In Ghana, PKC was included at 25%–35% in the rations of grower and finisher pigs, respectively (Rhule,1996).

2.5.3 Palm Kernel Cake in Ruminant Nutrition

PKC is widely used as the main ingredient in rations for feedlot cattle and buffaloes. In Malaysia, feedlot cattle are normally fed up to 80% PKC with live weight gain (LWG) of 0.6-0.8 kg day^{-1} and 1-1.2 kg day^{-1} for local (Kedah-Kelantan) and crossbred cattle respectively. PKC at almost 100% has been fed to feedlot cattle with no negative effect provided that the supply of Ca and vitamins (in particular, A, D and E) is sufficient to meet their requirements. Many studies have shown that supplementing the traditional rations of beef cattle with 30%-50% PKC gave improved performance and increased LWG. It is a common practice in Malaysia to produce complete feeds based on PKC, either as pellets, cubes or total mixed ration (TMR) (Wan Zahari *et al.*, 2000; 2003).

Carcass analysis indicated that the beef cuts were of superior quality when compared to those for cattle fed on grass or pasture.

In dairy cattle rations, PKC is used as a source of energy and fibre at the inclusion level of 30%-50%. PKC-based dairy cattle pellets are popular in Malaysia and are commonly fed together with grass and other concentrates. Grass and concentrates are fed at 50%-70% inclusion apart from PKC. Under Malaysian local conditions, a milk yield of 10-12 litres day^{-1} $head^{-1}$ can be achieved and with good formulation even higher yields. Most of the PKC exported to Europe are used in dairy cattle rations, but the level of inclusion is rather limited, *i.e.* about 7%-15%.

The recommended inclusion level of PKC in sheep rations is 30%. Long-term feeding of PKC at high inclusion level (>80%) can cause Copper (Cu) toxicity in sheep as sheep is known to be very susceptible to Cu poisoning. Some sheep breeds (especially crossbreds) accumulate Cu in their liver causing liver damage. Addition of 100 ppm of zinc sulphate or 5.2 mg kg^{-1} ammonium molybdate together with 440 mg kg^{-1} sodium sulphate in the rations can overcome the problem. Cu toxicity was not observed in cattle, buffaloes, goats and other animals. (Hair-Bejo, 1995).

Table 5 shows the various recommended levels for PKC inclusion in the diet of different livestock species.

Table 5: Recommended levels of Palm Kernel Cake in livestock feeds

Livestock Specie	Recommended Inclusion level (%)
Beef cattle	50-80
Dairy cattle	30-50
Sheep	Maximum 30
Goat	30-50
Poultry-broiler	15-20
Poultry-layer	15-25
Swine	15-25
Fresh water fish	10-20

Source: Wan Zahari and Alimon (2004)

2.6 Limitations to the use of Palm Kernel Cake in Non-Ruminant Nutrition

Reviewed literature has showed that palm kernel cake had been accepted as a viable feed ingredient. Many studies have been conducted to improve nutrient values of PKC through solid-state fermentation (SSF) either by using fungi such as *Aspergillus niger* (Iluyemi *et al*., 2006; Lawal *et al*., 2010 and Ramin *et al*., 2010), *Sclerotium rolfsii, Trichoderma harzianum* (Ramin *et al*., 2010), *Trichoderma longibrachiatum* and *Trichoderma koningii* (Iluyemi *et al*., 2006), *Rhizopus* spp. (Rahim *et al*., 2007; Lawal *et al*., 2010; Ramin *et al*., 2010), *Trichoderma varidae* and *Mucor mucedo* (Lawal *et al*., 2010) and bacteria such as *Bacillus 7DY7* (Wong *et al*., 2010). The fermented feed ingredients under SSF conditions have been found to be more suitable for low technology application, and there was hardly any waste disposal at the end because the whole product was used directly in the animal feeds (Iluyemi *et al*., 2006). Apart from that, the SSF of PKC produced a product that contained high protein content and low hemicellulose and cellulose concentration. The levels of unsaturated fatty acids increased while saturated fatty acids decreased as a result of SSF of PKC using fungi as culturing agents (Iluyemi *et al*., 2006). The unsaturated fatty acids were more nutritionally valuable compared to the saturated fatty acids. This is because all of the essential fatty acids are unsaturated and must be provided from feed (Murano, 2003; Iluyemi *et al*., 2006).

The use of different types of fungi or bacteria as an agent in SSF by several researchers elicited different results on the nutrient contents of PKC. In a study conducted by Ramin *et al*. (2010) using three different fungi species: *Aspergillus niger, Trichoderma harizianum* and *Rhizopus oryzae* in SSF of PKC, they reported that *A. niger* or *R. oryzae* were two potentially effective fungal species which could improve the nutrient content of PKC. The treatment improved the concentration of CP and reduced the NDF and ADF

values. The result appeared to be in line with observations by Ng *et al*. (2002), who reported that *Trichoderma koningii* almost doubled the protein content of PKC. The nutrient analysis of raw PKC and fermented PKC from different fungal strains is shown in Table 6.

Table 6: Proximate analysis of raw PKC and fermented PKC of different fungal strains

Nutrient	PKC[1]	*FPKC[1]	PKC[2]	FPKC *Rhizopus* sp..[2]	PKC[3]	FPKC *A. niger*[3]	FPKC *T. viridae*[3]	FPKC *M. mucedo*[3]
DM (%)	91.8	91.8	-	-	88.4	90.0	88.8	88.9
CP (%)	20.0	23.4	16.5	18.9	12.0	21.2	19.6	20.7
EE (%)	8.6	3.8	2.0	1.3	3.9	3.9	4.2	4.0
CF (%)	15.4	12.4	21.9	18.6	20.2	12.4	11.8	11.3
ASH (%)	7.5	8.3	-	-	13.9	19.6	19.8	18.9
ME **(MJ/Kg)	11.6	11.1	7.35	11.50	8.94	9.54	9.60	9.58

*FPKC: Fermented PKC **-Metabolizable Energy for Poultry (Determined)
[1]Dairo and Fasuyi (2007); [2]Rahim *et al*. (2007); [3]Lawal *et al*. (2010)

The current trend in modern animal nutrition is to find means of making the non-starch polysaccharides more available to farm animals, especially monogastrics. One approach that has proved useful in recent years is the addition of exogenous enzymes to the feed. The ability of exogenous enzymes to break down high fibre feedstuffs and improve their nutritive value has been reported by Ofuya and Nwajiuba (1990), Chen *et al.* (1997), Okai *et al.* (2000) and Iyayi and Davies (2005).

Sundu and Dingle (2003) have stated that there are basically three enzymes that are needed to improve the nutritive value of palm kernel meal, namely: mannanase, α galactosidase and celullase to digest the mannan, cellulose and the galactosidic side chains of the palm kernel cake. Laboratory studies have proven this theory (Balasubramaniam 1976). It is for this reason that exogenous enzymes are now being tested to determine the extent of improvement in the digestion of palm kernel meal

2.7 Use of enzyme in livestock feeding

The use of crude enzyme products as animal feed supplements has attracted considerable attention by the feed manufacturer and livestock producers as a means of improving animal performance. Enzymes have been used to degrade different structural carbohydrates found in cereals, particularly those that are not digested by avian and mammalian enzymes, and those that are highly viscous and have high water-binding capacity. The major cell-wall polysaccharides of concern are the β-glucans in barley and oats, the arabinoxylans in rye, wheat and triticale, and possibly other carbohydrates such as pectins, and the oligosaccharides of the raffinose family in other feedstuffs. The viscous polysaccharides reduce the rate of hydrolysis and absorption of nutrients in the diet, particularly the saturated fats and the fat-soluble vitamins.

Digestibility of all other constituent nutrients, including protein, carbohydrates and minerals, seem to be affected also. The presence of viscous carbohydrates has been shown to specifically reduce feed intake, weight gain, efficiency of feed utilization and apparent metabolizable energy (AMEn), and to increase water intake, beak impaction and vent plugging, the size of the gastrointestinal tract, the number of anaerobic microorganisms in the large intestine, and the water content of digesta and excreta. The production of wet litter often brings about management problems, particularly when the humidity is high and external temperatures are low. The effect of dietary enzyme is influenced by the type and concentration of the undesirable carbohydrate present in the feedstuff and the class and age of the livestock and poultry that consume it. (Campbell and Bedford, 1992)

Young chicks are affected to a greater degree by antinutritional compounds than older birds or swine. Specific enzymes that appear to be beneficial for non-ruminant animals are the xylanases, or more specifically the endoxylanases for wheat, triticale and rye and the β -glucanases or cellulases for barley and oats. Most commercial enzymes contain a spectrum of different enzymes including xylanases and β-glucanases and therefore can be used effectively with the above cereals. 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 enzymes is one which increases the availability of phosphorus from phytate, a bound form of phosphate found in cereals and other plant material. It has become available for use in the feed industry and should assist in reducing phosphorus requirements in non-ruminant animals and therefore the associated pollution problems. The use of enzymes in non-ruminant feeds has been reviewed by Campbell and

Bedford (1992). Factors that need to be considered when using exogenous enzymes are as follows:

- The enzyme supplement must contain the proper spectrum of enzymes so that antinutritive effects of target substrate will be neutralized
- The supplement must contain adequate amounts (activities) of the appropriate enzymes as to neutralize the effects of the antinutritional factors in the diet.
- Different cereals contain different amounts of the enzyme-sensitive antinutritional factor. Therefore, the response to enzyme treatment may vary within a given cereal.
- Results are affected by class and age of poultry. The responses in swine are usually less dramatic than those of poultry and have not been clearly established.
- The enzymes must not be inactivated by processing or by the low pH or digestive enzymes in the gastrointestinal tract.

Enzyme treatment has also been shown to affect the relative size of the digestive tract and certain organs such as the pancreas and the liver in chicks fed wheat and Scout barley (Brenes *et al.,* 1993b). For example, relative reductions in organ size in birds fed an enzyme-supplemented barley-based diet compared with the unsupplemented diet were: Pancreas, 24%; Liver, 8%; Proventriculus, 39%; Duodenum, 16%; Jejunum, 20%; Ileum, 18%; Colon, 29%. Relative crop and gizzard weights were not significantly affected by enzyme addition. Overall organ weight was reduced by 13% with enzyme supplementation, which represents 1% of the total weight of the bird. Similar but not identical results were obtained in another study with Scout and Bedford barley with the enzyme treatment being more dramatic with the former than with the latter cereal (Brenes

et al., 1993a). The exception was that the relative crop and gizzard weights were significantly reduced by 15% and 17%, respectively, in birds fed enzyme-supplemented Scout barley and by 7% and 8% in birds fed enzyme-supplemented Bedford barley.

Exogenous enzymes available in the market have different profile although most are produced for non starch polysaccharides (NSP) digestion (Alam et al., 2003). Enzyme supplementation is well documented as effective in breaking polymeric chains of NSPs and improve the nutritive value of fibrous feedstuffs (Adeniji and Jimoh, 2007; Elwakeel et al., 2007; Geraldo et al., 2008). However, due to variation in the chemical structure of these feedstuffs, a combination of various non-starch polysaccharide enzymes has been recommended to enhance better digestibility of non starch polysaccharides. Non starch polysaccharides are not chemically uniform constituents of the feed and their profile varies from feedstuff to feedstuff (Van Soest, 1967). Thus an enzyme that can achieve a good digestibility in a feedstuff may not be able to achieve the same level in another feedstuff. For instance, wheat offal has 46% neutral detergent fibre, 14% acid detergent fibre, 10.2% cellulose, 32% hemicelluloses and 3.8% acid detergent lignin. Maize offal also has 50.88% neutral detergent fibre, 28.5% acid detergent fibre, 24.4% cellulose, 22.38% hemicellulose and 4.1% acid detergent lignin (Onifade and Babatunde, 1998).

There are many commercial enzymes available for the livestock farmers and these include Nutrase Xyla, Roxazyme G, Ronozyme P, Natuzyme, Grindazyme, Natuphos-P *etc*. These enzymes have different profiles and activities. Although many of them are designed for fibre digestion, several research works have shown that no single enzyme can achieve complete fibre digestion. This is partly due to the complexity of the potential substrates, the profile of which varies from feed stuff to feed stuff and even within feed stuff of

different stages of maturity. Because of this, a growing body of literature advocating the use of multi-enzyme preparations has emerged, particularly of those with multicarbohydrase activities (Slominski, 2000).

2.8 Exogenous Enzymes in poultry nutrition

Feeding enzymes to poultry is one of the major nutritional advances in the last fifty years. Nutritionist realized it long age, but could not explain it until 1980s'. Indeed, the theory of feed enzymes is simple. Plants contain some compounds that either the animal cannot digest or which hinder its digestive system, this is often because the animal cannot produce the necessary enzymes to degrade them. Nutritionists can help the animal by identifying these indigestible compounds and feeding a suitable enzyme. These enzymes come from microorganisms that are carefully selected for the task and grown under controlled conditions (Wallis, 1996).

Enzymes are one of the many types of protein in biological systems. Their essential characteristic is to catalyze the rate of a reaction but is not altered by it. They are involved in all anabolic and catabolic pathways of digestion and metabolism. Enzymes tend to be very specific catalysts that act on one or, at most, a limited group of compounds known as substrates. Enzymes are not living organisms and are not concerned about viability or cross infection. They are stable at 80-85ºC for short time.

Another important feature of enzymes is that the rate of an enzyme catalyzed reaction increases with increasing substrate concentration, to the point where there is no further response and the enzyme is said to be saturated. Therefore, we need to match the amount of enzyme with the quantity of substrate (Acamovic and McCleary, 1996). It is common

practice to name enzymes by adding the suffix ‘ase’ to the name of the principal substrate. For example, β-glucanase is an enzyme that splits β-glucans, and proteases break protein. We may also broadly categorize the digestive enzymes as endogenous or exogenous, referring to those produced by the animal and those administered from outside respectively. For example, pancreatic lipase, which splits fat or lipid into glycerol and fatty acids, is an endogenous enzyme. Those enzymes added to feed as a supplement are exogenous (Classen, 1996; Classen and Bedford, 1991).

The use of enzymes in animal feed is of great importance. Consistent increase in the price of feed ingredients has been a major constraint in most of the developing countries. As a consequence, cheaper and non-conventional feed ingredients have to be used These non-conventional feed ingridients, most times contain higher percentage of Non-Starch Polysaccharides (soluble and insoluble/crude fibre) along with starch, Non-Starch Polysaccharides (NSPs) which are polymeric carbohydrates. They differ in composition and structure from starch (Morgan *et al.*,1995) and possess chemical cross linking among them. Therefore, they are not well digested by poultry (Adams and Pough,1993; Annison,1993). A part of these NSPs is water-soluble, and its notorious for forming a gel like viscous consistency in the intestinal tract (Ward, 1995) thus reducing gut performance. Predominantly, water soluble and viscous arabinoxylans, which belongs to pentosan group, are assumed to be the factor responsible. These pentosans also greatly increase the water intake by the birds, leading to unmanageable litter problems caused by wet and sticky droppings. This deteriorates the hygienic conditions and carcass quality (Dunn, 1996). On the other hand, β- glucans adversely affect all nutrients, especially

protein and starch utilization and are known to give rise to highly viscous conditions in the small intestine of the chicks (Hasselman and Aman, 1986).

Poultry do not produce enzymes for the hydrolysis of Non-Starch Polysaccharide present in the cell wall of the grains and they remain un-hydrolyzed. This results in low feed efficiency. Research in this area has suggested that the negative effects of NSPs can be overcome by dietary modifications including supplementation of diets with suitable exogenous enzyme preparations. Enzymes degraded the NSPs, decreased intestinal viscosity and eventually improved the digestibility of nutrients by improving gut performance. (Creswell, 1994).

2.8.1 Types of enzymes available for poultry

Some of the enzymes that have been used over the past several years or have potential for use in the feed industry include cellulase (β-glucanases, xylanases) and associated enzymes, phytases, proteases, lipases, and galactosidases. Enzymes in the feed industry have mostly been used for poultry to neutralize the effects of the viscous, non-starch polysaccharides in cereals. These antinutritive carbohydrates are undesirable, as they reduce digestion and absorption of all nutrients in the diet, especially fat and protein. Recently, considerable interest has been shown in the use of phytase as a feed additive, as it not only increases the availability of phosphate in plants but also reduces environmental pollution. Several other enzyme products are currently being evaluated in the feed industry, including protease to enhance protein digestion, lipases to enhance lipid digestion, β-galactosidases to neutralize certain antinutritive factors in non-cereal

feedstuffs, and amylase to assist in the digestion of starch in early-weaned animals (Khattak *et al*., 2006).

Exogenous enzymes such as carbohydrases, phytases and proteases or a combination of these enzymes are often incorporated into poultry diets but there is dearth of information on the efficacy of these enzymes in poultry diets containing varying levels of PKC. In addition to improving digestibility, supplementing diets containing PKC with exogenous enzymes may reduce variability in the nutritive value of the product. Reduction in the variability in nutrient quality of feed ingredients with the use of exogenous enzymes has been reported in literature (Bedford and Schulze, 1998; Bedford, 2000), and improvement in growth performance and nutrient utilisation have also been observed to be greater for poor quality raw materials (Classen *et al*.,1995; Bedford and Schulze, 1998).

2.8.1.1 Carbohydrases

These are enzymes that hydrolyse NSP into oligosaccharides and monosaccharides. The nutritive benefits of supplemental carbohydrases in diets includes reduced digesta viscosity in the gastrointestinal tract due to the hydrolysis of soluble arabinoxylans and β-glucans, the release of nutrients encapsulated in the NSP structure and gel matrix and a greater exposure of substrates to digestive enzymes (Bedford, 2000). The types and concentrations of NSP vary among feedstuffs. For example, wheat, maize, triticale and rye contain predominantly arabinoxylans, whereas barley and oats are rich in β-glucans. Therefore the types of carbohydrases that are supplemented to diets vary according to the dietary NSP composition. Hence, xylanases are supplemented to wheat, maize, triticale

and rye-based diets, whereas β-glucanases are more effective in barley and oat-based diets.

Xylanases are hydrolases depolymerising the plant cell wall component xylan. The depolymerisation action of endo-xylanase results in the conversion of the polymeric substance into xylooligosaccharides and xylose. The complex structure of xylan requires different enzymes for its complete hydrolysis. Endo-1, 4- β-xylanases depolymerise xylan by the random hydrolysis of xylan backbone and 1, 4- β-D-xylosidases split off small oligosaccharides. The side groups present in xylan are liberated by α-L-arabinofuranosidase, α-D-glucuronidase, galactosidase and acetyl xylan esterase. Diverse forms of these enzymes exist, displaying varying folds, mechanisms of action, substrate specificities, hydrolytic activities (yields, rates and products) and physicochemical characteristics (Adeola and Cowieson, 2011). Research has focused mainly on only two of the xylanase containing glycoside hydrolase families, namely families 10 and 11, yet enzymes with xylanase activity belonging to families 5, 7, 8 and 43 have also been identified and studied, although to a lesser extent (Collins *et al*., 2005).

The plant cell wall is a composite material in which cellulose, hemicellulose (mainly xylan) and lignin are closely associated. Wheat contains 5 to 8% arabinoxylans (pentosans consisting of the monosaccharides; arabinose and xylose linked in β-1-4 linkages), up to 1% β-glucans and 2-3% cellulose (Choct *et al*., 2004). Supplementation of wheat-based diets with exogenous xylanase has been documented to be effective at ameliorating the negative effects of NSP in poultry diet (Choct *et al*., 2004; Adeola and Cowieson, 2011).

Improvements in growth responses and nutrient digestibility with the supplementation of xylanase in wheat-based poultry diets have been widely reported. Olukosi *et al*. (2007) reported improvement in weight gain, feed intake and feed efficiency in broilers using low

and high levels of supplemental xylanase. Improvement in FCR in broilers fed either milled or whole wheat supplemented with a xylanase was reported by Wu *et al*. (2004). Amerah and Ravindran (2009) observed an increase in feed intake and BWG in broiler starters fed xylanase supplemented soft wheat-based diet; xylanase supplementation of high-viscosity wheat-based diet improved weight gain and feed efficiency by 13 and 12%, respectively, and true metabolisable energy in ducks (Adeola and Bedford 2004).

Veldman and Vahl (1994) reported an improvement in feed conversion ratio (FCR) and body weight gain (BWG) in broilers fed xylanase supplemented diets related to lowering of digesta viscosity, Nian *et al*. (2011) reported an improvement in FCR of diet, Apparent Metabolizable Energy (AME) and ileal digestibility of hemicellulose in 4 week old broilers. An increase in ileal digestibility of insoluble NSP in low-ME wheat was reported by Choct *et al*. (2004). Improvement in the apparent ileal digestibility of 17 amino acids (average of 4.8%) was observed by Selle *et al*. (2009) in xylanase supplemented diets for broilers, whereas supplementation of xylanase and β-glucanase enzymes yielded modest improvements in FCR of turkey receiving wheat, barley or wheat-based diets (Mathlouthi *et al*., 2003). The use of xylanases in wheat-based diets reduced the viscosity of digesta by 30% and 50% in studies by Wu *et al*. (2004) and Steenfeldt *et al*. (1998), respectively. Reducing digesta viscosity for poultry using carbohydrases is important. Adeola and Cowieson (2011) noted that the benefits derived from a reduction in digesta viscosity are often greater than improvement in energy utilisation and the effect of digesta viscosity are usually more pronounced in poultry compared to most other monogastrics.

2.8.1.2 Proteases

Protease refers to a group of enzymes whose catalytic function is to hydrolyze peptide bonds of proteins. Over the years, the use of proteases as feed additives has been a regular practice in cereal-based diets usually as an integral part of enzyme admixtures (Adebiyi, 2014).Two of the potential mode of action of proteases are these: that proteases may supplement endogenous peptidase production, reducing the requirement for amino acid and energy and also proteases may hydrolyse protein-based anti-nutrients such as lectins or trypsin inhibitors, improving the efficiency by which the bird utilizes amino acid and reducing protein turnover (Adeola and Cowieson, 2011).

Reports of using proteases alone are scarce as they are more often incorporated as a part of a mix of enzymes. Odetallah *et al*. (2003) determining the efficacy of a broad-spectrum protease enzyme (keratinase) in maize-SBM broiler starter diet reported improved growth performance, BWG and FCR in broiler chicks fed either low or high amounts of protein. Brenes *et al*. (1993a) similarly observed improved FCR and AME in a protease-based enzyme preparation fed to chicks and laying hens.

2.8.2 Enzyme Combinations

It is reasonable to assume that if carbohydrases can breakdown NSP and elicits beneficial improvements, a combination with other enzymes (proteases and phytases) exhibiting different catalytic activities and producing positive effects might improve the scale and consistency of response. Several studies have reported beneficial effects of supplemental enzyme admixtures in wheat-based, maize-based and barley-based poultry diets (Cowieson and Adeola,2005; Thacker, 2005; Francesch and Geraert, 2009; Olukosi *et al*.,

2007; Olukosi *et al*., 2008; Selle *et al*., 2009). Therefore, the use of a multi-enzyme complex in diets containing PKC may help improve its nutritive worth for poultry.

2.8.3 Effect of diet and exogenous enzymes on gut morphology

The efficiency of digestion and absorption of dietary nutrients by poultry is affected by the development and health of the gastrointestinal tract. The physical and chemical characteristics of the diet have been reported to have an effect on the morphology of the small intestinal absorptive structure (Smits and Annison, 1996). The changes to the morphology of the gastrointestinal tract are often due to the presence of toxins or the anti-nutritive effects of dietary fibre. (Smits and Annison, 1996). Short villi are indicative of less surface area for nutrient absorption. The crypt depth may give an indication of the rate of cell proliferation and an increase in crypt depth is an indication of faster cell turnover and greater metaboliccost for cell replacement (Yang *et al*., 2008; Rebole *et al*., 2010). However, the effect of exogenous enzymes on gastrointestinal tract morphology of broilers has not been consistent. Mathlouthi *et al*. (2002) reported improvements in the gut morphology of broilers with xylanase supplementation of a rye-based diet, whereas Yang *et al*.(2008) noted that supplemental xylanase did not affect jejunal villi height but reduced crypt depth of broilers receiving a wheat-SBM based diet at seven days of age. Using supplemental phytase, Wu *et al*. (2004) noted an increase in duodenal villi height but no effect on crypt depth in broilers at 21 days of age. In the study of Iji *et al*. (2001) there was no effect of xylanase on gut morphology of broilers receiving a wheat-based diet in their study. The responses noted in the studies described above indicate that the effect of exogenous enzymes on cellular development of the gastrointestinal tract structure is inconsistent and requires further investigation, (Adebiyi, 2014).

2.8.4 Benefits of enzymes

The use of enzyme in poultry diets confers benefits which include; reduction in digesta viscosity, enhanced digestion and absorption of nutrients, especially fat and protein, improved Apparent Metabolizable Energy (AME) value of the diet. Also, it causes increased feed intake, weight gain, and feed-gain ratio, reduced beak impaction and vent plugging. There is also a resultant decrease in the size of gastrointestinal tract, altered population of microorganisms in gastrointestinal tract, reduced water intake, reduced water content of excreta, reduced production of ammonia from excreta, reduced output of excreta and reduced Nitrogen and Phosphorus. (Ouhida *et al.*, 2000; Gill, 2001; Odetallah, 2002; Gracia, *et al.*, 2003; Saleh, *et al.*, 2003; Odetallah, *et al.*, 2005 and Wang *et al.*, 2005).

2.8.4.1 Reduction in digesta viscosity

Enzymes added to poultry diets; especially diets containing cereals rich in NSP such as wheat, barley, and rye, reduces viscosity in the diet and digesta of the animals fed the enzyme supplemented diets. Morgan *et al.* (1995) and Muramatsu *et al*. (1992) found that enzyme supplementation of wheat based diets significantly reduced foregut digesta viscosity of birds. The reduction in foregut digesta viscosity was achieved primarily by reducing the molecular weight through hydrolysis of xylan backbone by endo-xylanase into smaller compounds and thus reduction in viscous effects of the feed because foregut digesta viscosity is directly proportional to the molecular weight of wheat arabinoxylans (Bedford and Classen, 1993). As a result of endo-xylanase and ß-glucanase supplementation, the long backbones of the arabinoxylans and ß-glucans are cleaved into shorter fragments, thereby reducing their viscosity (Gruppen *et al*., 1993). Similar

findings on digesta viscosity were also reported by Bedford and Classen (1993); Bhatt *et al.* (1991) and Dunn, (1996) who inferred that the high viscosity in the gut contents caused by the pentosans led to increased water intake of the birds, which resulted in the wet and sticky droppings. (Khattak *et al*., 2006).

2.8.4.2 Increase in available energy

One of the main reasons for supplementing wheat- and barley-based poultry diets with enzymes is to increase the available energy content of the diet. Increased availability of carbohydrates for energy utilization is associated with increased energy digestibility (Partridge and Wyatt 1995; Van der Klis *et al*., 1995). The AME of wheat has been extensively studied and found to have a considerable range of 9,500-16,640 kJ/kg (Mollah *et al*., 1983; Rogel *et al*., 1987; Annison 1993; Choct *et al*., 1995; Ward 1995). Enzyme supplementation improves this range by enhancing carbohydrate digestibility, reducing gut viscosity, and improving fat utilization (Almirall *et al*., 1995). The improvements in AME resulting from enzyme supplementation are variable because of the variability in the NSP content of wheat. Classen *et al*. (1995), Schutte *et al*. (1995), and Van der Klis *et al*. (1995) reported improvements of 5-16, 3·1-4·5, and 4·5-12·4%, respectively. The increase in AME with the use of enzymes is difficult to predict, as nutrient ratios, such as energy-protein, and other factors also play important roles in poultry-feed formulations. The AME value of wheat has been correlated with its content of water soluble NSPs (Annison 1991), which in turn affects gut viscosity (Bedford *et al*., 1991). Unfortunately, NSP analyses are relatively lengthy processes and in a commercial situation rapid testing of incoming grains is required. No chemical test or detectable physical characteristics can be used to rapidly predict the AME value of wheat or to estimate the improvements to be

expected from the use of enzymes. This is part of the difficulty in trying to accurately estimate the energy content of wheat or barley in poultry feeds and compensate for the efficiency by adding enzymes. (Khattak *et al*., 2006)

Adding adequate activity levels of α-amylase, ß-glucanase, and xylanase to broiler starter and grower corn-soybean diets with a 3% reduction in dietary ME allowed for full restoration of growth performance of broilers comparable to those fed the adequate energy (Yu and Chung, 2004).

2.8.4.3 Improvement in nutrient digestibility

Enzymes have been shown to improve performance and nutrient digestibility when added to poultry diets containing cereals, such as barley (Hesselman *et al*., 1982; Hesselman and Åman 1986; Friesen *et al*., 1992; Marquardt *et al*., 1994), maize (Saleh *et al*., 2003), oats (Friesen *et al*., 1992), rye (Fengler and Marquardt 1988; Fengler *et al*., 1988; Friesen *et al*., 1991, 1992; Bedford and Classen 1992; Marquardt *et al*., 1994), and wheat (Fengler *et al*., 1988; Friesen *et al*., 1991; Marquardt *et al*., 1994), and to those containing pulses, such as lupins (Brenes *et al*., 1993b). The effect of enzyme supplementation on Dry Matter Digestibilities (DMD) in pigs and poultry depends on the type of diet and the type of animal for example, increases in DMD ranges from 0·9 % (Schutte *et al*., 1995) to 17 % (Annison and Choct 1993) in poultry. The enzymes currently used in monogastric diets are predominantly glucanases, which cleave NSPs into smaller polymers, thereby removing their ability to form viscous digesta and enhancing nutrient digestibilities. The effects of glucanases are generally nonspecific, except for their effect on fat (greater effect

on saturated fat than on unsaturated fat). Another enzyme used in feed is phytase, which increases the utilization of phytate phosphorus. The ability of phytase to improve the digestion of phytate phosphorus and subsequently to reduce the output of organic phosphorus to the environment has attracted a great deal of scientific and commercial interest. In poultry, use of phytase was reported to reduce phosphorus excretion by as much as 40% for broilers. When phytase was added to layer diets, increased egg production and positive effects on egg weight and tibia ash were also noted (Simons and Versteegh, 1991).

2.8.4.4 Reduction in excreta moisture

A reduction in the moisture content of poultry excreta is often noted when glucanases are included in the diet. Supplementing the NSP-enriched diet with three different commercial glycanase products improved performance, but their effectiveness in reducing the moisture levels of the excreta differed from 10 to 29%. This supports the view that different glucanases have similar performance enhancement effects in monogastric animals but the site of the breakdown of the NSPs in the gut and the molecular sizes of the released products differ (Choct and Annison, 1990). Graham (1996) also reported an increased water uptake and excretion in broilers given diets containing higher levels of viscous cereal grains.

2.8.4.5 Health improvement

Morgan and Bedford (1995) reported that coccidiosis problems could be prevented by using enzymes. Birds fed a wheat-based diet with and without glycanase supplementation showed vastly different responses to coccidiosis challenge. Growth was depressed by 52.5% in the control group but by only 30.5% in the enzyme group, which also had a much better lesion score. An increase in digesta passage rate and a reduction in excreta moisture are often noted when glucanases are added to poultry diets, which may be detrimental to the life cycle of the organism.

2.8.4.6 Precision and flexibility in least cost feed formulation

Enzymes provide greater flexibility in feed formulation and allow the use of a wide range of ingredients without compromising birds performance, thus providing great flexibility in least-cost feed formulation. The nutritive value of cereal grains for poultry varies greatly, and no suitable assays are currently available for rapid in-mill testing. For instance, the variability in the AME of wheat for poultry can be as great as 4 MJ/kg DM (Sibbald and Slinger 1962; Rogel *et al*., 1987). This problem can be largely overcome by using glucanases to bring the AME of different wheat to comparable levels (Choct *et al*., 1995).

2.8.4.7 Impact on environment

Enzymes have been approved for use in poultry feed because they are natural products of fermentation and therefore pose no threat to the animal or the consumer. Enzymes would

enable livestock and poultry producers to economically use new feedstuffs. It has also proved to be environmentally friendly, as they reduce the pollution associated with animal production. They also contributes to improved poultry production. Feed enzymes can have a positive impact on the environment. In areas with intensive poultry production, the phosphorus output is often very high, resulting in environmental problems such as eutrophication. This happens because most of the phosphorus contained in typical feedstuffs exists as the plant storage form phytate, which is indigestible for poultry. The phytase enzyme frees the phosphorus in feedstuffs and also achieves the release of other minerals (e.g. Ca, Mg), as well as proteins and amino acids bound to phytate. Thus, by releasing bound phosphorus in feed ingredients, phytase reduces the quantity of inorganic phosphorus needed in diets, makes more phosphorus available for the bird, and decreases the amount excreted into the environment. (Khattak *et al*., 2006).

2.8.5 Factors affecting enzyme utilization

The degree of improvement obtained by adding enzymes to the diet depends on many factors (Bedford, 1996), including the type and amount of cereal in the diet; the level of antinutritive factor in the cereal, which can vary within a given cereal (for example, low- versus high-ß-glucan barley); the spectrum and concentration of enzymes used; the type of animal (poultry tend to be more responsive to enzyme treatment than pigs); and the age of the animal (young animals tend to respond better to enzymes than older animals); type of gut micro flora present and the physiology of the bird. Older birds, because of the enhanced fermentation capacity of the micro flora in their intestines, have a greater

capacity to deal with negative viscosity effects (Allen *et al*., 1995; Choct *et al*., 1995; Vukic Vranjes and Wenk 1993).

2.9 Enzyme and palm kernel cake

The digestion of non starch polysaccharides (NSPs) of the cell wall of PKC in poultry is variable due to low digestive enzymic activity and their tendency to create a viscous environment in the intestinal lumen (Choct and Anisson, 1992; Józiefak *et al*., 2004). However, it can be broken down with the help of enzymes produced by the caecal microflora or by supplementation of poultry diets with specific enzymes (Choct *et al*., 1999; Józiefak *et al*., 2004). For example, a study conducted by Zanu *et al*. (2012) showed that layers could utilize PKC-based diet up to 5 and 10% inclusion without adverse effects on their production performance and there was a decrease in feed cost and a higher net return from birds fed PKC based diets thus, more profit to the poultry farmer. Although the inclusion of PKC in poultry diets has been studied by some researchers (Onwudike, 1986; Zulkifli *et al*., 2003; Mustafa *et al*., 2004) the recommended levels of inclusion seem to vary from one study to another (Chong *et al*., 2008).

2.10 Other oil-palm by-products

There is a wide variety of other by-products produced from the processing of oil palm and palm kernel extraction, some of which include Palm oil Mill Effluent (POME), Oil Palm Fronds (OPF), Palm Press Fibre (PPF), and Palm Oil Sludge (POS). The primary extraction of palm oil from pericarp of palm fruit yields the kernel alongside POS and PPF as by-products (Fafiolu *et al*., 2015). Although, PKC was ranked higher in nutritive

value than copra meal, but lower than Fish meal and groundnut cake, all these by-products are in varying nutritive value and only some of them have been used as effective replacement for conventional feedstuffs.

Two other products were used by Fafiolu *et al*. (2015) to feed broiler chickens and they are: Palm Kernel Extraction Residue (PKER) and Palm Kernel Sludge (PKS). PKER is obtained when the kernel is crushed to separate oil from cake as a residue at the bottom of uncooked oil, separated from the oil by decanting and sieving. It however, contains some uncrushed kernel and possesses high oil content relative to the other by-product. PKS is obtained as sediment at the bottom of cooking tank and allowed to drain for some hours to remove the bulk of oil from it. The texture and colour of PKER is different from that of PKS due to processing. The proximate composition of the PKER and PKS are given in the table below:

Table 7: Proximate Composition of PKER and PKS (% Dry Matter Basis)

Components	PKER	PKS
Dry Matter	90.08	89.95
Crude Protein	26.85	25.48
Crude Fat	8.88	4.66
Ash	11.88	12.05
Crude Fibre	13.15	12.78
Nitrogen Free Extract	39.24	45.06

Source: Fafiolu *et al*. (2015), PKER- Palm Kernel Extraction Residue, PKS- Palm Kernel Sludge

2.11 Viscosity in poultry

Viscosity is generally defined as the internal fluid resistance of a substance and is envisioned as being glutinous, thick, syrupy or sticky (Ward, 1995). Some NSPs like pectin and β glucans have the power to imbibe water and consequently swell thereby increasing the viscosity of the gut contents, interfering with the activity of enzymes and with the absorption process. Therefore, the glucose contained in the NSPs is not available as the birds do not possess the enzymes to break these substances down (Ramasubba and Bhosale, 2001). The increased intestinal viscosity can therefore suppress the digestibility of ingredients other than the source of NSPs.

2.12 Heamatological and serum parameters in poultry

Heamatological assays are among the methods that are useful for the detection of some changes in health status and can also be a useful aid for diagnosis of diseases in birds (Elizabeth *et al.,* 2009). When an animal population grows, there is often a proportional increase in disease incidence. It was also reported by Esonu *et al*. (2001) that haematological constituents reflect the physiological responsiveness of the animal to its internal and external environments which includes the nutritional aspect. Haematological and serum biochemistry assay of poultry suggest the physiological disposition of the birds to their nutrition (Aderemi, 2004). Diseases present such a wide variety of symptoms that the physical examination is not sufficient to provide a diagnosis and there is great variation in the haematological parameters as observed between breeds of farm animals (Tambuwal *et al.,* 2002). Blood components could be influenced by physiological factors, such as age, species and by pathological factors (Szabo *et al*., 2005; Lloyd and Gibson, 2006). Blood composition is usually altered during diseases or malnutrition conditions

(Feist and Longshaw (2000). Considering these factors, there is need to establish appropriate physiological baseline values for various breeds of livestock in Nigeria which could help in realistic evaluation of the management practice, nutrition, diagnosis of health condition (Daramola *et al.,* 2005), as well as in determining the physiological status of farm animals.

The determination of blood component values using laboratory examination is an important procedure to aid the diagnosis of several diseases and dysfunctions, as they provide reliable results and may also give inputs for research studies on nutrition, physiology and pathology (Bounous *et al*., 2000). Awosanya *et al.* (1999) observed the dependence of blood protein and creatinine on the quality of dietary protein. Creatinine may be defined as a nitrogenous waste product; it is not reusable but is excreted from the body in the urine via the kidney. It is produced and excreted at a constant rate which is proportional to the body muscle mass (Henry, 1974). Amino acid imbalance cause an increase in the uric acid concentration and that uric acid concentration could be reduced by restoring the dietary amino acid balance, while there is a direct correlation between uric acid and creatinine concentration. Albumin maintains the water balance in serum and plasma; hypo-albuminaemia is associated with impaired albumin synthesis in the liver. Liver disease malnutrition or malabsorption, hyper-albuminaemia has little diagnostic relevance except in dehydration. Cholesterol measurements are used in the diagnosis and treatments of lipid lipoprotein metabolism disorders. Lipids play important roles in the body, they serve as hormones or hormone precursors, aid in digestion, provide energy storage and metabolic fuels, it act as functional and structural components in bio-membranes and form insulation to allow nerve conduction and prevent heat loss

(Richmond, 1973). Serum Alanine Aminotransferase (SALT) and Serum Aspartate Aminotransferase (SAST) are the measurement of activities of enzymes associated with amino acids metabolism. SALT is normally low in blood but high when the plane of nutrition is low or there is the occurrence of liver damage. The value of SAST on the other hand increased when there is hepatic anorexia or metabolic disorder.

Table 8: Normal Range of Haematological Indices for Broiler Chickens

Parameters	Normal Range
PCV (%)	22.00-35.00
Hb (g/dL)	7.00-13.00
RBC (x10/ µl)	2.50-3.50
MCV (fl)	90.00-140.00
MCH (pg)	33.00-47.00
MCHC (%)	21.00-23.00
WBC (/µl)	1200-3000
Neutrophils (%)	45.00-75.00
Heterophil (%)	15.00-40.00
Lymphocytes (%)	45.00-70.00
Basophils (%)	Rare
Monocytes (%)	5.00-10.00
Eosinophils (%)	1.60-6.00

Source: Jain 1993

CHAPTER THREE

3.0 Materials and Methods

3.1 Experiment One

This feeding trial tested two different levels of PKC (Low, 7.5% and High, 15%) with or without enzyme supplementation replacing soybean meal on a weight for weight basis.

3.1.1 Location of Experiment

The study was conducted at the Poultry Unit of the Teaching and Research Farms, College of Animal Science and Livestock Production (COLANIM), Federal University of Agriculture Abeokuta, Ogun State. The farm is located in the sub-savannah region with an average temperature of 27.1 °C (https://en.climate-data.org/location/544/) and a relative humidity of 80 °C. It lies in the region 76m above sea level and falls within latitude 75 °C "N-708" N and longitude 30 11.2" E-30 2.5" E. (Google earth, 2014).

3.1.2 Test Ingredients

Palm kernel cake was obtained locally and incorporated into the feed compounded for the experimental animals.The enzyme (Zympex 014®) contains Xylanase (EC 3.2.1.8), β-glucanase (EC 3.2.1.6), β-mannnanase (EC 3.2.1.78), α-galactosidase (EC 3.2.1.22), amylase (EC 3.2.1.1) and protease (EC 3.4.21.112). It is therefore produced as a cocktail of enzymes intended to have varying degrees of activity on Carbohydrates (multi-carbohydrase), Non Starch Polysaccharides (NSPs) and Protein.

3.1.3 Experimental Diets

Two groups of diets were formulated. Group one (G1) contained diets 1, 2 and 3 which had no enzyme. Group two (G2) had diets 4,5 and 6 with 500g/ton of enzyme. Each group had three levels of PKC replacement for soybean meal. 0% / control (level 1), 7.5% (level 2) and 15% (level 3).

3.1.4 Experimental animals, design and management

The experiment was in a 2 x 3 factorial arrangement, having two levels of enzyme supplementation (0 and 500g/ton) and three levels of PKC addition (0 %, 7.5 % and 15 %). Seven hundred and twenty (720) 1-day old Marshall Strain of broiler chicks were obtained from Obasanjo Farms Nigeria Limited and randomly distributed into six (6) dietary treatments having six (6) replicates of twenty (20) birds each (Table 9). The experimental birds were housed in fabricated battery cages made of galvanized steel (30″) length, (18″) width and (19″) height, in diameter for the whole period of the experiment (42 days). Twenty birds were housed in each cell as day old chicks and 10 birds as mature birds. Each unit had galvanized feeders and nipple drinkers for easy accessibility to feed and water. Light was provided for brooding, easy accessibility to feed and water and as a heat source. Medication and vaccinations were administered to the birds in the cages as scheduled.

Table 9: Experimental Layout

	-ENZYME (0g/ton)			+ ENZYME (500g/ton)		
Replicate	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**
R1	20	20	20	20	20	20
R2	20	20	20	20	20	20
R3	20	20	20	20	20	20
R4	20	20	20	20	20	20
R5	20	20	20	20	20	20
R6	20	20	20	20	20	20
TOTAL	**120**	**120**	**120**	**120**	**120**	**120**

Without Enzyme Supplementation

D1- 0% replacement of SBM with PKC

D2- 7.5% replacement of SBM with PKC

D3- 15% replacement of SBM with PKC

With Enzyme Supplementation

D4- 0% replacement of SBM with PKC

D5- 7.5% replacement of SBM with PKC

D6- 15% replacement of SBM with PKC

TABLE 10: Gross composition of experimental diets (g kg^{-1}) 0-21 days

	-ENZYME			+ENZYME		
INGREDIENTS	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**
PKC	0.00	19.88	39.75	0.00	19.88	39.75
Soybean meal	265.00	245.12	225.25	265.00	245.12	225.25
Maize	520.00	505.00	490.00	520.00	505.00	490.00
Fish meal	30.00	30.00	30.00	30.00	30.00	30.00
Groundnut cake	95.00	110.00	125.00	95.00	110.00	125.00
Wheat offal	30.00	30.00	30.00	30.00	30.00	30.00
Bone meal	30.00	30.00	30.00	30.00	30.00	30.00
Oyster shell	20.00	20.00	20.00	20.00	20.00	20.00
Lysine	1.00	1.00	1.00	1.00	1.00	1.00
Methionine	3.00	3.00	3.00	3.00	3.00	3.00
*Vit./Min.Premix	3.00	3.00	3.00	3.00	3.00	3.00
Common Salt	3.00	3.00	3.00	3.00	3.00	3.00
Total	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**
Calculated Analyses (%)						
Metabolizable energy (MJ/Kg)	11.83	11.85	11.88	11.83	11.85	11.88
Crude protein	23.08	23.10	23.12	23.08	23.10	23.12
Fat	3.82	4.14	4.45	3.82	4.14	4.45
Crude fibre	3.52	3.55	3.57	3.52	3.55	3.57
Calcium	2.01	2.02	2.02	2.01	2.02	2.02
Phosphorus	0.68	0.67	0.67	0.68	0.67	0.67
Lysine	1.27	1.29	1.31	1.27	1.29	1.31
Methionine	0.65	0.66	0.67	0.65	0.66	0.67

**Vit./Min. Premix content: Premix contained Vit. A, 10 000 000iu; D_3 , 2 000 000iu; E, 12 500iu; K, 1.30g; B_1, 1.30; B_2, 4.00g; D Calcium-Pantothenate, 1.30g; B_6, 1.30g; B_{12}, 0.01g; nicotinic acid, 15.00g; folic acid, 0.05g; biotin, 0.02g; Co, 0.20g; Cu, 5.00g; Fe, 25.00g; I, 0.06g; Mn, 48.00g; Se, 0.10g; Zn, 45.00g; choline chloride, 200.00g; BHT, 50.00g*

PKC-Palm Kernel Cake, SBM- Soya Bean Meal

Without Enzyme Supplementation

D1- 0% replacement of SBM with PKC

D2- 7.5% replacement of SBM with PKC

D3- 15% replacement of SBM with PKC

With Enzyme Supplementation

D4- 0% replacement of SBM with PKC

D5- 7.5% replacement of SBM with PKC

D6- 15% replacement of SBM with PKC

TABLE 11: Gross composition of experimental diets (g kg^{-1}) (22-42 days)

	-ENZYME			+ENZYME		
INGREDIENTS	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**
PKC	0.00	12.00	24.00	0.00	12.00	24.00
Soybean meal	160.00	148.00	136.00	160.00	148.00	136.00
Maize	600.00	590.00	585.00	600.00	590.00	585.00
Fish meal	30.00	30.00	30.00	30.00	30.00	30.00
Groundnut cake	120.00	130.00	135.00	120.00	130.00	135.00
Wheat offal	30.00	30.00	30.00	30.00	30.00	30.00
Bone meal	30.00	30.00	30.00	30.00	30.00	30.00
Oyster shell	20.00	20.00	20.00	20.00	20.00	20.00
Lysine	1.00	1.00	1.00	1.00	1.00	1.00
Methionine	3.00	3.00	3.00	3.00	3.00	3.00
*Vit./Min.Premix	3.00	3.00	3.00	3.00	3.00	3.00
Common Salt	3.00	3.00	3.00	3.00	3.00	3.00
Total	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**
Calculated Analyses (%)						
Metabolizable energy (MJ/Kg)	12.19	12.20	12.23	12.19	12.20	12.23
Crude protein	20.30	20.35	20.22	20.30	20.35	20.22
Fat	3.92	4.11	4.30	3.92	4.11	4.30
Crude fibre	3.13	3.14	3.15	3.13	3.14	3.15
Calcium	2.00	2.00	2.00	2.00	2.00	2.00
Phosphorus	0.63	0.62	0.62	0.63	0.62	0.62
Lysine	1.03	1.05	1.05	1.03	1.05	1.05
Methionine	0.62	0.62	0.62	0.62	0.62	0.62

**Vit./Min. Premix content: Premix contained Vit. A, 10 000 000iu; D_3 , 2 000 000iu; E, 12 500iu; K, 1.30g; B_1, 1.30; B_2, 4.00g; D Calcium-Pantothenate, 1.30g; B_6, 1.30g; B_{12}, 0.01g; nicotinic acid, 15.00g; folic acid, 0.05g; biotin, 0.02g; Co, 0.20g; Cu, 5.00g; Fe, 25.00g; I, 0.06g; Mn, 48.00g; Se, 0.10g; Zn, 45.00g; choline chloride, 200.00g; BHT, 50.00g*

PKC-Palm Kernel Cake, SBM- Soya Bean Meal

Without Enzyme Supplementation

D1- 0% replacement of SBM with PKC

D2- 7.5% replacement of SBM with PKC

D3- 15% replacement of SBM with PKC

With Enzyme Supplementation

D4- 0% replacement of SBM with PKC

D5- 7.5% replacement of SBM with PKC

D6- 15% replacement of SBM with PKC

3.1.5 Data collection

The birds were fed the formulated feed from day old and their weights were recorded on weekly basis, based on each dietary treatment and on replicate basis to evaluate the following parameters:

3.1.5.1 Growth Performance

Live Body Weight: This was determined by weighing each bird using a weighing scale and recorded in grammes (g).

Weight Gain = Present week's weight - Previous week's weight.

$$\text{Feed Intake/Bird} = \frac{\text{(Weight of Feed given - Weight of Leftover feed)}}{\text{Number of birds}}$$

$$\text{Feed Conversion Efficiency} = \frac{\text{Total Weight Gained}}{\text{Total Feed Intake}}$$

3.1.5.2 Apparent Nutrient Digestibility Determination

At the 3rd and 6th week of the experiment, two birds were selected from each replicate, and placed in separate cages. The feed given to the birds was measured and their droppings were collected using total tract collection method. The measured feacal output were thereafter oven dried at 105ºC for 3 days. The dried excreta samples were milled and allowed to pass through 0.5mm sieve and stored in dessicator for further analyses. Dried

feacal samples were analyzed for proximate composition according to AOAC procedures (AOAC 2005).

3.1.5.3 Carcass quality determination

Two birds were selected from each replicate at the end of the feeding trial. The birds were starved of feed for 8 hours, then weighed and slaughtered. The slaughtered birds were properly bled, the feathers removed and the carcass eviscerated. The eviscerated birds were dissected and all internal organs (liver, gizzard, intestine, gall bladder and so on) and external offals (head, shank and neck) carefully removed. The hot carcasses were weighed to obtain the dressed weight and primal cuts. Their weights were taken and recorded. All these were done in order to evaluate the dietary effects on the carcass and meat characteristics.

3.1.5.4 Evaluation of blood parameters

At the sixth week of the experiment, 5ml of blood was obtained from the brachial vein of the wing of the chicken using needle and syringe and 2.5ml each was immediately transferred to the Ethylene diamine tetraacetic acid (EDTA) and plain bottles for haematological and serum indices determination respectively. Haemoglobin concentration was estimated using the cyanomethaemoglobin method. Packed cell volume (PCV), red blood cell (RBC), Heamoglobin (Hb) and white blood cell (WBC) and its components' count of blood samples were determined in Wintrobe haematocrit tube according to the method of Schalm *et al*. (1975).

Serum indices determined are Serum Cholesterol, Creatinine, Albumin, Serum Glucose, Total Protein, Alanine aminotransferase (ALT), Alkaline Phosphatase (AP), Uric Acid (UA). The total serum protein, albumin and globulin were determined using bromocresol

purple method (Varley *et al.*, 1980). Serum enzymes (alanine transaminase (ALT) and aspartate serum transaminase (AST)) were analysed using the commercial kits (Qualigens India. Pvt. Ltd., Catalogue number 72201-04). The serum cholesterol estimated using the enzymatic colorimetric methods (according to the manufacturer's manual) using Randox® diagnostic cholesterol kit.

3.1.5.5 Evaluation of gut morphology

About 0.5 cm portion of the duodenum, jejunum (duodenal loop to meckel's diverticulum) and ileum (meckel's diverticulum to ileo-ceacal junction) was taken at the median part of each of the three intestinal segments (duodenum, jejunum and ileum) and used for histological measurements. The samples were opened longitudinally, rinsed in cold saline and fixed in a buffered formalin solution for about 4 hrs. Histological analysis was carried out according to the procedures described by Goodlad *et al.* (1991). The preparations were mounted between slide and strip. Intestinal villi with their crypts were, individually separated under a dissecting microscope, while the length and width of the villi were measured according to the procedures described by Hampson (1986).

3.1.5.6 Feed Cost Analysis

The prevailing market prices of the feedstuffs used were gathered and used to calculate the cost of feed per kilogram. This value was then multiplied by the FCR of the experimental birds to determine the cost of feed per kilogram weight gain for the various treatments administered in this study.

3.2 Experiment Two

This feeding trial was used to test five different levels of PKC (0%, 25%, 50%, 75% and 100%) with or without enzyme supplementation so as to replace soybean meal on a protein for protein basis. The test enzyme and location used in this experiment, were similar to the ones described for the first experiment.

3.2.1 Experimental animals, design and management

The experiment was in a 2 x 5 factorial arrangement, having two levels of enzyme supplementation (0 and 500g/ton) and three levels of PKC addition (0 %, 25 %, 50%, 75% and 100 %). Four hundred (400) 1-day old Marshall Strain of broiler chicks were obtained from Obasanjo Farms Nigeria Limited and randomly distributed into ten (10) dietary treatments having four (4) replicates of ten (10) birds each (Table 12). The experimental birds were housed in fabricated battery cages made of galvanized steel (30″) length, (18″) width and (19″) height, in diameter for the whole period of the experiment (42 days). Ten birds were housed in each cell till the end of the experiment. Each unit had galvanized feeders and nipple drinkers for easy accessibility to feed and water.. Light was provided for brooding, easy accessibility to feed and water and as a heat source. Medication and vaccinations were administered to the birds in the cages as scheduled.

3.2.2 Experimental Diets

Two groups of diets were formulated. Group one (G1) contained diets 1, 2, 3, 4 and 5 which had no enzyme. Group two (G2) had diets 6, 7, 8, 9 and 10 with 500g/ton of enzyme. Each group had three levels of PKC replacement for soybean meal. 0% / control (level 1), 25% (level 2), 50% (level 3), 75% (level 4) and 100% (level 5).

Table 12: Experimental Layout

	-ENZYME					+ ENZYME				
REP.	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**
R1	10	10	10	10	10	10	10	10	10	10
R2	10	10	10	10	10	10	10	10	10	10
R3	10	10	10	10	10	10	10	10	10	10
R4	10	10	10	10	10	10	10	10	10	10
TOTAL	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**

PKC- Palm Kernel Cake

Without Enzyme Supplementation

D1- 0% replacement of SBM with PKC

D2- 25% replacement of SBM with PKC (protein for protein)

D3- 50% replacement of SBM with PKC (protein for protein)

D4- 75% replacement of SBM with PKC (protein for protein)

D5- 100% replacement of SBM with PKC (protein for protein)

With Enzyme Supplementation

D6- 0% replacement of SBM with PKC

D7- 25% replacement of SBM with PKC (protein for protein)

D8- 50% replacement of SBM with PKC (protein for protein)

D9- 75% replacement of SBM with PKC (protein for protein)

D10-100% replacement of SBM with PKC (protein for protein)

TABLE 13: Gross composition of experimental diets (g kg^{-1}) 0-21 days for experiment II

	Without Enzyme					With Enzyme				
INGREDIENTS	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**
PKC	0.00	147.00	293.00	440.00	587.00	0.00	147.00	293.00	440.00	587.00
Soybean meal	300.00	225.00	150.00	75.00	0.00	300.00	225.00	150.00	75.00	0.00
Maize	565.00	476.00	390.00	293.00	200.00	565.00	476.00	390.00	293.00	200.00
Fish meal	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Groundnut cake	25.00	50.00	77.00	102.00	123.00	25.00	50.00	77.00	102.00	123.00
Wheat offal	20.00	12.00	00.00	0.00	0.00	20.00	12.00	00.00	0.00	0.00
Bone meal	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Limestone	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Lysine	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Methionine	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
*Vit. Min.Premix	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Common Salt	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Total	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**
Calculated Analyses (%)										
Metabolizable energy (MJ/Kg)	12.00	12.05	12.13	12.13	12.15	12.00	12.05	12.13	12.13	12.15
Crude protein	22.57	22.67	22.80	22.97	22.99	22.57	22.67	22.80	22.97	22.99
Fat	3.67	4.47	5.28	6.09	6.89	3.67	4.47	5.28	6.09	6.89
Crude fibre	3.41	4.73	6.02	7.40	8.76	3.41	4.73	6.02	7.40	8.76
Lysine	1.36	1.26	1.16	1.05	0.94	1.36	1.26	1.16	1.05	0.94
Methionine	0.65	0.66	0.68	0.70	0.72	0.65	0.66	0.68	0.70	0.72

***Vit./Min. Premix content: Premix contained Vit. A, 10 000 000iu; D_3, 2 000 000iu; E, 12 500iu; K, 1.30g; B_1, 1.30; B_2, 4.00g; D Calcium-Pantothenate, 1.30g; B_6, 1.30g; B_{12}, 0.01g; nicotinic acid, 15.00g; folic acid, 0.05g; biotin, 0.02g; Co, 0.20g; Cu, 5.00g; Fe, 25.00g; I, 0.06g; Mn, 48.00g; Se, 0.10g; Zn, 45.00g; choline chloride, 200.00g; BHT, 50.00g*

PKC-Palm Kernel Cake, BD – Basal Diet, SBM- Soya Bean Meal

Without Enzyme Supplementation

D1- 0% replacement of SBM with PKC

D2- 25% replacement of SBM with PKC (protein for protein)

D3- 50% replacement of SBM with PKC (protein for protein)

D4- 75% replacement of SBM with PKC (protein for protein)

D5- 100% replacement of SBM with PKC (protein for protein)

With Enzyme Supplementation

D6- 0% replacement of SBM with PKC

D7- 25% replacement of SBM with PKC (protein for protein)

D8- 50% replacement of SBM with PKC (protein for protein)

D9- 75% replacement of SBM with PKC (protein for protein)

D10-100% replacement of SBM with PKC (protein for protein)

TABLE 14: Gross composition of experimental diets (g kg^{-1}) 22-42 days for experiment II

	Without Enzyme					With Enzyme				
INGREDIENTS	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**
PKC	0.00	108.00	215.00	323.00	430.00	0.00	108.00	215.00	323.00	430.00
Soybean meal	220.00	165.00	110.00	55.00	00.00	220.00	165.00	110.00	55.00	00.00
Maize	610.00	560.00	510.00	456.00	399.00	610.00	560.00	510.00	456.00	399.00
Fish meal	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Groundnut cake	50.00	57.00	70.00	76.00	80.00	50.00	57.00	70.00	76.00	80.00
Wheat offal	30.00	20.00	5.00	0.00	0.00	30.00	20.00	5.00	0.00	0.00
Bone meal	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Limestone	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Lysine	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Methionine	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
*Vit.Min.Premix	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Common Salt	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Total	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calculated Analyses (%)										
Metabolizable energy (MJ/Kg)	12.18	12.28	12.41	12.49	12.53	12.18	12.28	12.41	12.49	12.53
Crude protein	20.71	20.77	21.01	21.07	21.10	20.71	20.77	21.01	21.07	21.10
Fat	3.75	4.32	4.91	5.48	6.03	3.75	4.32	4.91	5.48	6.03
Crude fibre	3.19	4.11	5.00	5.94	6.90	3.19	4.11	5.00	5.94	6.90
Lysine	1.19	1.10	1.02	0.92	0.83	1.19	1.10	1.02	0.92	0.83
Methionine	0.62	0.63	0.64	0.65	0.66	0.62	0.63	0.64	0.65	0.66

**Vit./Min. Premix content: Premix contained Vit. A, 10 000 000iu; D_3 , 2 000 000iu; E, 12 500iu; K, 1.30g; B_1, 1.30; B_2, 4.00g; D Calcium-Pantothenate, 1.30g; B_6, 1.30g; B_{12}, 0.01g; nicotinic acid, 15.00g; folic acid, 0.05g; biotin, 0.02g; Co, 0.20g; Cu, 5.00g; Fe, 25.00g; I, 0.06g; Mn, 48.00g; Se, 0.10g; Zn, 45.00g; choline chloride, 200.00g; BHT, 50.00g*

PKC-Palm Kernel Cake, SBM- Soya Bean Meal

Without Enzyme Supplementation

D1- 0% replacement of SBM with PKC

D2- 25% replacement of SBM with PKC (protein for protein)

D3- 50% replacement of SBM with PKC (protein for protein)

D4- 75% replacement of SBM with PKC (protein for protein)

D5- 100% replacement of SBM with PKC (protein for protein)

With Enzyme Supplementation

D6- 0% replacement of SBM with PKC

D7- 25% replacement of SBM with PKC (protein for protein)

D8- 50% replacement of SBM with PKC (protein for protein)

D9- 75% replacement of SBM with PKC (protein for protein)

D10-100% replacement of SBM with PKC (protein for protein)

3.2.3 Data Collection and Statistical Analysis

These were carried out using same procedures applied in Experiment one.

3.2.4 Determination of the viscosity of ileal digesta

At the end of the experiment one bird from each replicate were selected randomly and slaughtered. The ileal digesta content was collected from the ileum (marked by Merckel's diverticulum to the ileo-caecal junction.) The ileal digesta for each replicate was emptied into a sample bottle and was properly labelled. A uniform weight of sample was taken from each sample bottle using sensitive scale and diluted to a volume of 400ml. Viscometer BROOKFIELD DV-E, UK was used to determine the viscosity of the digesta following manufacturers' calibration of 50rpm, 60rpm and 100rpm respectively.

3.2.5 Gut microbiology determination

At the end of the experiment (42 days), one bird was slaughtered per replicate and the gastrointestinal tracts from the base of the gizzard down to the rectum were dissected, and a section of approximately 3 cm long (including digesta) was cut from the mid region of the ceca. Samples were snap-frozen by immersion in liquid nitrogen and stored at −20°C prior to freeze-drying. Dissecting instruments were cleaned with 70% ethanol after use on each bird.

3.3 Statistical model

$Y_{ijk} = \mu + M_i + E_j + (ME)_{ij} + \varepsilon_{ijk}$

Where:

Y_{ijk} = Dependent Variable/ Yield

μ = Population Mean/ Number of birds used per treatment.

M_i = Effect of different levels of palm kernel cake.

E_j = Effect of enzyme on the levels of palm kernel cake.

M_iE_j = Interaction effect of PKC levels and Enzyme.

ε_{ijk} = Residual Error.

3.4 Statistical analysis

All data generated in these experiments were subjected to One-way Analysis of Variance (ANOVA), using a computer software SAS (1999). Where significant differences existed among the treatments means, Duncan's Multiple Range Test was used to separate the means at 5% confidence level.

CHAPTER FOUR

4.0 RESULTS

4.1 Proximate composition of palm kernel cake and soybean meal

The descriptive statistics of soybean meal and palm kernel cake collected from different literature is presented in Table 15. Dry Matter (DM) had a mean value of 91.63% and 91.26% for PKC and SBM respectively and was the least variable parameter for both PKC and SBM. Calcium was the most variable parameter for both SBM and PKC, with a value of 181.25 and 91.87 respectively for co-efficient of variation (CV). For PKC, Ether Extract (EE) was the next in variability to Calcium, followed by Ash, then Crude Fibre (CF), then Phosphorus, Crude Protein (CP), Nitrogen Free Extract (NFE) and finally DM. For SBM, the least variable next to DM was CP, then Ash, followed by NFE, Phosphorus, EE, CF and finally Calcium.

Table 15: Descriptive statistics of proximate compositions of palm kernel cake and soybean meal

			PKC						**SBM**			
Variable (%)	N	Min.	Max.	Mean	SD	CV	N	Min.	Max.	Mean	SD	CV
DM	22	87.30	94.00	91.63	1.71	1.87	15	79.00	95.60	91.26	3.98	4.36
CP	22	7.01	22.84	15.63	3.33	21.28	18	35.35	49.00	40.86	4.53	11.08
CF	22	4.02	24.90	14.69	4.78	32.55	18	2.27	28.34	9.34	7.35	78.64
EE	22	0.80	42.00	8.91	8.95	100.53	18	0.50	22.70	12.17	8.79	72.25
NFE	22	33.4	65.00	53.77	6.62	12.30	15	13.75	34.30	26.98	5.98	22.15
Ash	22	2.23	13.92	4.85	2.48	51.09	18	4.00	7.30	5.33	1.13	21.22
Calcium	22	0.20	4.50	0.55	1.01	181.25	14	0.21	1.81	0.48	0.44	91.87
Phos.	22	0.32	0.94	0.53	0.11	21.58	14	0.28	0.96	0.56	0.20	35.92

SD- Standard Deviation, CV- Co-efficient of Variation, SBM- Soybean Meal, PKC- Palm Kernel Cake, DM- Dry Matter, CP-Crude Protein, CF- Crude Fibre, EE- Ether Extract, NFE- Nitrogen Free Extract, Phos.- Phosphorus, Min- Minimum, Max- Maximum.

Sources: Ari, *et al*., 2012, FAO 2002, Banaszkiewicz 2000, Alimon, 2004, Dairo and Fasuyi, 2007, Sundu *et al.*,2005, Nuzul Amzri, 2013, Nwokolo *et al*., 1976, Mustafa *et al*., 2004, Chin 2008, Mohammad *et al*., 2012, Adesehinwa, 2007, Hutagalung, 1980, Nik Norulaini *et al*., 2011, Perez *et al*., 2000, Mirnawati *et al*., 2008, Abonyi and Uchendu, 2005.

4.2 Amino acid profile of palm kernel cake and soybean meal

The descriptive statistics of the amino acid profile of PKC and SBM gathered from different literature is presented in Table 16. This showed their minimum, maximum, mean standard deviation and coefficient of variation values, with the most variable parameter for PKC being Arginine, and the least variable being tryptophan. Other amino acids had intermediate variability with varying number of observations. For SBM, the least variable amino acid (Aspartic acid) had a CV of 5.41, with Phenylalanine next to it, followed by Alanine and others with varying CV and the highest CV (44.74) was obtained for Methionine.

4.3 Correlation between proximate compositions of palm kernel cake

The correlation matrix of proximate composition of PKC is presented in Table 17. Only DM-EE, DM-Ash and DM-Calcium were positively correlated indicating that an increase in one yields a resultant increase in the other. DM, EE and Ash were negatively correlated with CP. EE was negatively correlated with all other parameters except DM. NFE was only positively correlated with CP, while Ash had positive correlation only with DM, CF and Calcium..

4.4 Correlations between proximate compositions of soybean meal

The correlation matrix of the chemical composition of SBM as indicated in Table 18 shows that there is a positive relationship between DM and Ash, Calcium and Phosphorus. Also, between CP and NFE, Ash and phosphorus and between CF- EE and CF-Calcium there is a positive correlation. Ether extract is also positively correlated with Calcium, NFE with Ash and Phosphorus, Ash with Calcium and Phosphorus. Some of the

parameters were also negatively correlated including DM-CP, CP-EE, CF-NFE, EE-Ash, NFE-Calcium among others.

4.5 Correlation between amino acid profiles of palm kernel cake

The correlation matrix showing the relationship between the various amino acid content of PKC is presented in table 19. Most of the amino acid listed were significant ($P<0.01$), except for Alanine-Cystine, Arginine- Threonine, Aspartic acid-Cystine, Cystine-Isoleucine, Lysine, Serine, Proline, Threonine and Tyrosine. Also for Glutamic acid-tryptophan and Proline- Threonine relationships which were only significant at 5% ($P<0.05$). All the amino acid correlated positively except for Arginine-Tryptophan and Glutamic acid-Tryptophan relationship.

4.6 Correlation between amino acid profiles of soybean meal

The relationship between the various amino acids of SBM gathered from literature is presented in Table 20. Most of the values observed were significantly different ($P<0.01$ and $P<0.05$) for varying relationships between the amino acids considered. However, Alanine-Cystine, Methionin and Histidine were not ($P<0.05$) significant with majority of amino acids co-relating with Cystine, Histidine and methionine. Few of them were also negatively correlated, some of which include Alanine-Histidine, Arginine-Histidine, Aspartic acid-Histidine and Glycine-Histidine.

Table16: Descriptive statistics of amino acid profile of palm kernel cake and soybean meal.

	PKC						SBM					
	N	Min.	Max.	Mean	SD	CV	N	Min.	Max.	Mean	SD	CV
Ala	10	0.46	3.83	1.05	1.00	99.83	20	3.04	4.76	4.23	0.52	13.35
Arg	10	0.46	11.56	2.72	3.16	116.08	42	3.64	8.69	7.23	1.13	15.68
Asp	10	0.89	3.63	1.37	0.81	59.41	17	10.49	12.90	11.92	0.64	5.41
Cys	7	0.13	1.13	0.35	0.36	102.79	22	0.64	1.78	1.18	0.35	29.48
Gly	14	0.53	4.17	0.95	0.93	97.35	20	2.71	4.8	4.03	0.57	14.21
Glu	10	1.39	16.80	4.10	4.51	109.85	42	1.26	21.07	17.55	4.11	23.43
His	14	0.17	1.91	0.42	0.43	103.81	42	1.78	4.24	2.54	0.40	15.91
Iso	14	0.41	3.22	0.75	0.71	94.09	42	1.81	8.21	4.92	1.06	21.60
Leu	14	0.71	6.07	1.42	1.34	95.06	42	2.94	8.52	7.63	1.08	14.22
Lys	14	0.36	2.68	0.68	0.61	88.80	42	0.65	7.07	6.04	1.41	23.33
Meth	14	0.17	1.75	0.38	0.40	104.08	42	0.52	4.93	1.41	0.63	44.74
Phe	14	0.47	3.96	0.90	0.88	98.37	40	3.06	5.37	4.92	0.52	10.57
Pro	9	0.36	3.31	0.85	0.93	108.64	20	3.08	6.04	4.97	0.92	18.62
Ser	14	0.35	4.11	0.85	0.95	111.09	20	1.90	5.68	4.53	1.23	27.11
Thre	14	0.33	2.75	0.65	0.62	94.57	42	1.47	4.22	3.75	0.58	15.39
Trp	6	0.05	0.29	0.17	0.08	47.49	23	0.70	1.64	1.46	0.21	14.13
Tyr	13	0.24	2.60	0.58	0.62	106.19	20	1.69	5.00	3.47	0.69	20.08
Val	14	0.43	5.05	1.07	1.15	106.99	42	1.69	5.79	4.86	0.98	20.17

Min- Minimum, Max- Maximum, SD- Standard Deviation, CV- Coefficient of Variation, N- Number of observations, PKC- Palm Kernel Cake, SBM- Soybean Meal, Ala-Alanine, Arg- Arginine, Asp- Aspartic acid, Cys- Cystine, Gly- Glycine, Glu-Glutamic acid, His- Histidine, Iso- Isoleucine, Leu- Leucine, Lys- Lysine, Meth-Methionine, Phe-Phenylalanine, Pro-Proline, Ser-Serine Thr- Threonine, Trp- Tryptophan, Tyr- Tyrosine, Val-Valine.

Sources: Alimon, 2004, Cavins *et* al., 1971, Yeong, 1983, Nwokolo *et al.,* 1976; Hutagalung, 1980, NRC 1994, Shakila *et al*., 2012, Sundu *et al*., 2005, Boateng *et al*., 2008, Sulabo *et al*., 2013, Kuiken and Lyman, 1948.

Table 17: Correlation matrix of proximate composition of palm kernel cake

	DM	CP	CF	EE	NFE	Ash	Calcium	Phosphorus
DM	1							
CP	-0.154	1						
CF	-0.167	0.237	1					
EE	0.183	-0.507	-0.333	1				
NFE	-0.336	0.357	-0.098	-0.618	1			
Ash	0.302	-0.002	0.087	-0.014	-0.244	1		
Calcium	0.119	0.255	-0.047	-0.200	-0.047	0.103	1	
Phosphorus	-0.395	0.082	0.086	-0.001	-0.011	-0.017	0.034	1

PKC- Palm Kernel Cake, DM- Dry Matter, CP- Crude Protein, CF- Crude Fibre, EE- Ether Extract, NFE- Nitrogen Free Extract

Table 18: Correlation Matrix of Chemical Components of Soybean Meal (SBM)

	DM	CP	CF	EE	NFE	Ash	Calcium	Phosphorus
DM	1							
CP	-0.222	1						
CF	-0.415	-0.480	1					
EE	0.464	-0.881	0.279	1				
NFE	-0.112	0.732	-0.847	-0.692	1			
Ash	0.119	0.614	-0.482	-0.594	0.768	1		
Calcium	0.182	-0.471	0.294	0.521	-0.730	0.145	1	
Phosphorus	0.477	0.363	-0.752	-0.226	0.862	0.801	0.204	1

SBM- Soybean Meal, DM- Dry Matter, CP- Crude Protein, CF- Crude Fibre, EE- Ether Extract, NFE- Nitrogen Free Extract

Table 19: Correlation matrix of amino acid profile of palm kernel cake

	Ala	Arg	Asp	Cys	Gly	Glu	His	Iso	Leu	Lys	Meth	Phe	Pro	Ser	Thr	Trp	Tyr	Val
Ala	1																	
Arg	0.943**	1																
Asp	0.913**	0.954**	1															
Cys	0.896*	0.967**	0.893*	1														
Gly	0.948**	0.972**	0.946**	0.976**	1													
Glu	0.950**	0.998**	0.941**	0.964**	0.974**	1												
His	0.947**	0.972**	0.928**	0.976**	0.975**	0.989**	1											
Iso	0.885**	0.854**	0.841**	0.757*	0.808**	0.875**	0.821**	1										
Leu	0.953**	0.972**	0.940**	0.976**	0.989**	0.989**	0.997**	0.821**	1									
Lys	0.869**	0.877**	0.905**	0.837*	0.815**	0.867**	0.772**	0.706**	0.791**	1								
Meth	0.950**	0.972**	0.933**	0.976**	0.981**	0.990**	1.000**	0.822**	0.999**	0.780**	1							
Phe	1.000**	0.936**	0.913**	0.890**	0.947**	0.950**	0.944**	0.871**	0.951**	0.815**	0.947**	1						
Pro	0.896**	0.963**	0.863**	0.885*	0.856**	0.909**	0.865**	0.852**	0.866**	0.887**	0.866**	0.896**	1					
Ser	0.917**	0.913**	0.903**	0.837*	0.898**	0.880**	0.845**	0.838**	0.869**	0.883**	0.854**	0.905**	0.857**	1				
Thr	0.890**	0.822**	0.942**	0.790*	0.813**	0.875**	0.797**	0.852**	0.807**	0.771**	0.802**	0.826**	0.742*	0.867**	1			
Trp	0.668**	-0.349*	0.412**	0.101**	0.503**	-0.359*	0.970**	0.583**	0.592**	0.257**	0.110**	0.514**	0.999**	0.540**	0.640**	1		
Tyr	0.953**	0.907**	0.945**	0.893*	0.905**	0.984**	0.884**	0.805**	0.897**	0.845**	0.889**	0.878**	0.878**	0.866**	0.848**	0.556**	1	
Val	0.953**	0.912**	0.946**	0.976**	0.967**	0.984**	0.963**	0.772**	0.970**	0.738**	0.966**	0.918**	0.863**	0.839**	0.747**	0.652**	0.809**	1

Ala-Alanine, Arg- Arginine, Asp- Aspartic acid, Cys- Cystine, Gly- Glycine, Glu-Glutamic acid, His- Histidine, Iso- Isoleucine, Leu- Leucine, Lys- Lysine, Meth- Methionine, Phe-Phenylalanine, Pro- Proline, Ser- Serine, Thr- Threonine, Trp- Tryptophan, Tyr- Tyrosine, Val- Valine

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 20: Correlation Matrix of Amino Acid Profile of Soybean Meal

	Ala	Arg	Asp	Cys	Gly	Glu	His	Iso	Leu	Lys	Meth	Phe	Pro	Ser	Thre	Trp	Tyr	Val
Ala	1																	
Arg	0.741**	1																
Asp	0.620**	0.601*	1															
Cys	0.420	0.471*	0.000	1														
Gly	0.757**	0.776**	0.502*	0.441	1													
Glu	0.713**	0.632**	0.472	0.072	0.808**	1												
His	-0.042	-0.075	-0.359	0.121	-0.056	-0.322*	1											
Iso	0.669**	0.678**	0.561*	0.467*	0.708**	0.324*	-0.151	1										
Leu	0.610**	0.683**	0.333	0.133	0.608**	0.785**	-0.269	0.574**	1									
Lys	0.599**	0.704**	0.368	0.061	0.590**	0.851**	-0.311*	0.394**	0.892**	1								
Meth	0.425	-0.037	0.000	0.386	0.511*	-0.657**	0.365*	0.329*	-0.338*	-0.536**	1							
Phe	0.653**	0.780**	0.620**	0.309	0.603**	0.733**	-0.459**	0.875**	0.823**	0.838**	0.353*	1						
Pro	0.684**	0.657**	0.616**	0.112	0.643**	0.808**	-0.233	0.746**	0.704**	0.582**	0.218	0.787**	1					
Ser	0.637**	0.863**	0.539*	0.162	0.781**	0.792**	-0.026	0.729**	0.723**	0.704**	0.298	0.808**	0.773**	1				
Thr	0.718**	0.758**	0.406	0.300	0.712**	0.644**	-0.182	0.788**	0.873**	0.704**	-0.025	0.826**	0.772**	0.819**	1			
Trp	.[a]	0.704**	.[a]	0.781	.[a]	0.741**	-0.583**	-0.016	0.711**	0.797**	-0.637**	0.062	.[a]	.[a]	0.526**	1		
Tyr	0.615**	0.671**	0.387	0.429	0.625**	0.643**	-0.044	0.485*	0.597**	0.589**	0.501*	0.636**	0.643**	0.703**	0.695**	.[a]	1	
Val	0.522*	0.743**	0.301	0.402	0.672**	0.615**	-0.303	0.802**	0.741**	0.696**	-0.036	0.786**	0.543*	0.693**	0.845**	0.635**	0.410	1

Ala-Alanine, Arg- Arginine, Asp- Aspartic acid, Cys- Cystine, Gly- Glycine, Glu-Glutamic acid, His- Histidine, Iso- Isoleucine, Leu- Leucine, Lys- Lysine, Meth- Methionine, Phe- Phenylalanine, Pro- Proline, Ser- Serine, Thr- Threonine, Trp- Tryptophan, Tyr- Tyrosine, Val- Valine

** - Correlation is significant at the 0.01 level (2-tailed).
* - Correlation is significant at the 0.05 level (2-tailed).
[a] - Cannot be computed because at least one of the variables is constant.

4.7 Main effects of palm kernel cake supplementation and enzyme on the performance of broiler chickens (0-21 days).

Table 21 shows the main effect of palm kernel cake on the performance of broiler chickens fed diets containing varying levels of PKC (0%, 7.5% and 15%), and the main effect of enzyme addition (with or without) between 0-21 days. The broiler chicks fed the three levels of PKC had varying values for the different parameters observed, which include final weight, weight gain, daily weight gain, feed intake and feed conversion ratio, but they were not statistically different at 5% level of significance ($P<0.05$). The effect of PKC on the cost of the diet fed to each treatment showed a higher price of ₦ 118.27/kg for birds fed control diet, and the lowest price of ₦ 116.15/kg for birds on 15% of PKC as replacement for SBM on weight for weight basis. The feed cost reduced ($P<0.05$) as the level of PKC inclusion increased. However, the effect of adding enzyme to the PKC included diet was observed for final weight where bird on diet supplemented with enzyme had a higher final weight of 402.06g as compared to those without enzyme which had a significantly ($P<0.05$) lower value of 342.68g. A similar trend was observed for weight gain and daily weight gain, meanwhile the feed intake and feed conversion ratio had a different trend where birds on enzyme supplementation had significantly lower feed intake and better FCR values for birds on diets with enzyme supplementation and higher values for those without enzyme. Enzyme supplementation significantly increased ($P<0.05$) cost of feed and feed cost per weight gain (CPWG). Cost of feed was lower for birds on diet without enzyme supplementation but CPWG was lower for birds on diet with enzyme supplementation.

Table 21: Effect of PKC and enzyme on performance characteristics of broiler chickens (0-21 days)

Diet No	PKC	Initial weight (g)	Final Weight (g)	Weight Gain (g)	Daily Weight Gain (g/day)	Feed Intake (g)	FCR	Feed Cost (₦/Kg)	CPWG (₦/Kg)
1	0	40.22	362.44	322.23	15.34	410.10	1.28	118.27[a]	150.83
2	7.5	40.22	370.88	330.66	15.75	413.90	1.27	117.18[b]	148.61
3	15.0	40.23	383.79	343.56	16.36	414.25	1.24	116.15[c]	144.41
SEM		0.004	5.876	5.876	0.280	4.90	0.035	0.000	0.521
P-Value		0.411	0.337	0.337	0.337	0.933	0.936	0.0001	0.8055
	Enzyme								
	Without (-)	40.22	342.68[b]	302.46[b]	14.40[b]	440.58[a]	1.46[a]	116.28[b]	169.50[a]
	With (+)	40.23	402.06[a]	361.83[a]	17.23[a]	384.92[b]	1.07[b]	118.12[a]	126.40[b]
SEM		0.004	5.88	5.87	0.280	4.90	0.04	0.920	21.550
P-Value		0.1300	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

[a,b,c] Mean values having different superscripts were significantly ($P<0.05$) different within columns

REP- Number of Replicates, SEM- Standard Error Mean, FCR- Feed Conversion Ratio, PKC- Palm Kernel Cake, CPWG- Cost per weight gain.

4.8 Interaction effects of palm kernel cake supplementation and enzyme on performance of broiler chickens (0-21 days).

Table 22 show the interaction of palm kernel cake and Enzyme on the performance characteristics of broiler chickens over a period of 0-21 days. The birds fed enzyme supplemented diets (D4,D5 and D6) had significantly (P<0.05) higher values for final weight, weight gain and daily weight gain, than birds fed diets without enzyme supplementation (D1, D2 and D3). The birds on D6 (15% PKCE) had the highest final live weight for the phase (433.14g), followed by D5 (7.5% PKCE) having a significantly lower (P<0.05) value of 399.89g. The lowest value of 334.44g final weight was observed for birds on D3 (15% PKC). A similar trend was observed on the birds for weight gain and daily weight gain. Meanwhile, feed intake showed a different trend where bird on D2 and D3 had statistically (P<0.05) similar values of 445.07g and 447.73g respectively which were higher than those for other treatments. The lowest (P<0.05) feed intake value was observed for birds on D6 with a value of 380.77g. The values for FCR also differed and showed the lowest and significantly best (P<0.05) value of 1.02 for birds on D6. Cost of feed was significantly (P<0.05) highest at D4 (₦ 119.22/kg) and lowest at D3 (₦ 115.25/kg) with an overall observation of higher values for enzyme supplemented diet fed birds than for their unsupplemented counterparts. CPWG was however significantly (P<0.05) reduced for birds on enzyme supplemented diets such that D6 converted the diet to weight with the lowest cost of ₦ 113.43/kg

Table 22: Interaction effect of PKC and enzyme on performance of broiler chickens (0-21days)

Diet No	PKC	Enzyme supplementation	Initial weight (g)	Final Weight (g)	Weight Gain(g)	Daily Weight Gain(g/day)	Feed Intake(g)	FCR	Feed Cost(₦ /Kg)	CPWG (₦ /Kg)
D1	0	0	40.21	351.72^{d}	311.51^{d}	14.83^{d}	428.94^{b}	1.37^{c}	117.32^{c}	161.55^{c}
D2	7.5	0	40.21	341.87^{e}	301.66^{e}	14.37^{e}	445.07^{a}	1.48^{b}	116.28^{e}	171.56^{b}
D3	15.0	0	40.24	334.44^{f}	294.21^{f}	14.01^{f}	447.73^{a}	1.52^{a}	115.25^{f}	175.39^{a}
D4	0	0.5	40.23	373.16^{c}	332.93^{c}	15.85^{c}	391.26^{c}	1.17^{d}	119.22^{a}	140.11^{d}
D5	7.5	0.5	40.23	399.89^{b}	359.65^{b}	17.13^{b}	382.73^{cd}	1.06^{e}	118.08^{b}	125.66^{e}
D6	15.0	0.5	40.23	433.14^{a}	392.91^{a}	18.71^{a}	380.77^{d}	1.02^{f}	117.05^{d}	113.43^{f}
SEM			0.004	5.876	5.876	0.280	4.900	0.035	0.000	0.737
PVALUE										
PKC			0.411	0.337	0.337	0.337	0.933	0.936	0.0001	0.8055
ENZYME			0.130	0.001	0.001	0.001	0.001	0.001	0.0001	0.0001
PKCE			0.280	0.001	0.001	0.001	0.001	0.001	0.0001	0.0001

^{a,b,c,d,e,f} Mean values having different superscripts were significantly (P<0.05) different within columns
D1- 0% PKC, D2- 7.5% PKC, D3- 15% PKC, D4- 0% PKCE, D5- 7.5% PKCE, D6- 15% PKCE,
REP- Number of Replicates, SEM- Standard Error Mean, FCR- Feed Conversion Ratio, PKC- Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme, CPWG- Cost per weight gain.

4.9 Main effects of palm kernel cake supplementation and enzyme on the performance of broiler chickens (22-42 days).

Table 23 showed the main effect of PKC and enzyme supplementation on the performance of broiler chickens between 22-42 days. Final weight, weight gain, feed intake and feed conversion ratio were all significantly (P<0.05) different. Final weight of the birds at this phase showed that broiler chickens fed the control diet had the significantly (P<0.05) highest final weight of 1427.29g, while birds on 7.5% and 15% inclusion had (P>0.05) similar values which were lower than the control. Daily weight gain also showed highest value for the birds fed control diet. Birds on control diet also had lowest (P<0.05) and best values for feed intake and FCR values respectively. Feed cost was lowest (P<0.05) for birds on the highest PKC inclusion level (₦ 111.71/kg), so also the CPWG (₦ 306.80/kg).

The sole effect of enzyme supplementation was however different as the birds with the enzyme supplemented diets had higher (P<0.05) values for final weight and weight gain parameters, but consumed lesser than the birds without enzyme supplementation. FCR was also best for birds on enzyme supplementation. Cost of feed showed that birds fed enzyme supplemented diets had the highest (P<0.05) cost of (₦ 113.31/kg), but the lower CPWG of (₦ 285.27/kg).

Table 23: Effect of PKC and enzyme on performance of broiler chickens (22-42days)

Diet No	PKC	Initial weight (g)	Final Weight (g)	Weight Gain (g)	Daily Weight Gain (g/day)	Feed Intake (g)	FCR	Feed Cost (₦/Kg)	CPWG (₦/Kg)
1	0	362.44	1427.29^{a}	1065.85^{a}	50.71^{a}	2699.01^{b}	2.54^{b}	113.12^{a}	287.93^{b}
2	7.5	370.88	1400.11^{ab}	1029.23^{ab}	49.01^{ab}	2743.73^{a}	2.67^{ab}	112.54^{ab}	300.60^{ab}
3	15.0	383.79	1392.11^{ab}	1009.12^{b}	48.05^{b}	2771.01^{a}	2.75^{a}	111.71^{b}	306.80^{a}
SEM		5.88	12.12	8.72	0.42	8.79	0.029	0.000	1.160
P-Value		0.3372	0.0472	0.0254	0.0254	0.0015	0.0125	0.0019	0.0173
	Enzyme								
	Without (-)	342.68	1338.01^{b}	995.33^{b}	47.39^{b}	2779.07^{a}	2.79^{a}	111.61^{b}	311.62^{a}
	With (+)	346.11	1475.54^{a}	1073.47^{a}	51.12^{a}	2696.77^{b}	2.51^{b}	113.31^{a}	285.27^{b}
SEM		5.88	12.12	8.72	0.42	8.79	0.029	0.850	13.175
P-Value		0.0628	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

^{a,b} Mean values having different superscripts were significantly ($P<0.05$) different within columns

REP- Number of Replicates, SEM- Standard Error Mean, FCR- Feed Conversion Ratio, PKC- Palm Kernel Cake, CPWG- Cost per weight gain.

4.10 Interaction effects of palm kernel cake supplementation and enzyme on performance of broiler chickens (22-42 days).

The result of the interaction effect of PKC and enzyme supplementation on performance of broiler chickens between 22-42days is presented in table 24, where birds on D4 had the highest ($P<0.05$) value for final weight (1502.47g). Birds that received D5 and D6 had significantly similar ($P>0.05$) values lower than the control diet fed birds, and all the diets without enzyme supplementation showed similar ($P<0.05$) result for final weight. Weight gain and daily weight gain parameters were also highest ($P<0.05$) for birds on D4. The birds on diets without enzyme supplementation had significantly higher ($P<0.05$) values for feed intake and FCR. Furthermore, best FCR of 2.34 was observed for birds on the enzyme treated diets without PKC inclusion. Feed cost was highest ($P<0.05$) for birds on control diet with enzyme supplementation (D4) and lowest at D3 but with the highest ($P<0.05$) CPWG at D2 and D3.

Table 24: Interaction effect of PKC and enzyme on performance of broiler chickens (22-42days)

Diet No	PKC	Enzyme	Initial weight (g)	Final Weight (g)	Weight Gain (g)	Daily Weight Gain (g/day)	Feed Intake (g)	FCR	Feed Cost (₦/Kg)	CPWG (₦/Kg)
D1	0	0	351.72	1352.12^{c}	1000.39^{cd}	47.64^{cd}	2749.29^{c}	2.75^{b}	112.27^{d}	308.54^{a}
D2	7.5	0	351.87	1331.14^{c}	989.27^{d}	47.11^{d}	2774.54^{b}	2.80^{ab}	111.69^{e}	313.25^{a}
D3	15.0	0	352.44	1330.76^{c}	996.32^{d}	47.44^{d}	2813.37^{a}	2.82^{a}	110.86^{f}	313.01^{a}
D4	0	0.5	352.16	1502.47^{a}	1129.00^{a}	53.78^{a}	2648.73^{e}	2.34^{e}	113.97^{a}	267.31^{d}
D5	7.5	0.5	356.89	1469.08^{b}	1069.19^{b}	50.91^{b}	2712.91^{d}	2.54^{d}	113.39^{b}	287.95^{c}
D6	15.0	0.5	354.14	1455.07^{b}	1021.93^{c}	48.66^{c}	2728.65^{d}	2.67^{c}	112.56^{c}	300.55^{b}
SEM			5.886	12.123	8.725	0.423	8.792	0.029	0.000	1.641
P-VALUE										
PKC			0.3372	0.4876	0.0254	0.0254	0.0015	0.0125	0.0019	0.0173
ENZ			0.0628	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
PKCE			0.3534	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

^{a,b,c,d,e,f} Mean values having different superscripts were significantly (P<0.05) different within columns

D1- 0% PKC, D2- 7.5% PKC, D3- 15% PKC, D4- 0% PKCE, D5- 7.5% PKCE, D6- 15% PKCE, REP- Number of Replicates, SEM- Standard Error Mean, FCR- Feed Conversion Ratio, PKC- Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme, CPWG- Cost per weight gain.

4.11 Main effects of palm kernel cake supplementation on gut morphology of broiler chickens.

The main effect of palm kernel cake and exogenous multi-enzyme on gut morphology of experimental broiler chickens is presented in Table 25. The result shows that villus height (VH) for the ileum was highest when PKC replaced SBM at 7.5% on a weight for weight basis with a value of 800.83mm, while the other two levels had different values which were similar ($P<0.05$). Apical Width (AW), Basal Width (BW) and Laminal Proprial Depth (LPD) values were not statistically ($P<0.05$) different. However, the ratio of villus height to laminal proprial depth (VLR) had significantly ($P<0.05$) higher value at the 7.5% inclusion level. The duodenum values showed a different trend for the parameters observed with VH having the highest ($P<0.05$) value of 1277.50mm at 7.5% inclusion level, followed by 15% and 0% with 1250.83mm and 855.00mm respectively. BW was also different but highest ($P<0.05$) at 15% inclusion level, then at 0% and lowest at 7.5% inclusion level. LPD and VLR also had significantly different ($P<0.05$) values with the highest at 7.5% and 15% inclusion levels respectively.

The values of the Villi Height (VH), Basal Width (BW) and VLR for the jejunum were not different ($P<0.05$), but variations were observed for AW which had similar values ($P<0.05$) at 7.5% inclusion level and at 15% inclusion level. LPD value was also highest ($P<0.05$) at 7.5% inclusion level.

Table 25: Effect of PKC on gut morphology of broiler chickens

	PKC (%)	VH (µm)	AW (µm)	BW (µm)	LPD (µm)	VLR
Ileum	0	433.33^{b}	34.17	70.50	153.50	2.87^{c}
	7.5	800.83^{a}	37.33	91.50	185.00	4.29^{a}
	15.0	544.17^{b}	38.00	63.00	155.17	3.52^{b}
SEM		43.71	1.14	5.43	5.85	0.17
P-Value		0.0001	0.3652	0.0761	0.0352	0.0001
Duodenum	0	855.00^{b}	41.50	111.67^{ab}	199.17^{b}	4.30^{b}
	7.5	1277.50^{a}	36.83	71.67^{b}	270.00^{a}	4.82^{b}
	15.0	1250.83^{ab}	41.67	147.50^{a}	150.00^{c}	8.34^{a}
SEM		76.08	1.82	10.16	12.70	0.58
P-Value		0.0280	0.4960	0.0026	0.0001	0.0020
Jejunum	0	430.33	36.83^{b}	92.83	173.00^{b}	2.60
	7.5	822.17	67.67^{a}	116.33	235.50^{a}	3.42
	15	675.00	62.50^{a}	185.17	165.00^{b}	3.97
SEM		72.77	4.87	18.35	8.69	0.31
P-Value		0.0765	0.0111	0.0963	0.0001	0.2002

^{a,b,c} Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC- Palm Kernel Cake, VH: Villus Height, AW: Apical Width, BW: Basal Width, LPD: Laminal Proprial Depth, VLR: Villus Height, Laminal proprial Depth Ratio, SEM- Standard Error of Mean

4.12 Main effects of enzyme supplementation on gut morphology of broiler chickens.

The effect of enzyme supplementation on the gut morphology parameters of the broiler chickens fed PKC supplemented diet is presented in table 26, where only LPD values in the ileum were significantly ($P<0.05$) affected by enzyme supplementation with birds on diets without enzyme supplementation having a higher ($P<0.05$) value of 182.11mm. The duodenum also had varying values for the parameters determined as observed for the ileum but significant enzyme effect was only observed for AW where the birds fed this dietary treatment had higher ($P<0.05$) value of 45.22mm. The values for jejunum however had significance ($P<0.05$) for VH, AW and BW parameters where the birds without enzyme supplementation recorded higher ($P<0.05$) values than those fed enzyme supplemented diets for the three parameters.

Table 26: Effect of enzyme supplementation on gut morphology of broiler chickens

	Enzyme	VH (µm)	AW (µm)	BW (µm)	LPD (µm)	VLR
Ileum	With	538.89	35.67	65.33	147.00[b]	3.63
	Without	646.67	37.33	84.67	182.11[a]	3.49
	SEM	43.71	1.14	5.43	5.85	0.17
	P-Value	0.2281	0.4831	0.0734	0.0006	0.6825
Duodenum	With	1070.00	45.22[a]	97.78	216.11	5.21
	Without	1185.55	34.78[b]	122.78	196.67	6.44
	SEM	76.08	1.82	10.16	12.70	0.58
	P-Value	0.4644	0.0013	0.2290	0.4607	0.3026
Jejunum	With	480.55[b]	45.33[b]	94.22[b]	174.67[b]	2.83
	Without	804.44[a]	66.00[a]	168.67[a]	207.67[a]	3.84
	SEM	72.77	4.87	18.35	8.69	0.31
	P-Value	0.0208	0.0288	0.0382	0.0545	0.1046

[a,b] Mean values having different superscripts were significantly ($P<0.05$) different within columns

VH: Villus Height, AW: Apical Width, BW: Basal Width, LPD: Laminal Proprial Depth, VLR: Villus Height, Laminal proprial Depth Ratio, SEM- Standard Error of Mean

4.13 Interaction effects of palm kernel cake and enzyme supplementation on gut morphology of broiler chickens (ileum).

Table 27 showed the interaction effect of PKC and enzyme supplementation on the morphology of the ileum with significance ($P<0.05$) observed for all the parameters determined. VH was highest for birds on D5 (7.5% PKCE) with a value of 951.67mm and lowest for birds on D1 (0% PKC). AW was highest for birds on D5 (7.5% PKCE) and D3 (15%PKC) with a value of 41.67mm while the other diets had statistically similar ($P<0.05$) values. BW was highest for birds on D4 and D5 and lowest for birds on the control diet. LPD and VLR values were also highest ($P<0.05$) for birds on D5

Table 27: Interaction effect of PKC and enzyme on gut morphology of broiler chickens (Ileum)

Diet No	PKC	Enzyme supplementation	VH (µm)	AW (µm)	BW (µm)	LPD (µm)	VLR
D1	0	0	400.00^{e}	32.33^{b}	41.00^{e}	127.67^{e}	3.13^{d}
D2	7.5	0	650.00^{b}	33.00^{ab}	82.33^{b}	165.67^{c}	3.92^{b}
D3	15.0	0	566.67^{bc}	41.67^{a}	72.67^{c}	147.67^{d}	3.84^{bc}
D4	0	0.5	466.67^{de}	36.00^{ab}	100.00^{a}	179.33^{b}	2.60^{d}
D5	7.5	0.5	951.67^{a}	41.67^{a}	100.67^{a}	204.33^{a}	4.66^{a}
D6	15.0	0.5	521.67^{cd}	34.33^{ab}	53.33^{d}	162.67^{c}	3.21^{cd}
SEM			43.71	1.14	5.43	5.85	0.17
P-VALUE							
PKC			0.0001	0.3652	0.0761	0.0352	0.0001
ENZYME			0.2281	0.4831	0.0734	0.0006	0.6825
PKCE			0.0001	0.0138	0.0001	0.0001	0.0001

^{a,b,c,d,e} Mean values having different superscripts were significantly (P<0.05) different within columns

D1- 0% PKC, D2- 7.5% PKC, D3- 15% PKC, D4- 0% PKCE, D5- 7.5% PKCE, D6- 15% PKCE, SEM- Standard Error Mean,PKC- Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme, VH: Villus Height, AW: Apical Width, BW: Basal Width, LPD: Laminal Proprial Depth, VLR: Villus Height, Laminal proprial Depth Ratio.

4.14 Interaction effects of palm kernel cake and enzyme supplementation on gut morphology of broiler chickens (duodenum).

The result of interaction between PKC and enzyme in the diet of the experimental birds on the duodenal properties of the birds presented in Table 28, shows that the highest value for VH, BW and VLR parameters were observed with birds fed D6 (15%PKCE), while the birds on diet with neither PKC nor enzyme supplementation (D1) had the highest ($P<0.05$) values for AW and the lowest values were observed for birds on diet with enzyme supplementation. Enzyme addition had no effect on the BW value as birds on 7.5% inclusion of PKC with or without enzyme (D2 and D5) had similar values. A similar trend was observed for birds on D1 and D4 for LPD parameter. VLR however showed that as the level of PKC in the diet increased, the value of VLR also increased for both diets with and without enzyme supplementation

Table 28: Interaction effect of PKC and enzyme on gut morphology of broiler chickens (Duodenum)

Diet No	PKC	Enzyme supplementation	VH (µm)	AW (µm)	BW (µm)	LPD (µm)	VLR
D1	0	0	540.67^{c}	41.00^{c}	103.33^{c}	152.33^{e}	3.55^{c}
D2	7.5	0	501.00^{c}	52.67^{b}	105.00^{c}	221.67^{b}	2.26^{e}
D3	15.0	0	400.00^{d}	42.33^{c}	74.33^{d}	150.00^{e}	2.67^{d}
D4	0	0.5	320.00^{e}	32.67^{d}	82.33^{d}	193.67^{c}	1.65^{f}
D5	7.5	0.5	1143.33^{a}	82.67^{a}	127.67^{b}	249.33^{a}	4.58^{b}
D6	15.0	0.5	950.00^{b}	82.67^{a}	296.00^{a}	180.00^{d}	5.28^{a}
SEM			72.77	4.87	18.35	8.69	0.31
P-VALUE							
PKC			0.0765	0.0111	0.0963	0.0001	0.2002
ENZYME			0.0208	0.0288	0.0382	0.0545	0.1046
PKCE			0.0001	0.0001	0.0001	0.0001	0.0001

^{a,b,c,d,e,f} Mean values having different superscripts were significantly ($P<0.05$) different within columns

D1- 0% PKC, D2- 7.5% PKC, D3- 15% PKC, D4- 0% PKCE, D5- 7.5% PKCE, D6- 15% PKCE, SEM- Standard Error Mean, PKC- Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme, VH: Villus Height, AW: Apical Width, BW: Basal Width, LPD: Laminal Proprial Depth, VLR: Villus Height, Laminal proprial Depth Ratio.

4.15 Interaction effects of palm kernel cake and enzyme supplementation on gut morphology of broiler chickens (jejunum).

The effect of PKC and enzyme on the morphology of the jejunum of the broiler chickens fed the experimental diets is as shown in table 29. Enzyme supplementation influenced ($P<0.05$) all the parameters evaluated. VH decreased ($P<0.05$) as the level of PKC increased for enzyme supplemented diet fed birds, and with the highest value of 1591.67 µm at D6. The highest ($P<0.05$) value of 52.33µm for AW was observed when birds were fed the control diet without enzyme supplementation, but BW was highest ($P<0.05$) for birds on D6 (195.00 µm). LPD and VLR also had the highest ($P<0.05$) values at D2 and D6 respectively.

Table 29: Interaction effect of PKC and enzyme on gut morphology of broiler chickens (Jejunum)

Diet No	PKC	Enzyme supplementation	VH (µm)	AW(µm)	BW (µm)	LPD(µm)	VLR
D1	0	0	1100.00^{d}	52.33^{a}	121.67^{b}	198.33^{c}	5.55^{b}
D2	7.5	0	1200.00^{c}	41.67^{b}	71.67^{d}	300.00^{a}	4.00^{c}
D3	15.0	0	910.00^{e}	41.67^{b}	100.00^{c}	150.00^{d}	6.07^{b}
D4	0	0.5	610.00^{f}	30.67^{c}	101.67^{c}	200.00^{c}	3.05^{d}
D5	7.5	0.5	1355.00^{b}	32.00^{c}	71.67^{d}	240.00^{b}	5.65^{b}
D6	15.0	0.5	1591.67^{a}	41.67^{b}	195.00^{a}	150.00^{d}	10.62^{a}
SEM			76.08	1.82	10.16	12.70	0.58
P-VALUE							
PKC			0.0280	0.4960	0.0026	0.0001	0.0020
ENZYME			0.4644	0.0013	0.2290	0.4607	0.3026
PKCE			0.0001	0.0001	0.0001	0.0001	0.0001

^{a,b,c,d,e,f} Mean values having different superscripts were significantly ($P<0.05$) different within columns

D1- 0% PKC, D2- 7.5% PKC, D3- 15% PKC, D4- 0% PKCE, D5- 7.5% PKCE, D6- 15% PKCE, SEM- Standard Error Mean, PKC- Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme, VH: Villus Height, AW: Apical Width, BW: Basal Width, LPD: Laminal Proprial Depth, VLR: Villus Height, Laminal proprial Depth Ratio.

4.16 Main effects of palm kernel cake and enzyme supplementation on gut morphometry of broiler chickens.

The effect of PKC and enzyme on the gut morphometry of broiler chickens fed the experimental diet is shown in table 30. No significant ($P<0.05$) difference occurred for Gut Length (GL), Duodenum Length (DL), Jejunum Length (JL) and Ileum Length (IL) in respect of the PKC inclusion effect. The effect of enzyme almost showed a similar trend but for jejunum length (JL) where birds on diet without enzyme supplementation had a higher ($P<0.05$) value of 5.24mm compared to those fed enzyme supplemented diets which recorded a value of 4.48mm.

Table 30: Effect of PKC and enzyme on gut morphometry of broiler chickens

Diet No	PKC	GL (mm)	DL (mm)	JL (mm)	IL (mm)
1	0	14.03	3.22	5.06	5.76
2	7.5	13.30	3.17	4.71	5.42
3	15.0	13.52	3.16	4.80	5.56
SEM		0.38	0.15	0.17	0.16
P-Value		0.756	0.989	0.707	0.724
	Added Enzyme				
	Without (-)	14.34	3.20	5.24[a]	5.90
	With (+)	12.90	3.16	4.48[b]	5.26
SEM		0.38	0.15	0.17	0.16
P-Value		0.0581	0.9048	0.0177	0.0454

[a,b] Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC- Palm Kernel Cake, GL- Gut Length, DL- Duodenum Length, JL- Jejunum Length, IL- Ileum Length, SEM- Standard Error Mean

4.17 Interaction effects of palm kernel cake and enzyme supplementation on gut morphometry of broiler chickens.

The interaction effect of PKC and enzyme on gut Morphometry shown in table 31 revealed no significance ($P<0.05$) for all the parameters examined for both enzyme supplemented and unsupplemented diets.

Table 31: Interaction effect of PKC and enzyme on gut morphometry of broiler chickens

Diet No	PKC	Enzyme supplementation	GL (mm)	DL (mm)	JL (mm)	IL (mm)
D1	0	0	14.09	2.86	5.28	5.95
D2	7.5	0	14.76	3.43	5.25	6.08
D3	15.0	0	14.16	3.31	5.17	5.68
D4	0	0.5	13.97	3.57	4.83	5.57
D5	7.5	0.5	11.85	2.92	4.17	4.76
D6	15.0	0.5	12.87	3.00	4.42	5.45
SEM			0.38	0.15	0.17	0.16
P-VALUE						
PKC			0.756	0.989	0.707	0.724
ENZYME			0.0581	0.9048	0.0177	0.0454
PKCE			0.2828	0.7618	0.2614	0.2358

D1- 0% PKC, D2- 7.5% PKC, D3- 15% PKC, D4- 0% PKCE, D5- 7.5% PKCE, D6- 15% PKCE, SEM- Standard Error Mean, PKC- Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme, GL- Gut Length, DL- Duodenum Length, JL- Jejunum Length, IL- Ileum Length SEM- Standard Error Mean

4.18 Main effects of palm kernel cake and enzyme supplementation on serum chemistry of broiler chickens.

The result of serum chemistry of the experimental birds fed PKC and enzyme supplemented diet is presented in table 32, where the effect of PKC was significantly ($P<0.05$) observed for only protein, albumin and aspartate aminotransferase (AST). Proteins was higher ($P<0.05$) for Birds on 0% and 15% PKC inclusion which had similar ($P>0.05$) serum protein values of 54.35 mg/dl and 54.58 mg/dl respectively which were however higher than the value for birds fed the diet containing 7.5% PKC. A similar trend was observed for serum Albumin. AST also had the highest ($P<0.05$) value of 119.02 µ/L at 15% inclusion level and the lowest of 96.58 µ/L at 7.5% inclusion level.

Significant ($P<0.05$) effect of enzyme supplementation was observed only for the enzymes AST, Alanine Aminotransferase (ALT) and Alkaline Phosphatase (ALP) with values of 115.65 µ/L, 34.00 µ/L and 187.25 µ/L respectively for birds on diets without enzyme supplementation.

Table 32: Effect of PKC and enzyme on serum chemistry of broiler chickens

Diet No	PKC	Proteins (mg/dl)	Albumin (mg/dl)	Globulin (mg/dl)	Uric acid (mg/dl)	AST (µ/L)	ALT (µ /L)	ALP (µ /L)	Creatinine (mg/dl)
1	0	54.35[a]	31.20[a]	23.43	47.32	100.73[ab]	33.15	156.85	1.47
2	7.5	47.65[b]	26.89[b]	24.02	36.85	96.58[b]	30.28	143.65	1.25
3	15.0	54.58[a]	31.67[a]	23.07	38.63	119.02[a]	24.47	175.32	1.57
SEM		0.903	0.704	0.609	2.531	3.850	1.780	9.270	0.07
P-Value		0.0001	0.0026	0.8320	0.2023	0.0288	0.1260	0.3988	0.2148
	Added Enzyme								
	Without (-)	52.55	29.53	23.22	36.58	115.65[a]	34.00[a]	187.25[a]	1.50
	With (+)	51.83	30.30	23.78	45.29	95.23[b]	24.60[b]	129.95[b]	1.35
SEM		0.903	0.704	0.609	2.531	3.850	1.780	9.270	0.070
P-Value		0.7018	0.5991	0.6560	0.0849	0.0040	0.0043	0.0003	0.2148

[a,b] Mean values having different superscripts were significantly (P<0.05) different within columns.

PKC-Palm Kernel Cake, AST- Aspartate Aminotramsferase, ALT- Alanine Aminotransferase, ALP- Alkaline Phosphatase, SEM-Standard Error Mean.

4.19 Interaction effects of palm kernel cake and enzyme supplementation on serum chemistry of broiler chickens.

The interaction of PKC and enzyme on the serum chemistry of broiler chickens is shown in table 33, where only globulin was not significantly ($P<0.05$) affected. Proteins were lowest for birds on D5 and highest ($P<0.05$) for birds fed D1, D3, D4 and D6 which all had similar ($P<0.05$) values. Albumin values were highest ($P<0.05$) for birds on D6 and lowest for birds fed D2, uric acid was highest ($P<0.05$) at 15% inclusion with enzyme supplementation (D6). However, the enzymes (AST,ALT, ALP) were higher for birds on diets without enzyme supplementation with the highest ($P<0.05$) value for AST at D3, ALT at D1 and ALP having similar ($P>0.05$) values for all the diets without enzyme supplementation (D1,D2 and D3) and with 15% inclusion of PKC with enzyme supplementation (D6). Creatinine values were also highest ($P<0.05$) for birds on D3 (15% PKC) and similar ($P>0.05$) for D1, D2, D4 and D6.

Table 33: Interaction effect of PKC and enzyme on serum chemistry of broiler chickens

Diet No	PKC	Enzyme supplementation	Proteins (mg/dl)	Albumin (mg/dl)	Globulin (mg/dl)	Uric acid (mg/dl)	AST (µ /L)	ALT (µ /L)	ALP (µ /L)	Creatinine (mg/dl)
D1	0	0	54.37^{a}	32.20^{ab}	22.47	48.33^{ab}	116.03^{ab}	37.43^{a}	205.16^{a}	1.30^{ab}
D2	7.5	0	48.77^{ab}	26.57^{c}	22.37	34.13^{ab}	102.70^{bcd}	35.73^{a}	172.63^{a}	1.37^{ab}
D3	15.0	0	54.53^{a}	29.83^{abc}	24.83	27.27^{b}	128.23^{a}	28.83^{ab}	183.97^{a}	1.83^{a}
D4	0	0.5	54.33^{a}	30.20^{abc}	24.40	46.30^{ab}	85.43^{d}	28.86^{ab}	108.53^{b}	1.63^{ab}
D5	7.5	0.5	46.53^{b}	27.22^{bc}	25.67	39.57^{ab}	90.47^{cd}	24.83^{ab}	114.67^{b}	1.13^{b}
D6	15.0	0.5	54.63^{a}	33.50^{a}	21.30	50.00^{a}	109.80^{abc}	20.10^{b}	166.67^{a}	1.30^{ab}
SEM			0.903	0.704	0.609	2.53	3.85	1.78	9.27	0.07
P-VALUE										
PKC			0.0001	0.0026	0.8320	0.2023	0.0288	0.1260	0.3988	0.2148
ENZYME			0.7018	0.5991	0.6560	0.0849	0.0040	0.0043	0.0003	0.2148
PKCE			0.0013	0.0043	0.2661	0.0270	0.0001	0.0146	0.0001	0.0396

^{a,b,c,d} Mean values having different superscripts were significantly ($P<0.05$) different within columns

D1- 0% PKC, D2- 7.5% PKC, D3- 15% PKC, D4- 0% PKCE, D5- 7.5% PKCE, D6- 15% PKCE, SEM- Standard Error Mean, PKC-Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme, AST- Aspartate Aminotramsferase, ALT- Alanine Aminotransferase, ALP- Alkaline Phosphatase,

4.20 Main effects of palm kernel cake and enzyme supplementation on haematological indices of broiler chickens.

Table 34 shows the effect of PKC and enzyme on the haematological indices of broiler chickens fed the experimental diets, where the PKC effect was only significant ($P<0.05$) on Packed Cell Volume (PCV), Heamoglobin concentration (Hb), Red blood Cells (RBC) and one of the white blood cells differentials Eosinophil. The highest ($P<0.05$) value for all the parameters listed above were observed at 7.5% inclusion level of PKC; PCV- 47.67%, Hb- 15.89 g/dl, RBC- 2.68 x $10^{12/L}$ and eosinophil 1.85 %. The values for 0% and 15% PKC inclusion varied also but was similar ($P>0.05$) for PCV, Hb and RBC. The lowest ($P<0.05$) value of 0.17 % for eosinophil was observed when PKC was included in the diets of the experimental birds at 15%. The effect of enzyme on the heamatological indices also showed that only White Blood Cells (WBC) was significantly ($P<0.05$) affected by the use of enzyme with a higher value of 22.37 x $10^{9/L}$ for the birds on diets with enzyme supplementation as against 11.74 x $10^{9/L}$ for birds on diets not supplemented with enzyme.

Table 34: Effect of PKC and enzyme on heamatological indices of broiler chickens

Diet No	PKC	PCV (%)	HB (g/dl)	RBC (x $10^{12/L}$)	WBC (x $10^{9/L}$)	NEUT (%)	LYMP (%)	MONO (%)	EOSIN (%)	BASO (%)
1	0	42.67[b]	14.22[b]	2.26[b]	13.42	14.67	81.00	2.17	1.33[ab]	0.17
2	7.5	47.67[a]	15.89[a]	2.68[a]	19.47	12.50	83.67	0.67	1.85[a]	0.83
3	15.0	41.83[b]	13.94[b]	2.29[b]	18.27	16.83	80.50	1.67	0.17[b]	0.83
SEM		0.913	0.304	0.065	2.053	1.37	1.65	0.345	0.290	0.270
P-Value		0.0087	0.0087	0.0058	0.4696	0.4621	0.7259	0.2025	0.0441	0.5359
	Added Enzyme									
	Without (-)	44.78	14.92	2.45	11.74[b]	14.11	82.22	1.44	1.22	0.44
	With (+)	43.33	14.44	2.37	22.37[a]	15.22	81.22	1.55	1.00	0.78
SEM		0.913	0.304	0.065	2.053	1.37	1.65	0.345	0.290	0.270
P-Value		0.4455	0.4455	0.5492	0.0053	0.6982	0.7718	0.8778	0.7140	0.5530

[a,b] Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC-Palm Kernel Cake, SEM- Standard Error of Mean, PCV- Packed Cell Volume, HB- Haemoglobin, RBC- Red Blood cells, WBC- White Blood Cells, NEUT- Neutrophils, LYMP- Lymphocytes, MONO- Monocytes, EOSIN- Eosiniphils, BASO- Basophils

4.21 Interaction effects of palm kernel cake and enzyme supplementation on haematological indices of broiler chickens.

The interaction effect of PKC and enzyme on the haematological indices of the experimental birds is presented in Table 35, where all parameters were not affected ($P>0.05$) except WBC which had lowest ($P<0.05$) value of 9.37 x $10^{9/L}$ for birds on D2.

Table 35: Interaction effect of PKC and enzyme on heamatological indices of broiler chicken

Diet No	PKC	Enzyme supplementation	PCV (%)	HB (g/dl)	RBC (x $10^{12/L}$)	WBC (x $10^{9/L}$)	NEUT (%)	LYMP (%)	MONO (%)	EOSIN (%)	BASO (%)
D1	0	0	44.00	14.67	2.33	14.63^{bc}	12.00	83.67	2.33	1.33	0.00
D2	7.5	0	47.67	15.89	2.70	9.37^{c}	16.67	79.00	0.33	2.33	1.33
D3	15.0	0	42.67	14.22	2.31	11.23^{c}	13.67	84.00	1.67	0.00	0.00
D4	0	0.5	41.33	13.78	2.19	12.20^{c}	17.33	78.33	2.00	1.33	0.33
D5	7.5	0.5	47.67	15.89	2.65	29.61^{a}	8.33	88.33	1.00	1.33	0.33
D6	15.0	0.5	41.00	13.67	2.27	25.30^{ab}	20.00	77.00	1.67	0.33	1.67
SEM			1.222	0.407	0.087	3.406	1.711	1.769	0.295	0.340	0.291
P-VALUE											
PKC			0.0087	0.0087	0.0058	0.4696	0.4621	0.7259	0.2025	0.0441	0.5359
ENZYME			0.4455	0.4455	0.5492	0.0053	0.6982	0.7718	0.8778	0.7140	0.5530
PKCE			0.0758	0.0758	0.0758	0.0005	0.145	0.3543	0.6633	0.2247	0.3477

^{a,b,c} Mean values having different superscripts were significantly ($P<0.05$) different within columns

D1- 0% PKC, D2- 7.5% PKC, D3- 15% PKC, D4- 0% PKCE, D5- 7.5% PKCE, D6- 15% PKCE, SEM- Standard Error Mean, PKC- Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme, PCV- Packed Cell Volume, HB- Haemoglobin, RBC- Red Blood cells, WBC- White Blood Cells, NEUT- Neutrophils, LYMP- Lymphocytes, MONO- Monocytes, EOSIN- Eosiniphils, BASO- Basophils

4.22 Main effects of palm kernel cake and enzyme supplementation on carcass characteristics of broiler chickens.

The carcass characteristics of broiler chickens fed PKC and enzyme supplemented diet shown in Table 36. The effect of PKC on the cut parts and organ weights revealed no significant ($P<0.05$) difference for the parameters observed, except for drumstick which had the highest significant ($P<0.05$) value at 15% PKC inclusion valued at 10.67%. All organ weights were not significantly ($P<0.05$) different.

TABLE 36: Effect of PKC and enzyme on the carcass characteristics of broiler chickens

Diet No	1	2	3	P-Value	ENZYME		SEM	P-Value
PKC	**0**	**7.5**	**15.0**		Without	With		
Live Weight (g)	1603.33	1530.00	1513.33	0.6597	1474.44	1623.33	40.82	0.0661
Dressed Weight (%)	82.44	82.75	82.84	0.9785	82.95	82.40	0.758	0.7311
Eviscerated Weight (%)	68.54	68.42	70.68	0.5223	69.41	69.02	0.873	0.8335
Neck	5.37	5.87	6.20	0.0959	5.77	5.86	0.159	0.7874
Head	2.83	2.80	2.94	0.7861	3.08^{a}	2.63^{b}	0.086	0.0051
Shank	4.36	4.45	4.88	0.0974	4.81^{a}	4.32^{b}	0.106	0.0152
Cut Parts (%)								
Wing	9.46	10.53	10.92	0.3840	10.22	10.39	0.434	0.8494
Thigh	10.94	10.77	10.83	0.9611	10.73	10.97	0.226	0.6100
Drumstick	10.26^{ab}	9.67^{b}	10.67^{a}	0.0500	10.36	10.04	0.176	0.3805
Breast	15.30	14.72	14.97	0.7580	14.66	15.34	0.299	0.2678
Back	15.77	16.00	14.86	0.4081	16.25^{a}	14.83^{b}	0.356	0.0410
Internal Organs (%)								
Liver	2.88	2.11	2.58	0.1225	2.77	2.28	0.155	0.1185
Heart	0.50	0.51	0.54	0.8897	0.58	0.45	0.038	0.0884
Spleen	0.06	0.07	0.07	0.3615	0.07	0.06	0.004	0.0526
Intestine	5.97	6.29	6.29	0.8946	6.81	5.56	0.299	0.0319
Abdominal fat	1.10	0.96	0.97	0.8087	0.88	1.13	0.0094	0.1910
Proventriculus	0.64	0.65	0.72	0.7464	0.74	0.60	0.043	0.1046
Gizzard	2.41	2.32	2.11	0.4343	2.33	2.24	0.093	0.6432

[a,b]Mean values having different superscripts were significantly ($P<0.05$) different across rows

PKC- Palm Kernel Cake, SEM- Standard Error of Mean

4.23 Interaction effects of palm kernel cake and enzyme supplementation on carcass characteristics of broiler chickens.

The interaction effect of PKC and enzyme on the carcass characteristics of the broiler chickens is presented in Table 37. Head, shank and back were significantly ($P<0.05$) influenced by the use of PKC and enzyme for cut parts with 15% inclusion of PKC without enzyme supplementation (D3) having the highest value for head (3.29 %) and shank (5.11 %), while the lowest value was at D4 weighing 2.50 % and 4.11 % respectively. Back values was highest ($P<0.05$) for birds on D1 and lowest for birds on D6. Meanwhile, the organ weight across treatments for both supplemented and unsupplemented diets were not significantly ($P<0.05$) influenced.

Table 37: Interaction effect of PKC and enzyme on the carcass characteristics of broiler chickens

Diet	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	SEM	P-VALUE
PKC	**0**	**7.5**	**15.0**	**0**	**7.5**	**15.0**		
Live Weight (g)	1576.67	1526.67	1320.00	1630.00	1533.33	1706.67	40.82	0.0973
Dressed Weight (%)	83.48	82.63	82.73	81.41	82.86	82.94	0.758	0.9902
Eviscerated Weight (%)	69.36	67.71	71.15	67.72	69.14	70.21	0.873	0.8889
Neck	5.37	5.77	6.17	5.38	5.97	6.23	0.159	0.8013
Head	3.16^{ab}	2.80^{ab}	3.29^{a}	2.50^{b}	2.80^{ab}	2.60^{ab}	0.086	0.0208
Shank	4.61^{ab}	4.70^{ab}	5.11^{a}	4.11^{b}	4.19^{ab}	4.64^{ab}	0.106	0.0398
Cut Parts (%)								
Wing	9.79	9.71	11.16	9.12	11.36	10.69	0.434	0.6789
Thigh	10.66	10.46	11.05	11.21	11.08	10.61	0.226	0.9399
Drumstick	10.73	9.86	10.49	9.78	9.49	10.85	0.176	0.0986
Breast	14.52	15.07	14.38	16.07	14.37	15.57	0.299	0.5126
Back	16.92^{a}	15.70^{ab}	16.14^{ab}	14.61^{ab}	16.30^{ab}	13.58^{b}	0.356	0.0377
Internal Organs (%)								
Liver	3.10	2.23	2.97	2.66	2.00	2.20	0.155	0.2016
Heart	0.61	0.50	0.64	0.39	0.52	0.45	0.038	0.4532
Spleen	0.06	0.08	0.08	0.06	0.06	0.06	0.004	0.2003
Intestine	6.13	7.02	7.27	5.81	5.56	5.30	0.299	0.3333
Abdominal fat	1.18	0.77	0.71	1.02	1.16	1.22	0.0094	0.5086
Proventriculus	0.68	0.65	0.88	0.59	0.65	0.55	0.043	0.3276
Gizzard	2.29	2.20	2.50	2.54	2.44	1.74	0.093	0.1106

^{a,b} Mean values having different superscripts were significantly ($P<0.05$) different within columns

D1- 0% PKC, D2- 7.5% PKC, D3- 15% PKC, D4- 0% PKCE, D5- 7.5% PKCE, D6- 15% PKCE, SEM- Standard Error Mean, PKC- Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme

4.24 Main effects of palm kernel cake and enzyme supplementation on nutrient digestibility of broiler chickens (0-21 days).

The effect of PKC inclusion on the nutrient digestibility of broiler chickens for the first twenty one days of life is presented in Table 38. Crude Protein (CP) was highest ($P<0.05$) for birds on 15% inclusion of PKC (73.08%) and the lowest ($P<0.05$) for birds on 7.5% inclusion of PKC (70.58%), a similar trend of result was observed for the ether extract. However, Crude Fibre (CF) and Ash had a different trend with their highest ($P<0.05$) values of 86.52% and 77.25% observed at 0% for CF and at 7.5% of PKC inclusion for Ash parameter. The effect of enzyme was not significant ($P<0.05$) for this trial.

Table 38: Effect of PKC on the nutrient digestibility of broiler chickens (0-21 days)

Diet No	PKC	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	Ash (%)
1	0	71.36[ab]	71.57[ab]	86.52[a]	64.22[b]
2	7.5	70.58[b]	68.11[b]	84.43[a]	77.25[a]
3	15.0	73.08[a]	72.70[a]	66.51[b]	66.78[b]
SEM		0.540	0.974	2.777	1.125
P-Value		0.0150	0.0121	0.0002	0.0001
	Added Enzyme				
	Without (-)	71.21	71.45	74.31	69.59
	With (+)	72.14	70.14	84.03	69.24
SEM		0.465	0.655	4.860	0.175
P-Value		0.2416	0.3731	0.0650	0.9102

[a,b] Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC- Palm Kernel Cake, SEM- Standard Error of Mean

4.25 Interaction effects of palm kernel cake and enzyme supplementation on nutrient digestibility of broiler chickens (0-21 days).

The effect of both PKC and enzyme on the nutrient digestibility parameters of the experimental birds is shown in table 39 with ether extract having the highest ($P<0.05$) value (74.94%) at D1 followed by D6 (73.83%) and lowest ($P<0.05$) value of 67.83% at D2. However, CF had its highest ($P<0.05$) value of 90.91% when birds were fed the control diet supplemented with enzyme, while the fibre available for utilization was lowest at D3 (57.45%). Ash value was highest ($P<0.05$) for birds at D2 and D5 (7.5% inclusion level with or without enzyme).

Table 39: Interaction effect of PKC and enzyme on the nutrient digestibility of broiler chickens (0-21days)

Diet No	PKC	Enzyme supplementation	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	Ash (%)
D1	0	0	71.02	74.94^{a}	82.14^{bc}	65.25^{b}
D2	7.5	0	69.72	67.83^{c}	83.34^{b}	78.41^{a}
D3	15.0	0	72.90	71.58^{b}	57.45^{d}	65.13^{b}
D4	0	0.5	71.70	68.20^{c}	90.91^{a}	63.20^{b}
D5	7.5	0.5	71.45	68.40^{c}	85.52^{ab}	76.09^{a}
D6	15.0	0.5	73.27	73.83^{ab}	75.58^{c}	68.44^{b}
SEM			0.761	0.500	1.476	1.519
P-VALUE						
PKC			0.0150	0.0121	0.0002	0.0001
ENZYME			0.2416	0.3731	0.0650	0.9102
PKCE			0.0612	0.0001	0.0001	0.0001

^{a,b,c} Mean values having different superscripts were significantly ($P<0.05$) different within columns

D1- 0% PKC, D2- 7.5% PKC, D3- 15% PKC, D4- 0% PKCE, D5- 7.5% PKCE, D6- 15% PKCE, SEM- Standard Error Mean, PKC- Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme.

4.26 Main effects of palm kernel cake and enzyme supplementation on nutrient digestibility of broiler chickens (22-42 days).

At the 22-42 days period, nutrient digestibility result, presented in table 40 shows the highest ($P<0.05$) values of 78.98% and 77.76% for CP and EE parameters respectively were observed for birds fed the control diet. CF values were similar ($P>0.05$) for birds on 7.5 and 15% inclusion levels of PKC while Ash also had similar ($P>0.05$) value, but at 0% and 7.5%. The result did not follow any definite pattern with either an increase or decrease in PKC inclusion.

Table 40: Effect of PKC on the nutrient digestibility of broiler chickens (22-42 days)

Diet No	PKC	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	Ash (%)
1	0	78.98[a]	77.76[a]	77.69[b]	88.54[a]
2	7.5	72.95[b]	67.72[b]	83.23[a]	83.13[b]
3	15.0	76.79[ab]	71.76[b]	82.01[a]	91.21[a]
SEM		1.218	1.220	0.870	0.957
P-Value		0.0105	0.0001	0.0011	0.0001
	Added Enzyme				
	Without (-)	75.71	72.46	79.60	88.04
	With (+)	76.76	72.37	82.34	87.21
SEM		0.742	0.063	1.937	1.370
P-Value		0.5725	0.9742	0.0631	0.6842

[a,b] Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC- Palm Kernel Cake, SEM- Standard Error of Mean

4.27 Interaction effects of palm kernel cake and enzyme supplementation on nutrient digestibility of broiler chickens (22-42 days).

The table showing the interactive effect of PKC and enzyme on the nutrient digestibility of broiler chickens fed the experimental diets between 22-42 days is presented below. Ether extract, CF and Ash were significantly ($P<0.05$) influenced by the combined effect of both PKC and enzyme. Ether extract was highest ($P<0.05$) at D4 with a value of 78.66% and lowest ($P<0.05$) when birds were fed 7.5% inclusion of PKC without adding enzyme (D2). Crude fibre and Ash values were highest ($P<0.05$) at D5 and D3 but lowest ($P<0.05$) at D1 and D5 respectively. No definite pattern was observed for this result.

Table 41: Interaction effect of PKC and enzyme on the nutrient digestibility of broiler chickens (22-42days)

Diet No	PKC	Enzyme supplementation	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	Ash (%)
1	0	0	77.40	76.87^{ab}	76.75^{c}	88.39^{abc}
2	7.5	0	73.20	66.90^{c}	82.23^{ab}	83.97^{bc}
3	15.0	0	76.54	73.60^{abc}	79.84^{bc}	91.75^{a}
4	0	0.5	80.56	78.66^{a}	78.63^{bc}	88.69^{abc}
5	7.5	0.5	72.71	68.54^{c}	84.23^{a}	82.28^{c}
6	15.0	0.5	77.03	69.93^{bc}	84.19^{a}	90.68^{ab}
SEM			1.809	1.706	0.887	1.456
P-VALUE						
PKC			0.0105	0.0001	0.0011	0.0001
ENZYME			0.5725	0.9742	0.0631	0.6842
PKCE			0.0820	0.0019	0.0003	0.0036

^{a,b,c} Mean values having different superscripts were significantly ($P<0.05$) different within columns

D1- 0% PKC, D2- 7.5% PKC, D3- 15% PKC, D4- 0% PKCE, D5- 7.5% PKCE, D6- 15% PKCE, SEM- Standard Error Mean, PKC- Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme

4.28 Main effects of palm kernel cake and enzyme supplementation on the performance of broiler chickens (0-21 days).

The performance of birds fed graded levels of palm kernel cake (PKC) at 0, 25, 50, 75 and 100% for 0-21 days is presented in Table 42. Final weight, weight gain, daily weight gain and feed conversion ratio were significantly (P<0.05) affected by the utilization of PKC in the diet of broiler chickens. Birds on 0% inclusion of PKC had the highest (P<0.05) final weight and daily weight gain. Also, an increase in the level of PKC showed a resultant decrease (P<0.05) in the final weight and weight gain of experimental birds across the treatments with the lowest value of 283.98g for final weight of birds on the diet containing 100% PKC. However, for the feed conversion ratio, birds on the control diet had the lowest (P<0.05) and best FCR of 1.82. Effect of PKC on cost of feed for each treatment revealed that the control diet had the highest price of ₦ 171.80/kg and the price reduced (P<0.05) as the level of PKC inclusion increased. However, the Cost per Weight gain (CPWG) value was highest at 100% inclusion of PKC at a price of ₦377.42/kg weight gain and the lowest value when 50% of PKC was fed to the experimental birds. The enzyme effect showed no difference (P<0.05) for all the parameters observed.

Table 42: Effect of PKC and enzyme on performance of broiler chickens (0-21 days)

Diet No	PKC	Initial weight (g)	Final Weight (g)	Weight Gain (g)	Daily Weight Gain(g/day)	Feed Intake (g)	FCR	Feed Cost (₦/Kg)	CPWG (₦/Kg)
1	0	37.07	507.12^{a}	470.00^{a}	22.38^{a}	854.14	1.82^{c}	171.80^{a}	313.01^{bc}
2	25	37.06	461.37^{b}	424.31^{b}	20.20^{b}	835.37	1.97^{c}	157.53^{b}	310.36^{bc}
3	50	37.05	460.94^{b}	423.88^{b}	20.18^{b}	818.48	1.94^{c}	143.54^{c}	278.42^{c}
4	75	37.06	364.50^{c}	327.44^{c}	15.59^{c}	822.18	2.52^{b}	128.83^{d}	325.03^{b}
5	100	37.06	283.98^{d}	246.92^{d}	11.76^{d}	813.96	3.30^{a}	114.21^{e}	377.42^{a}
SEM		0.004	10.846	9.472	0.451	13.372	0.0710	0.335	9.502
P-Value		0.5745	0.0001	0.0001	0.0001	0.2394	0.0001	0.0001	0.0001
	Enzyme								
	Without (-)	37.06	414.14	377.08	17.95	818.53	2.31	142.43	317.97
	With (+)	37.06	417.02	379.96	18.09	839.12	2.31	143.93	323.65
SEM		0.001	1.44	1.44	0.07	10.295	0.001	0.750	2.840
P-Value		1.000	0.9277	0.9277	0.9273	0.0959	0.9879	0.8468	0.6995

^{a,b,c,d,e} Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC- Palm Kernel Cake, SEM- Standard Error of Mean, FCR- Feed Conversion Ratio, CPWG- Cost per weight gain.

4.29 Interaction effects of palm kernel cake and enzyme supplementation on the performance of broiler chickens (0-21 days).

Table 43 shows the interaction effect of the graded levels of PKC and enzyme on the performance of the experimental birds. The result showed that final weights of the experimental birds were significantly (P<0.05) different, with the highest value of 513.33g observed for birds on D6. The values observed for diets 1, 2, 3, 7 (D1), (D2), (D3) and (D7) were similar (P>0.05) and the lowest (P<0.05) value of 279.63g was observed for birds on D5 for weight gain. Feed intake was significantly (P<0.05) different with the lowest and best values found for birds fed D10. Birds that consumed the highest quantity of feed were those on D6, while birds on D4, D5, D7 and D8 had similar (P>0.05) values. Feed intake values for birds on enzyme supplemented diets (D6-D10) were higher (P<0.05) than for those on diets not supplemented with enzyme (D1-D5). However, the lowest and best value for feed conversion ratio was observed with birds on the control diet without enzyme supplementation (D1), with a value of 1.76 and feed cost was highest (P<0.05) at D6 with a value of (₦ 172.25/kg) and lowest (P<0.05) at D5 (₦ 113.46/kg) which also had the highest (P<0.05) value of ₦ 388.94/kg for CPWG.

Table 43: Interaction effect of PKC and enzyme on performance of broiler chickens (0-21 days)

Diet No	PKC	Enzyme supplementation	Initial weight(g)	Final Weight(g)	Weight Gain(g)	Daily Weight Gain(g/day)	Feed Intake(g)	FCR	Feed Cost (₦ /Kg)	CPWG (₦/Kg)
D1	0	0	37.06	500.91^{ab}	463.84^{ab}	22.09^{ab}	815.62^{b}	1.76^{d}	171.05^{b}	302.24^{cd}
D2	25	0	37.06	456.06^{ab}	419.00^{ab}	19.95^{ab}	812.73^{b}	1.94^{d}	156.78^{d}	304.11^{bcd}
D3	50	0	37.05	477.43^{ab}	440.37^{ab}	20.96^{ab}	804.99^{b}	1.83^{d}	142.79^{f}	261.34^{d}
D4	75	0	37.06	356.67^{c}	319.60^{c}	15.22^{c}	827.84^{ab}	2.60^{b}	128.08^{h}	333.41^{abc}
D5	100	0	37.06	279.63^{d}	242.57^{d}	11.55^{d}	831.46^{ab}	3.43^{a}	113.46^{j}	388.94^{a}
D6	0	0.5	37.06	513.33^{a}	476.27^{a}	22.68^{a}	892.65^{a}	1.87^{d}	172.25^{a}	323.79^{bcd}
D7	25	0.5	37.06	466.67^{ab}	429.61^{ab}	20.46^{ab}	858.00^{ab}	2.00^{cd}	158.28^{c}	316.62^{bcd}
D8	50	0.5	37.05	444.44^{b}	407.39^{b}	19.39^{b}	831.96^{ab}	2.04^{cd}	144.29^{e}	295.51^{cd}
D9	75	0.5	37.06	372.33^{c}	335.27^{c}	15.96^{c}	816.52^{b}	2.44^{bc}	129.58^{g}	316.65^{bcd}
D10	100	0.5	37.06	288.33^{d}	251.27^{d}	11.96^{d}	796.46^{b}	3.18^{a}	129.58^{g}	365.90^{ab}
SEM			0.0013	27.031	27.031	1.287	8.909	0.187	0.000	12.676
P-VALUE										
PKC			0.5745	0.0001	0.0001	0.0001	0.2394	0.0001	0.0001	0.0001
ENZYME			1.000	0.9277	0.9277	0.9273	0.0959	0.9879	0.8468	0.6995
PKCE			0.9779	0.0001	0.0001	0.0001	0.0044	0.0001	0.0001	0.0001

^{a,b,c,d,e,f,g,h,i} Mean values having different superscripts were significantly (P<0.05) different within columns

D1- 0% PKC, D2- 25% PKC, D3- 50% PKC, D4- 75% PKC, D5- 100% PKC, D6- 0% PKCE, D7- 25% PKCE, D8-50% PKCE, D9- 75% PKCE, D10- 100%PKCE SEM- Standard Error Mean, PKC-Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme, REP- Number of Replicates, FCR- Feed Conversion Ratio, CPWG- Cost per weight gain

4.30 Main effects of palm kernel cake and enzyme supplementation on the performance of broiler chickens (22-42 days).

The sole effect of PKC and enzyme on the performance of broiler chickens between 22-42 days is presented in table 44. Final weight, weight gain, daily weight gain, feed intake and FCR were significantly ($P<0.05$) influenced by the treatment administered to the experimental birds. Final weight of birds on diet containing PKC at 0% was the highest ($P<0.05$) with a value of 1470.33g, and was significantly ($P>0.05$) similar to result obtained for birds on 25% and 50% PKC based diets. The lowest ($P<0.05$) final weight value of 1077.08g was observed for birds fed 100% PKC based diet. A similar trend of result was observed for weight gain and daily weight gain parameters. Feed intake values were however lowest ($P<0.05$) for birds on 100% PKC supplemented diet, while 0, 25 and 50% PKC based diets fed birds had different values that were similar ($P>0.05$), though higher than that observed at the 100% PKC inclusion level. The FCR was lowest ($P<0.05$) for birds on 25% PKC based diet with a value of 2.06. Feed cost was also highest ($P<0.05$) for the birds fed the control diet and lowest ($P<0.05$) when PKC replaced SBM completely. However the lowest ($P<0.05$) value of ₦ 338.37/kg weight gain was observed for birds on 50% inclusion of PKC to replace SBM. However, the sole effect of enzyme used in the experimental diets fed to the birds showed no significant ($P<0.05$) effect.

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Table 44: Effect of PKC and enzyme on performance of broiler chickens (22-42 days)

Diet No	PKC	Initial weight (g)	Final Weight (g)	Weight Gain (g)	Daily Weight Gain(g/day)	Feed Intake (g)	FCR	Feed Cost (₦/Kg)	CPWG (₦/Kg)
1	0	432.33	1470.33^{a}	1038.03^{a}	49.43^{a}	2128.79^{a}	2.13^{b}	170.42^{a}	350.64^{ab}
2	25	432.60	1418.53^{a}	985.92^{a}	46.95^{a}	2090.40^{a}	2.06^{b}	160.38^{b}	341.35^{b}
3	50	432.58	1375.73^{a}	943.16^{a}	44.91^{a}	2113.16^{a}	2.25^{ab}	150.60^{c}	338.37^{b}
4	75	432.70	1255.40^{b}	822.70^{b}	39.18^{b}	2074.14^{ab}	2.53^{b}	140.32^{d}	354.51^{ab}
5	100	432.62	1077.08^{c}	644.45^{c}	30.69^{c}	1908.15^{b}	2.99^{a}	129.90^{e}	389.63^{a}
SEM		0.16	29.52	29.47	1.40	44.45	0.07	0.000	9.192
P-Value		0.5854	0.0001	0.0001	0.0001	0.0088	0.0001	0.0001	0.0065
	Enzyme								
	Without(-)	432.47	1317.85	888.94	42.33	2068.51	2.34	149.57	354.49
	With (+)	432.66	1320.99	885.01	42.14	2057.38	2.33	151.07	355.31
SEM		0.09	1.57	1.96	0.09	5.565	0.005	0.750	0.410
P-Value		0.1835	0.9522	0.9552	0.9555	0.8103	0.9524	0.7482	0.9374

$^{a,b,c.d.e}$ Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC- Palm Kernel Cake, SEM- Standard Error of Mean, FCR- Feed Conversion Ratio, CPWG- Cost per weight gain.

4.31 Interaction effects of palm kernel cake and enzyme supplementation on the performance of broiler chickens (22-42 days).

The interaction effect of PKC and enzyme on the performance of broiler chickens between 22-42 days is presented in Table 45. The final weight of the birds were significantly (P<0.05) affected by the diet, with the highest (P<0.05) and lowest (P<0.05) values of 1496.40g and 1077.30g observed at D6 and D5 respectively. Birds on PKC supplemented diets with enzyme supplementation had higher (P<0.05) final weight than those on PKC diets without enzyme supplementation. Weight gain and daily weight gain parameters had a similar trend with birds on D5 having the lowest (P<0.05) values. Feed intake parameter was also different with birds on D5 having the lowest (P<0.05) value of 1804.50g. Birds on D1, D2, D3, D4, D7 and D8 had similar (P<0.05) values. Meanwhile, the lowest (P<0.05) FCR for this phase was observed when birds were fed the control diet with enzyme supplementation (D6). Feed cost was lowest (P<0.05) for birds on D5 (₦ 129.27/kg) and CPWG for birds fed with 100% PKC supplemented with multi-enzyme (D10).

Table 45: Interaction effect of PKC and enzyme on performance of broiler chickens (22-42 days)

Diet No	PKC	Enzyme supplementation	Initial weight(g)	Final Weight(g)	Weight Gain(g)	Daily Weight Gain (g/day)	Feed Intake (g)	FCR	Feed Cost (₦/Kg)	CPWG (₦/Kg)
D1	0	0	432.19	1444.20^{abc}	1011.80^{abc}	48.18^{abc}	2102.10^{ab}	2.08^{d}	171.26^{a}	356.44^{a}
D2	25	0	432.27	1377.00^{abc}	944.78^{abc}	44.99^{abc}	2078.90^{ab}	2.20^{bc}	159.63^{d}	352.38^{ab}
D3	50	0	432.65	1371.90^{abc}	939.31^{abc}	44.73^{abc}	2075.50^{ab}	2.21^{bc}	149.82^{f}	350.39^{ab}
D4	75	0	432.35	1266.40^{cd}	834.07^{bcd}	39.72^{bcd}	2069.00^{ab}	2.48^{ab}	139.64^{h}	347.18^{ab}
D5	100	0	432.88	1077.30^{d}	644.48^{d}	30.69^{d}	1804.50^{c}	2.78^{a}	129.27^{j}	345.66^{ab}
D6	0	0.5	432.46	1496.40^{a}	1064.20^{a}	50.68^{a}	2155.40^{a}	2.03^{d}	169.73^{b}	344.83^{ab}
D7	25	0.5	432.93	1460.00^{ab}	1027.00^{ab}	48.91^{ab}	2102.00^{ab}	2.05^{d}	161.18^{c}	330.32^{b}
D8	50	0.5	432.51	1379.50^{abc}	947.00^{abc}	45.09^{abc}	2078.70^{ab}	2.18^{cd}	151.48^{e}	319.35^{b}
D9	75	0.5	433.04	1365.30^{bc}	938.32^{bc}	42.63^{bc}	2143.10^{a}	2.28^{bc}	141.16^{g}	310.84^{bc}
D10	100	0.5	432.36	1176.70^{cd}	783.42^{cd}	35.68^{cd}	1835.70^{bc}	2.34^{ab}	130.63^{i}	308.61^{c}
SEM			0.20	43.18	43.12	2.05	53.43	0.09	0.000	12.99
P-VALUE										
PKC			0.5854	0.0001	0.0001	0.0001	0.0088	0.0001	0.0001	0.0065
ENZYME			0.1835	0.9522	0.9552	0.9555	0.8103	0.9524	0.7482	0.9374
PKCE			0.0570	0.0001	0.0001	0.0001	0.0008	0.0001	0.0001	0.0050

^{a,b,c,d,e,f,g,h,i,j} Mean values having different superscripts were significantly (P<0.05) different within columns

D1- 0% PKC, D2- 25% PKC, D3- 50% PKC, D4- 75% PKC, D5- 100% PKC, D6- 0% PKCE, D7- 25% PKCE, D8-50% PKCE, D9- 75% PKCE, D10- 100%PKCE SEM- Standard Error Mean, PKC-Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme, REP- Number of Replicates, FCR- Feed Conversion Ratio, CPWG- Cost per weight gain.

4.32 Main effects of palm kernel cake supplementation on the gut morphology of broiler chickens.

The sole effect of PKC on the intestinal structure of the experimental birds is presented in table 46. The parameters observed were Villus Height (VH), Apical Width (AW), Basal Width (BW), Laminal Proprial Depth (LPD) and ratio of Villus Height to Laminal Proprial Depth (VLR).

For the ileum properties, all parameters observed were not different ($P<0.05$). In the duodenum, AW was highest ($P<0.05$) for birds on 100% PKC inclusion in their diets with a value of 50.00 µm. LPD was highest for birds on 75% PKC supplemented diet with a value of 236.67 µm, while the control diet recorded the highest value of 6.25 for VLR parameter. Jejunum had highest ($P<0.05$) values for VH at 25%, (901.67µm) AW at 50% (43.33 µm) and BW at 0 % (123.33). VLR and LPD values were not significantly ($P<0.05$) different across the treatments.

Table 46: Effect of PKC on gut morphology of broiler chickens

	PKC (%)	VH (µm)	AW (µm)	BW (µm)	LPD (µm)	VLR
Ileum	0	698.33	41.67	100.00	193.33	3.62
	25	703.33	38.33	100.00	196.67	3.56
	50	766.67	43.33	110.00	208.33	3.77
	75	770.00	36.67	105.00	238.33	3.37
	100	683.33	38.33	106.67	218.33	3.08
SEM		18.27	1.22	1.94	8.14	0.12
P-Value		0.8426	0.6286	0.3988	0.1489	0.6894
Duodenum	0	1076.70	30.00^{b}	98.33	176.67^{b}	6.25^{a}
	25	1206.70	36.67^{b}	95.00	216.67^{ab}	5.63^{ab}
	50	933.30	40.00^{ab}	105.00	225.00^{ab}	4.26^{ab}
	75	926.70	35.00^{b}	111.67	236.67^{a}	4.01^{b}
	100	1017.50	50.00^{a}	116.67	208.33^{ab}	4.82^{ab}
SEM		51.75	3.33	4.03	10.15	0.42
P-Value		0.2375	0.0023	0.0827	0.0381	0.0346
Jejunum	0	688.33^{b}	31.67^{b}	123.33^{a}	195.00	3.56
	25	901.67^{a}	35.00^{ab}	96.67^{ab}	208.33	4.34
	50	876.67^{ab}	43.33^{a}	103.33^{ab}	188.33	4.78
	75	850.00^{ab}	36.67^{ab}	85.00^{b}	178.33	4.82
	100	835.00^{ab}	40.00^{ab}	111.67^{ab}	180.00	4.77
SEM		37.29	2.01	6.51	5.48	0.24
P-Value		0.0469	0.0243	0.0287	0.1747	0.1707

[a,b] Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC- Palm Kernel Cake, SEM- Standard Error of Mean, VH: Villus Height, AW: Apical Width, BW: Basal Width, LPD: Laminal Proprial Depth, VLR: Villus Height, Laminal proprial Depth Ratio

4.33 Main effect of enzyme supplementation on the gut morphology of broiler chickens.

The effect of enzyme supplementation on the gut parameter is presented in table 47. The result shows that VH, BW and VLR had higher ($P<0.05$) values for birds on enzyme supplemented diets compared to result observed for those on the unsupplemented diets with values of 804.67µm, 110.67 µm and 3.82 respectively in the ileum. The duodenum result shows that only AW and BW were significantly ($P<0.05$) affected by the use of enzyme and recorded higher ($P<0.05$) values for both parameters for birds on diet supplemented with enzyme. The addition of enzyme did not significantly ($P<0.05$) influence jejunum parameters.

Table 47: Effect of enzyme on gut morphology of broiler chickens

	Enzyme	VH (µm)	AW (µm)	BW (µm)	LPD (µm)	VLR
Ileum	With	804.67[a]	40.67	110.67[a]	214.00	3.82[a]
	Without	644.00[b]	38.67	98.00[b]	208.00	3.14[b]
	SEM	80.34	1.00	6.33	3.00	0.34
	P-Value	0.0044	0.5078	0.0003	0.6428	0.0224
Duodenum	With	1030.67	42.67[a]	111.33[a]	209.33	4.92
	Without	1033.67	34.00[b]	99.33[b]	216.00	5.07
	SEM	1.50	4.33	6.00	3.33	0.07
	P-Value	0.9734	0.0132	0.0337	0.6234	0.7892
Jejunum	With	871.33	36.67	97.33	192.67	4.61
	Without	789.33	38.00	110.67	187.33	4.30
	SEM	41.00	0.66	6.67	2.67	0.15
	P-Value	0.0998	0.6062	0.1086	0.1086	0.4286

[a,b] Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC- Palm Kernel Cake, SEM- Standard Error of Mean, VH: Villus Height, AW: Apical Width, BW: Basal Width, LPD: Laminal Proprial Depth, VLR: Villus Height, Laminal proprial Depth Ratio

4.34 Interaction effects of palm kernel cake and enzyme supplementation on the gut morphology of broiler chickens (ileum).

The interaction effect of PKC and enzyme on the morphology of the ileum of the experimental birds fed PKC based diets with or without enzyme supplementation is represented in Table 48. VH was higher ($P<0.05$) for birds on D8 and D9 (diets with enzyme supplementation at 50% and 75% PKC inclusion) than for those on diets without enzyme supplementation (D1-D5), D5 had the lowest ($P<0.05$) value of 533.33µm. BW was highest ($P<0.05$) but similar ($P>0.05$) for birds on D8 and D9 with a value of 120.00 µm and lowest ($P<0.05$) for birds on D4 with a value of 90.00 µm. Values for birds on diets without enzyme supplementation were lower ($P<0.05$) than for those on enzyme supplemented diets. The VLR was also significantly ($P<0.05$) different across the treatments, with the lowest ($P<0.05$) value of 2.71 realized for birds on D3. AW and LPD were not significantly ($P<0.05$) affected.

Table 48: Interaction effect of PKC and enzyme on gut morphology of broiler chickens (Ileum)

Diet No	PKC	Enzyme supplementation	VH (µm)	AW (µm)	BW (µm)	LPD (µm)	VLR
1	0	0	673.33^{ab}	43.33	100.00^{bc}	193.33	3.47^{ab}
2	25	0	773.33^{ab}	43.33	100.00^{bc}	200.00	3.87^{ab}
3	50	0	600.00^{ab}	40.00	100.00^{bc}	233.33	2.71^{b}
4	75	0	640.00^{ab}	33.33	90.00^{c}	243.33	2.74^{b}
5	100	0	533.33^{b}	33.33	100.00^{bc}	180.00	2.92^{b}
6	0	0.5	723.33^{ab}	40.00	100.00^{bc}	193.33	3.76^{ab}
7	25	0.5	633.33^{ab}	33.33	100.00^{bc}	193.33	3.26^{ab}
8	50	0.5	938.33^{a}	46.67	120.00^{a}	193.33	4.83^{a}
9	75	0.5	900.00^{a}	40.00	120.00^{a}	233.33	4.00^{ab}
10	100	0.5	833.33^{ab}	43.33	113.33^{ab}	256.67	3.25^{ab}
SEM			42.28	1.53	3.14	8.47	0.21
P-VALUE			0.0066	0.4026	0.0001	0.0425	0.0176
PKC			0.8426	0.6286	0.3988	0.1489	0.6894
ENZYME			0.0044	0.5078	0.0003	0.6428	0.0224

^{a,b,c} Mean values having different superscripts were significantly ($P<0.05$) different within columns

D1- 0% PKC, D2- 25% PKC, D3- 50% PKC, D4- 75% PKC, D5- 100% PKC, D6- 0% PKCE, D7- 25% PKCE, D8-50% PKCE, D9- 75% PKCE, D10- 100%PKCE SEM- Standard Error Mean, PKC-Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme, VH: Villus Height, AW: Apical Width, BW: Basal Width, LPD: Laminal Proprial Depth, VLR: Villus Height, Laminal proprial Depth Ratio

4.35 Interaction effects of palm kernel cake and enzyme supplementation on the gut morphology of broiler chickens (duodenum).

The interaction effect of PKC and enzyme on the duodenal properties of the experimental birds fed the formulated diets showed that four (4) parameters were significantly ($P<0.05$) influenced. AW was highest ($P<0.05$) for birds on D10 and lowest ($P<0.05$) for control diet fed birds, birds on the other treatments had various values which were similar ($P>0.05$) but not more than the value obtained for D10. BW had a different trend where birds on D9 and D10 had the highest ($P<0.05$) values of 123.33 µm and 120.00 µm and were similar ($P>0.05$). Others had the same level of significance, except for D2 which had the lowest ($P<0.05$) value of 83.33 µm. LPD was lowest for birds on the control diet without enzyme supplementation (D1) and this treatment also had the highest ($P<0.05$) value of 7.57 for VLR.

Table 49: Interaction effect of PKC and enzyme on gut morphology of broiler chickens (Duodenum)

Diet No	PKC	Enzyme supplementation	VH (µm)	AW (µm)	BW (µm)	LPD (µm)	VLR
1	0	0	1166.7	30.00^{b}	90.00^{ab}	153.33^{b}	7.57^{a}
2	25	0	1180.0	33.33^{b}	83.33^{b}	200.00^{ab}	5.90^{ab}
3	50	0	866.7	36.67^{b}	110.00^{ab}	250.00^{a}	3.53^{bc}
4	75	0	720.0	30.00^{b}	100.00^{ab}	253.33^{a}	2.84^{c}
5	100	0	1235.0	40.00^{b}	113.33^{ab}	223.33^{ab}	5.50^{abc}
6	0	0.5	986.7	30.00^{b}	106.66^{ab}	200.00^{ab}	4.93^{abc}
7	25	0.5	1233.3	40.00^{b}	106.66^{ab}	233.33^{a}	5.36^{abc}
8	50	0.5	1000.0	43.33^{b}	100.00^{ab}	200.00^{ab}	5.00^{abc}
9	75	0.5	1133.3	40.00^{b}	123.33^{a}	220.00^{ab}	5.18^{abc}
10	100	0.5	800.0	60.00^{a}	120.00^{a}	193.33^{ab}	4.13^{bc}
SEM			59.03	2.86	3.95	9.44	0.41
P-VALUE			0.0247	0.0001	0.0147	0.0063	0.0005
PKC			0.2375	0.0023	0.0827	0.0381	0.0346
ENZYME			0.9734	0.0132	0.0337	0.6234	0.7892

^{a,b,c} Mean values having different superscripts were significantly (P<0.05) different within columns

D1- 0% PKC, D2- 25% PKC, D3- 50% PKC, D4- 75% PKC, D5- 100% PKC, D6- 0% PKCE, D7- 25% PKCE, D8-50% PKCE, D9- 75% PKCE, D10- 100%PKCE SEM- Standard Error Mean, PKC-Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme, VH: Villus Height, AW: Apical Width, BW: Basal Width, LPD: Laminal Proprial Depth, VLR: Villus Height, Laminal proprial Depth Ratio

4.36 Interaction effects of palm kernel cake and enzyme supplementation on the gut morphology of broiler chickens (jejunum).

The effect of PKC and enzyme on the jejunum of birds fed the experimental diets is presented in Table 50. AW and LPD values were not significantly ($P<0.05$) affected by the test ingredients. VH was highest ($P<0.05$) for birds on D8, while the lowest ($P<0.05$) VH value of 583.33µm was observed for birds on the control diet without enzyme supplementation (D1). BW had the highest ($P<0.05$) value of 146.67 µm at D1 and similar ($P>0.05$) value of 100.00 µm for birds fed D3, D6, D7 and D10. VLR was highest ($P<0.05$) at D5 and lowest for birds fed D1 with values of 5.92 and 3.02 respectively.

Table 50: Interaction effect of PKC and enzyme on gut morphology of broiler chickens (Jejunum)

Diet No	PKC	Enzyme supplementation	VH (µm)	AW (µm)	BW (µm)	LPD (µm)	VLR
1	0	0	583.33^{c}	33.33	146.67^{a}	196.67	3.02^{d}
2	25	0	853.33^{ab}	36.67	93.33^{b}	200.00	4.27^{abcd}
3	50	0	786.67^{c}	43.33	100.00^{ab}	200.00	3.93^{bcd}
4	75	0	776.67^{abc}	36.67	90.00^{b}	180.00	4.36^{abcd}
5	100	0	946.67^{ab}	40.00	123.33^{ab}	160.00	5.92^{a}
6	0	0.5	793.33^{abc}	30.00	100.00^{ab}	193.33	4.10^{abcd}
7	25	0.5	950.00^{ab}	33.33	100.00^{ab}	216.67	4.41^{abcd}
8	50	0.5	966.67^{a}	43.33	106.67^{ab}	176.67	5.63^{ab}
9	75	0.5	923.33^{ab}	36.67	80.00^{b}	176.67	5.28^{abc}
10	100	0.5	723.33^{bc}	40.00	100.00^{ab}	200.00	3.62^{cd}
SEM			38.62	1.39	5.92	5.19	0.29
P-VALUE			0.0002	0.2815	0.0058	0.1471	0.0010
PKC			0.0469	0.0243	0.0287	0.1747	0.1707
ENZYME			0.0998	0.6062	0.1086	0.1086	0.4286

^{a,b,c,d} Mean values having different superscripts were significantly (P<0.05) different within columns

D1- 0% PKC, D2- 25% PKC, D3- 50% PKC, D4- 75% PKC, D5- 100% PKC, D6- 0% PKCE, D7- 25% PKCE, D8-50% PKCE, D9- 75% PKCE, D10- 100%PKCE SEM- Standard Error Mean, PKC-Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme, VH: Villus Height, AW: Apical Width, BW: Basal Width, LPD: Laminal Proprial Depth, VLR: Villus Height, Laminal proprial Depth Ratio

4.37 Main effects of palm kernel cake and enzyme supplementation on the ileal digesta viscosity of broiler chickens.

The effect of PKC and enzyme on the viscosity of the digesta collected from the ileum (which ranged from Meckel diverticulum to ileo-cecal junction) is shown in Table 51. The viscosity was examined at three different revolutions per minutes (RPM) which are: 50 RPM, 60 RPM and 100 RPM. At all the levels, ileal digesta viscosity was significantly ($P<0.05$) influenced by the level of PKC inclusion, with birds on 100% PKC having the highest ($P<0.05$) value 77.17cP, 85.83 cP and 142.33 cP for 50, 60 and 100 RPM respectively, and these values reduced ($P<0.05$) as the levels of PKC in the diet reduced across the treatments. Enzyme effect was only significantly ($P<0.05$) noted at 50RPM (57.08 cP) and 100RPM (119.95 cP) for birds on diets supplemented with the multi-carbohydrase, having lower ($P<0.05$) values compared to those on the other group.

Table 51: Effect of PKC and enzyme on ileal digesta viscosity of broiler chickens

Diet No	PKC	50RPM (cP)	60RPM (cP)	100RPM (cP)
1	0	50.50^{b}	67.52^{c}	105.50^{c}
2	25	53.15^{b}	73.52^{bc}	121.00^{bc}
3	50	57.90^{b}	75.23^{bc}	125.41^{ab}
4	75	67.72^{a}	82.03^{ab}	142.22^{a}
5	100	77.17^{a}	85.83^{a}	142.33^{a}
SEM		2.326	2.213	4.487
P-Value		0.0001	0.0001	0.0001
	Enzyme			
	Without (-)	65.49^{a}	78.96	134.63^{a}
	With (+)	57.08^{b}	74.69	119.95^{b}
SEM				
P-Value		0.0401	0.1615	0.0183

^{a,b,c} Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC- Palm Kernel Cake, SEM- Standard Error of Mean, RPM: Revolution per minute,
cP = centipoise (1 cP = 1/100 dyne s/cm^2).

4.38 Interaction effects of palm kernel cake and enzyme supplementation on the ileal digesta viscosity of broiler chickens.

The interaction effect of PKC and enzyme on ileal digesta viscosity of the experimental birds presented in table 52 shows significant ($P<0.05$) values at 50, 60 and 100 RPM. However, birds on diets with enzyme supplementation had lower values compared with their counterparts without enzyme supplementation at the varying levels of PKC inclusion with the lowest values of 48.33 cP, 66.50 cP and 105.33 cP observed at 50RPM, 60RPM and 100RPM respectively for the birds on D6, reflecting the effect of enzyme use even on the control diet (without PKC). Also, values of viscosity increased ($P<0.05$) as the speed of the analytical tool increased from 50RPM to 60RPM and to 100RPM.

Table 52: Interaction effect of PKC and enzyme on ileal digesta viscosity of broiler chickens

Diet No	PKC	Enzyme supplementation	50RPM (cP)	60RPM (cP)	100RPM (cP)
D1	0	0	52.67^{de}	68.53^{cd}	105.67^{d}
D2	25	0	55.67^{cde}	78.50^{abcd}	125.67^{bc}
D3	50	0	61.46^{c}	75.00^{bcd}	128.07^{b}
D4	75	0	76.00^{ab}	82.20^{ab}	157.97^{a}
D5	100	0	81.66^{a}	90.57^{a}	155.80^{a}
D6	0	0.5	48.33^{e}	66.50^{e}	105.33^{d}
D7	25	0.5	50.63^{e}	68.53^{cd}	116.33^{c}
D8	50	0.5	54.33^{cde}	75.47^{bcd}	122.76^{bc}
D9	75	0.5	59.43^{cd}	81.86^{abc}	126.47^{bc}
D10	100	0.5	72.67^{b}	81.10^{abc}	128.87^{b}
SEM			1.506	2.722	2.124
P-VALUE					
PKC			0.0001	0.0001	0.0001
ENZYME			0.0401	0.1615	0.0183
PKCE			0.0001	0.0001	0.0001

^{a,b,c,d,e} Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC- Palm Kernel Cake, SEM- Standard Error of Mean, RPM: Revolution per minute D1- 0% PKC, D2- 25% PKC, D3- 50% PKC, D4- 75% PKC, D5- 100% PKC, D6- 0% PKCE, D7- 25% PKCE, D8-50% PKCE, D9- 75% PKCE, D10- 100%PKCE SEM- Standard Error Mean, PKC- Palm Kernel Cake, PKCE- Interaction of Palm Kernel Cake and Enzyme. cP = centipoise (1 cP = 1/100 dyne s/cm^2)

4.39 Main effects of palm kernel cake and enzyme supplementation on the gut microbiology of broiler chickens.

The gut microbiology of experimental birds fed PKC supplemented diets at 0, 25, 50, 75 and 100% is shown in Table 53. The main effect of PKC on the birds was not significantly ($P<0.05$) different across the treatments for Total Bacteria Count (TBC). However, Total Coliform Count (TCC) was highest ($P<0.05$), for birds on 0% and 25% PKC and the lowest ($P<0.05$) TCC was observed for birds on 50% PKC with a value of 0.67. Total Saccharomycete Count (TSC) was highest ($P<0.05$) at 100% PKC supplementation level with a value of 0.53, but at 25% and 75%, the values were similar ($P>0.05$). Birds on 50% PKC inclusion level, had the lowest ($P<0.05$) value of 0.23. The effect of enzyme on the gut microbiology of the birds showed no significance ($P<0.05$) for the three parameters with and without enzyme supplementation.

Table 53: Effect of PKC and enzyme on gut microbiology of broiler chickens

Diet No	PKC	TBC	TCC	TSC
1	0	2.15	1.17[a]	0.47[ab]
2	25	2.48	1.20[a]	0.28[bc]
3	50	2.52	0.67[b]	0.23[c]
4	75	2.55	0.97[ab]	0.28[bc]
5	100	3.01	1.07[a]	0.53[a]
SEM		0.310	0.076	0.055
P-Value		0.4278	0.0003	0.0021
	Enzyme			
	Without (-)	2.37	1.07	0.37
	With (+)	2.72	0.96	0.35
SEM		0.17	0.05	0.01
P-Value		0.2079	0.2703	0.6812

[a,b,c] Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC- Palm Kernel Cake, SEM- Standard Error of Mean, TBC- Total Bacteria Count, TCC-Total Coliform Count TSC- Total Sachromyces Count.

4.40 Interaction effects of palm kernel cake and enzyme supplementation on the gut microbiology of broiler chickens.

Table 54 shows the interaction effect of PKC and enzyme on the gut microbiology of the experimental birds. TBC was not significantly ($P<0.05$) affected by the combined use of PKC and the enzyme. Meanwhile, TCC and TSC values showed significant ($P<0.05$) difference for the treatment diets. TCC was highest ($P<0.05$) and ($P>0.05$) similar for birds on D1 and D2 with values of 1.37 and 1.43 respectively, while birds on D3 had the lowest ($P<0.05$) value of 0.63. The TSC values were however, similar ($P>0.05$) for birds on 100% PKC diet without enzyme supplementation (D5) and those fed the control diet with enzyme supplementation (D6). Birds with PKC at 25, 50 and 75 % with enzyme supplementation had a similar ($P>0.05$) values with the birds on the control diet without enzyme supplementation.

Table 54: Interaction effect of PKC and enzyme on gut microbiology of broiler chickens.

Diet No	PKC	Enzyme supplementation	TBC	TCC	TSC
D1	0	0	2.27	1.37^{a}	0.33^{bc}
D2	25	0	2.90	1.43^{a}	0.37^{ab}
D3	50	0	2.07	0.63^{c}	0.17^{c}
D4	75	0	2.23	0.93^{b}	0.33^{b}
D5	100	0	2.37	0.97^{b}	0.67^{a}
D6	0	0.5	2.03	0.97^{b}	0.60^{a}
D7	25	0.5	2.13	0.97^{b}	0.20^{bc}
D8	50	0.5	2.90	0.70^{c}	0.30^{bc}
D9	75	0.5	2.87	1.00^{b}	0.23^{bc}
D10	100	0.5	3.67	1.16^{ab}	0.40^{ab}
SEM			0.393	0.062	0.052
P-VALUE					
PKC			0.4278	0.0003	0.0021
ENZYME			0.2079	0.2903	0.6812
PKCE			0.1349	0.0001	0.0001

PKC- Palm Kernel Cake, SEM- Standard Error of Mean, D1- 0% PKC, D2- 25% PKC, D3- 50% PKC, D4- 75% PKC, D5- 100% PKC, D6- 0% PKCE, D7- 25% PKCE, D8-50% PKCE, D9- 75% PKCE, D10- 100%PKCE, PKCE- Interaction of Palm Kernel Cake and Enzyme, TBC- Total Bacteria Count, TCC-Total Coliform Count TSC- Total Sachromyces Count.

4.41 Main effects of palm kernel cake supplementation on the carcass characteristics of broiler chickens.

The effect of PKC and enzyme on the carcass characteristics of experimental birds is presented in table 55. The live weight, plucked weight and dressed weight of the experimental birds were significantly ($P<0.05$) different, with the birds on 0% PKC inclusion level (control diet) having the highest ($P<0.05$) values of 1976.76g for live weight, 83.12% and 76.02 % for plucked and dressed weight respectively, and the lowest ($P<0.05$) value of 78.55 % and 72.17 % for plucked and dressing percentage at 100% PKC supplemental level.

Neck values was highest ($P<0.05$) at 100% PKC inclusion level, while drumstick was highest ($P<0.05$) for birds on 25%, and 75% inclusion level with values of 10.91% and 10.84% respectively. For the organ weights of the birds, the value of liver for birds on 75% PKC supplemented diet was the lowest ($P<0.05$) compared to other levels of inclusion. Intestine of the birds on 75% PKC also had the highest ($P<0.05$) value of 4.59%, while the lowest ($P<0.05$) value of 3.79% was observed for birds on 25% PKC supplementation. Whole gizzard and empty gizzard measured were similar in trend, with the highest ($P<0.05$) value (3.56% and 2.86%) observed for birds on 100% PKC inclusion for both parameters respectively.

Table 55: Effect of PKC on carcass characteristics of broiler chickens

Diet No	D1	D2	D3	D4	D5	SEM	P-Value
PKC	**0**	**25**	**50**	**75**	**100**		
Live Weight (g)	1976.67^{a}	1926.67^{a}	1868.33^{ab}	1718.33^{bc}	1560.00^{c}	76.06	0.0001
Dressed Weight (%)	83.12^{a}	83.22^{a}	83.31^{a}	82.16^{ab}	78.55^{b}	0.90	0.0064
Eviscerated Weight (%)	76.02^{a}	75.85^{ab}	76.08^{a}	73.68^{ab}	72.17^{b}	0.79	0.0160
Neck	3.65^{ab}	3.88^{ab}	3.74^{ab}	3.21^{b}	4.38^{a}	0.19	0.0063
Head	2.56	2.69	2.73	2.93	3.00	0.080	0.0844
Shank	4.46	5.10	4.41	5.15	4.70	0.155	0.1036
Cut Parts (%)							
Wing	9.21	8.62	8.92	8.52	9.19	0.14	0.7197
Thigh	11.16	11.02	10.77	10.94	10.97	0.063	0.9768
Drumstick	10.24^{ab}	10.91^{a}	9.96^{ab}	10.84^{a}	9.42^{b}	0.278	0.0141
Breast	19.06	17.92	19.17	17.88	16.86	0.427	0.1050
Back	17.05	18.17	17.76	17.62	16.26	0.331	0.2627
Internal Organs (%)							
Liver	1.86^{ab}	2.07^{a}	1.72^{ab}	1.61^{b}	1.86^{ab}	0.077	0.0298
Heart	0.44	0.44	0.42	0.48	0.49	0.013	0.5427
Spleen	0.11	0.10	0.09	0.10	0.11	0.033	0.9782
Intestine	3.89^{ab}	3.79^{b}	4.03^{ab}	4.59^{a}	4.38^{ab}	0.151	0.0322
Abdominal fat	1.98	1.35	1.44	1.36	1.78	0.127	0.4181
Proventriculus	0.37	0.36	0.35	0.44	0.44	0.019	0.0443
Whole Gizzard	2.18^{d}	2.40^{cd}	2.96^{bc}	3.24^{ab}	3.56^{a}	0.257	0.0001
Empty Gizzard	1.61^{d}	1.81^{cd}	2.22^{bc}	2.48^{ab}	2.86^{a}	0.225	0.0001
Gall Bladder	0.11	0.10	0.13	0.12	0.11	0.005	0.5757

PKC- Palm Kernel Cake, SEM- Standard Error of Mean.

4.42 Main effects of enzyme supplementation on the carcass characteristics of broiler chickens.

The effect of enzyme supplementation on the carcass characteristics of the experimental birds fed PKC based diets is presented in table 56 above. Shank, head, abdominal fat and gall bladder were significantly ($P<0.05$) different. Birds on diets with enzyme supplementation had higher ($P<0.05$) values than those on unsupplemented diets for head and shank with 2.93 % and 5.04 % respectively. However, abdominal fat was higher ($P<0.05$) for birds on diets without enzyme supplementation, and the gall bladder percentage in relation to the live weight followed a similar trend as abdominal fat.

Table 56: Effect of enzyme on the carcass characteristics of broiler chickens

	+ Enzyme	- Enzyme	SEM	P-VALUE
Live Weight (g)	1772.67	1847.33	37.33	0.2596
Dressed Weight (%)	81.75	82.39	0.32	0.5480
Eviscerated Weight (%)	74.12	75.39	0.63	0.1878
Neck	3.66	3.87	0.10	0.3473
Head	2.93[a]	2.62[b]	0.15	0.0042
Shank	5.04[a]	4.49[b]	0.27	0.0140
Cut Parts (%)				
Wing	9.18	8.59	0.29	0.1193
Thigh	10.83	11.11	0.14	0.4433
Drumstick	10.56	9.98	0.29	0.0835
Breast	17.73	18.63	0.45	0.1562
Back	17.42	17.31	0.05	0.8483
Internal Organs (%)				
Liver	1.85	1.79	0.03	0.5629
Heart	0.47	0.44	0.01	0.3542
Spleen	0.11	0.10	0.01	0.6761
Intestine	4.06	4.20	0.07	0.4717
Abdominal fat	1.30[b]	1.87[a]	0.28	0.0219
Proventriculus	0.39	0.39	0.00	0.8910
Whole Gizzard	2.87	2.86	0.01	0.9912
Empty Gizzard	2.20	2.18	0.01	0.9168
Gall Bladder	0.10[b]	0.12[a]	0.01	0.0304

[a,b] Mean values having different superscripts were significantly ($P<0.05$) different across rows

SEM- Standard Error of Mean

4.43 Interaction effects of palm kernel cake and enzyme supplementation on the carcass characteristics of broiler chickens.

The interaction effect of carcass characteristics of broiler chickens is presented in table 57 above. Result obtained showed that live weight was significantly ($P<0.05$) affected by the treatment administered, with the birds on D6 having the highest ($P<0.05$) value of 2006.67g among other treatment. D7 also had higher values which was similar ($P>0.05$) to D6. For the cut parts parameters, only head, shank and drumstick were significantly ($P<0.05$) influenced by the treatment diets. For head, D10 had the highest ($P<0.05$) value of 3.17%, while shank value was highest for birds on D7 (5.57%). Also, drumstick was highest ($P<0.05$) with birds on D9 and lowest ($P<0.05$) for birds on D5. The internal organs affected by the treatment are liver, heart and gizzard (whole and empty). The liver of the experimental birds was larger ($P<0.05$) in relation to live weight for birds on D7 and lowest ($P<0.05$) for those on D4. Heart had the highest ($P<0.05$) values for birds on D7 and lowest ($P<0.05$) for those on D2, Whole gizzard was higher ($P<0.05$) for birds on 100% PKC diets with or without enzyme (D5 and D10) and lowest ($P<0.05$) for birds fed the control diet without enzyme supplementation.

Table 57: Interaction effect of PKC and enzyme on carcass characteristics of broiler chickens

Diet	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	SEM	P-VALUE
PKC	**0**	**25**	**50**	**75**	**100**	**0**	**25**	**50**	**75**	**100**		
Live Weight (g)	1946.67^{a}	1880.00^{ab}	1853.33^{ab}	1636.37^{bc}	1546.67^{c}	2066.67^{a}	1973.33^{a}	1883.33^{ab}	1800.00^{abc}	1573.33^{c}	53.375	0.0001
Dressed Weight (%)	82.22	83.09	82.74	82.46	78.26	84.01	83.36	83.88	81.85	78.83	1.446	0.1149
Eviscerated Weight (%)	74.33	74.75	75.87	73.50	72.16	77.70	76.95	76.28	73.86	72.18	1.285	0.0662
Neck	3.66	3.95	4.19	3.27	4.30	3.63	3.83	3.29	3.14	4.45	0.274	0.0280
Head	2.33^{c}	2.47^{bc}	2.74^{abc}	2.74^{abc}	2.82^{abc}	2.78^{abc}	2.90^{abc}	2.71^{abc}	3.11^{ab}	3.17^{a}	0.138	0.0102
Shank	4.11^{b}	4.63^{ab}	4.56^{ab}	4.70^{ab}	4.44^{ab}	4.81^{ab}	5.58^{a}	4.25^{ab}	5.60^{a}	4.94^{ab}	0.279	0.0143
Cut Parts (%)												
Wing	9.17	8.13	8.98	8.42	8.28	9.25	9.12	8.85	8.62	10.09	0.605	0.5456
Thigh	11.03	10.79	11.42	10.84	11.47	11.29	11.25	10.12	11.04	10.47	0.612	0.8616
Drumstick	9.72^{ab}	11.02^{ab}	9.86^{ab}	10.08^{ab}	9.23^{b}	10.76^{ab}	10.79^{ab}	10.05^{ab}	11.60^{a}	9.60^{ab}	0.402	0.0107
Breast	20.20	18.20	18.94	19.03	16.78	17.93	17.65	19.40	16.74	16.94	0.889	0.1321
Back	17.57	19.51	16.88	16.81	16.16	16.53	17.18	18.64	18.43	16.36	0.840	0.2036
Internal Organs (%)												
Liver	1.94^{ab}	1.87^{ab}	1.76^{ab}	1.44^{b}	1.95^{ab}	1.78^{ab}	2.26^{a}	1.68^{ab}	1.78^{ab}	1.76^{ab}	0.122	0.0193
Heart	0.42^{ab}	0.33^{b}	0.45^{ab}	0.47^{ab}	0.52^{ab}	0.46^{ab}	0.54^{a}	0.39^{ab}	0.49^{ab}	0.46^{ab}	0.042	0.0686
Spleen	0.12	0.08	0.12	0.09	0.11	0.09	0.13	0.07	0.12	0.11	0.022	0.6315
Intestine	3.98	3.95	3.96	4.61	4.53	3.81	3.64	4.09	4.57	4.22	0.290	0.2692
Abdominal fat	2.51	1.51	1.72	1.89	1.70	1.46	1.19	1.16	0.82	1.86	0.363	0.1611
Proventriculus	0.39	0.34	0.36	0.49	0.38	0.36	0.38	0.34	0.40	0.49	0.034	0.0319
Whole Gizzard	2.17^{e}	2.28^{cde}	3.15^{abcde}	3.19^{abcd}	3.54^{ab}	2.19^{de}	2.52^{bcde}	2.76^{abcde}	3.28^{abc}	3.59^{a}	0.205	0.0001
Empty Gizzard	1.64^{bc}	1.80^{bc}	2.26^{abc}	2.44^{abc}	2.77^{a}	1.57^{c}	1.82^{bc}	2.18^{abc}	2.50^{ab}	2.94^{a}	0.181	0.0002
Gall Bladder	0.12	0.11	0.14	0.14	0.11	0.10	0.09	0.12	0.09	0.11	0.017	0.3549

^{a,b,c,d,e} Mean values having different superscripts were significantly (P<0.05) different within columns

PKC- Palm Kernel Cake, SEM- Standard Error of Mean, D1- 0% PKC, D2- 25% PKC, D3- 50% PKC, D4- 75% PKC, D5- 100% PKC, D6- 0% PKCE, D7- 25% PKCE, D8-50% PKCE, D9- 75% PKCE, D10- 100%PKCE SEM- Standard Error Mean,

4.44 Main effects of palm kernel cake and enzyme supplementation on the haematological indices of broiler chickens.

The effect of PKC and the effect of enzyme on the haematological indices of broiler chickens is presented in Table 58. Packed Cell Volume (PCV), Heamoglobin (Hb) and Red Blood Cells (RBC) were ($P<0.05$) influenced by the use of PKC with their highest ($P<0.05$) values of 34.76%, 13.35g/dL and 3.21 (x $10^{12/L}$) respectively. Birds on the 100% inclusion of PKC had the lowest ($P<0.05$) values for the three parameters. WBC value was not significantly ($P<0.05$) different across the various levels of PKC inclusion. The effect of enzyme use was observed only for RBC and neutrophils with the highest ($P<0.05$) values of 2.86 (x $10^{12/L}$) and 27.47% respectively for birds on the enzyme supplemented diets. Other parameters had values that were not different ($P<0.05$) between the enzyme supplemented and unsupplemented diet fed birds.

Table 58: Effect of PKC and enzyme on heamatological indices of broiler chickens

Diet No	PKC	PCV (%)	HB (g/dl)	RBC (x 10^{12})	WBC (x $10^{9/L}$)	NEUT (%)	LYMP (%)	EOSIN (%)	BASO (%)	MONO (%)
1	0	34.76[a]	13.35[a]	3.21[a]	11.13	23.67	76.00	0.17	0.00	0.00
2	25	32.07[b]	11.97[b]	2.98[ab]	11.58	24.83	78.00	0.17	0.00	0.17
3	50	29.59[b]	11.15[c]	2.73[bc]	12.23	26.83	77.50	0.00	0.17	0.33
4	75	26.63[c]	10.24[d]	2.35[cd]	12.47	29.17	68.83	0.00	0.17	0.67
5	100	35.98[d]	9.77[d]	2.12[d]	12.12	23.67	79.67	0.00	0.33	0.33
SEM		0.293	0.089	0.050	0.501	1.489	3.315	0.105	0.149	0.183
P-Value		0.0001	0.0001	0.0001	0.2857	0.1717	0.1865	0.5674	0.4402	0.1424
	Enzyme Effect									
	Without (-)	28.21	11.24	2.50[b]	11.83	23.80[b]	75.60	0.13	0.13	0.40
	With (+)	30.71	11.35	2.86[a]	11.98	27.47[a]	76.40	0.00	0.13	0.20
SEM		1.250	0.055	0.180	0.075	1.835	0.400	0.065	0.000	0.100
P-Value		0.0929	0.8277	0.0312	0.7384	0.0262	0.7978	0.1534	1.0000	0.2467

[a,b,c,d] Mean values having different superscripts were significantly ($P<0.05$) different within columns. PKC-Palm Kernel Cake, SEM- Standard Error of Mean, PCV- Packed Cell Volume, HB- Haemoglobin, RBC- Red Blood Cells, WBC- White Blood Cells, NEUT- Neutrophils, LYMP- Lymphocytes, MONO- Monocytes, EOSIN- Eosiniphils, BASO- Basophils

4.45 Interaction effects of palm kernel cake and enzyme supplementation on the haematological indices of broiler chickens.

The interaction effect of PKC and enzyme on heamatological indices of broiler chickens shows that PCV was highest ($P<0.05$) at D6 (35.37%) and the lowest value ($P<0.05$) of 22.56% was observed for birds on D5, the result shows a decrease ($P<0.05$) in values observed for PCV as the level of PKC increased with or without enzyme supplementation, but the birds on enzyme supplemented diets had higher values though not ($P<0.05$) different. Heamoglobin (Hb) concentration was also highest ($P<0.05$) and similar ($P>0.05$) for birds on D6 (13.58g/dL) and D1 (13.12g/dL), while birds on D5 had the lowest ($P<0.05$) value of 9.17g/dL this was similar to the trend observed for RBC having the lowest ($P<0.05$) value of 1.94 (x $10^{12/L}$) at D5. Of all the WBC differentials, only neutrophil was influenced by the treatment administered with the highest ($P<0.05$) value of 32.00% at D8 and lowest value of 21.33% at D5. The values for other WBC differentials varied though not significantly ($P<0.05$) and did not follow any definite pattern.

Table 59: Interaction effect of PKC and enzyme on heamatological indices of broiler chickens

Diet No	PKC	Enzyme supplementation	PCV (%)	HB (g/dl)	RBC (x 10^{12})	WBC (x $10^{9/L}$)	NEUT (%)	LYMP (%)	EOSIN (%)	BASO (%)	MONO (%)
D1	0	0	34.16^{ab}	13.12^{a}	3.10^{abc}	11.00	24.33^{ab}	75.00	0.33	0.00	0.00
D2	25	0	30.85^{c}	12.34^{b}	2.79^{cd}	11.13	23.33^{ab}	75.00	0.33	0.00	0.33
D3	50	0	28.41^{d}	11.36^{cd}	2.50^{de}	12.27	21.67^{ab}	81.67	0.00	0.00	0.33
D4	75	0	25.06^{e}	10.21^{f}	2.19^{ef}	12.23	28.33^{ab}	65.00	0.00	0.33	1.00
D5	100	0	22.56^{f}	9.17^{g}	1.94^{f}	12.53	21.33^{b}	81.33	0.00	0.33	0.33
D6	0	0.5	35.07^{a}	13.58^{a}	3.33^{a}	11.27	23.00^{ab}	77.00	0.00	0.00	0.00
D7	25	0.5	33.29^{b}	11.60^{c}	3.16^{ab}	12.03	26.33^{ab}	81.00	0.00	0.00	0.00
D8	50	0.5	30.79^{c}	10.93^{de}	2.97^{bc}	12.20	32.00^{a}	73.33	0.00	0.33	0.33
D9	75	0.5	28.19^{d}	10.28^{f}	2.53^{de}	12.70	30.00^{ab}	72.67	0.00	0.00	0.33
D10	100	0.5	25.93^{e}	10.37^{ef}	2.30^{e}	11.70	26.00^{ab}	78.00	0.00	0.33	0.33
SEM			0.414	0.126	0.070	0.709	2.106	4.688	0.149	0.211	0.258
P-VALUE											
PKC			0.0001	0.0001	0.0001	0.2857	0.1717	0.1865	0.5674	0.4402	0.1424
ENZYME			0.0929	0.8277	0.0312	0.7384	0.0262	0.7978	0.1534	1.0000	0.2467
PKCE			0.0001	0.0001	0.0001	0.6899	0.0227	0.3634	0.5516	0.7289	0.3076

^{abcdef} Mean Values having different superscripts were significantly ($P<0.05$) different within coumns

PKC-Palm Kernel Cake, SEM- Standard Error of Mean, PCV- Packed Cell Volume, HB- Haemoglobin, RBC- Red Blood Cells, WBC- White Blood Cells, NEUT- Neutrophils, LYMP- Lymphocytes, MONO- Monocytes, EOSIN- Eosiniphils, BASO- Basophils

4.46 Main effect of palm kernel cake and enzyme supplementation on the serum chemistry of broiler chickens.

Table 60 shows the effect of PKC and enzyme on the serum chemistry of broiler chickens. The result shows that only Creatinine and Albumin:Globulin ratio were not significantly ($P<0.05$) influenced by the use of PKC. Serum Protein values decreased ($P<0.05$) with increasing levels of PKC and the birds fed the control diet had the highest ($P<0.05$) value of 4.53mg/dL. A similar trend of decreasing ($P<0.05$) value was observed for Albumin with control diet having the highest ($P<0.05$) values for Uric acid, glucose, AST, ALT and Globulin of 3.50mg/dL, 129.67mg/dL, 63.67U/L, 34.83U/L and 2.03g/dL respectively. The birds on 100% PKC inclusion had the lowest ($P<0.05$) values for these parameters. However, the ratio of AST: ALT was different with the result showing similar ($P>0.05$) values for 0, 25, 50 and 75% inclusion, and a lowest ($P<0.05$) value of 0.44 for 100% inclusion of PKC in the diet of the experimental birds.

Table 60: Effect of PKC and enzyme on serum chemistry of broiler chickens

Diet No	PKC	Proteins (g/dl)	Albumin (g/dl)	Uric Acid (mg/dl)	Creatinine (mg/dl)	Glucose (mg/dl)	AST (µ/L)	ALT (µ/L)	Globulin (g/dl)	A:G	AST:ALT
1	0	4.53^{a}	2.50^{a}	3.50^{a}	1.25	129.67^{a}	63.67^{a}	34.83^{a}	2.03^{a}	1.23	0.55^{a}
2	25	4.43^{a}	2.43^{a}	3.02^{b}	1.22	126.33^{ab}	60.93^{b}	30.33^{b}	2.00^{ab}	1.22	0.50^{a}
3	50	4.23^{ab}	2.34^{ab}	2.84^{b}	1.13	128.50^{ab}	61.13^{ab}	30.83^{b}	1.89^{ab}	1.24	0.50^{a}
4	75	4.22^{ab}	2.29^{ab}	2.95^{b}	1.10	128.00^{ab}	60.00^{b}	31.50^{ab}	1.92^{ab}	1.19	0.53^{a}
5	100	3.93^{b}	2.09^{b}	3.02^{b}	1.00	119.17^{d}	60.43^{b}	26.33^{c}	1.83^{b}	1.15	0.44^{b}
SEM		0.684	0.053	0.044	0.057	0.957	0.671	0.606	0.033	0.033	0.013
P-Value		0.0005	0.0126	0.0001	0.0978	0.0473	0.0056	0.0001	0.0138	0.7979	0.0003
Added Enzyme											
Without (-)		4.35	2.39	3.08	1.20	121.40^{b}	60.93	29.67	1.96	1.22	0.48
With (+)		4.18	2.27	3.06	1.08	131.27^{a}	61.53	31.87	1.91	1.19	0.52
SEM		2.695	0.565	0.010	0.060	4.935	0.300	1.100	0.025	0.015	0.02
P-Value		0.1019	0.1458	0.8516	0.0551	0.0001	0.4141	0.0712	0.2346	0.5571	0.0843

^{a,b,c,d} Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC-Palm Kernel Cake, AST- Aspartate Aminotramsferase, ALT- Alanine Aminotransferase, SEM-Standard Error Mean

4.47 Interaction effects of palm kernel cake and enzyme supplementation on the serum chemistry of broiler chickens.

The interactive effect of PKC and enzyme on the serum chemistry of the experimental birds is presented in Table 61, this result shows different ($P<0.05$) values across board for both enzyme supplemented and unsupplemented diets fed birds for all parameters, except Creatinine. Total Serum Protein was highest ($P<0.05$) and similar ($P>0.05$) at D1 (4.56 mg/dL), D2 (4.53mg/dL) D4 (4.50 mg/dL) and D6 (4.50mg/dL). The results for birds on enzyme supplemented diets were lower than for their counterpart without enzyme addition. Albumin values, however, had a different trend with the highest ($P<0.05$) value observed when birds fed on the enzyme unsupplemented diets. Serum uric acid was highest ($P<0.05$) at D6 (3.60mg/dL) and lowest ($P<0.05$) at D10 (2.73mg/dL), the values does not however, follow a definite pattern. Highest ($P<0.05$) value for glucose was found for birds on D9 (134.68mg/dL) and lowest ($P<0.05$) at D5 (111.66mg/dL) but overall result shows higher ($P<0.05$) values for enzyme supplemented diets fed birds. Liver enzymes were found to be highest ($P<0.05$) at D6 with 64.67U/L and 36.33U/L for AST and ALT respectively. Globulin parameter had similar ($P>0.05$) values at D1 (2.00g/dL), D4 (2.01g/dL), D6 (2.07g/dL) and D7 (2.03g/dL) and the lowest ($P<0.05$) value of 1.73g/dL was observed at D10. The ratio of Albumin to Globulin was close, but significantly lowest ($P<0.05$) at D5 (0.98), and followed the same trend for AST: ALT with D5 having the lowest ($P<0.05$) value of 0.41.

Table 61: Interaction effect of PKC and enzyme on serum chemistry of broiler chickens

Diet No	PKC	Enzyme supplementation	Proteins (g/dl)	Albumin (g/dl)	Uric Acid (mg/dl)	Creatinine (mg/dl)	Glucose (mg/dl)	AST (µ/L)	ALT (µ/L)	Globulin (g/dl)	A:G	AST:ALT
D1	0	0	4.56^{a}	2.57^{a}	3.40^{ab}	1.40	126.00^{cde}	62.67^{ab}	33.33^{ab}	2.00^{a}	1.28^{a}	0.53^{ab}
D2	25	0	4.53^{a}	2.57^{a}	2.88^{cd}	1.27	123.00^{de}	61.20^{ab}	28.67^{c}	1.97^{ab}	1.30^{a}	0.47^{bc}
D3	50	0	4.32^{ab}	2.49^{a}	2.82^{d}	1.27	125.00^{de}	60.58^{ab}	30.00^{bc}	1.90^{ab}	1.27^{a}	0.49^{abc}
D4	75	0	4.50^{a}	2.42^{ab}	2.97^{cd}	1.07	121.33^{e}	60.34^{ab}	32.00^{bc}	2.01^{a}	1.23^{ab}	0.53^{ab}
D5	100	0	3.86^{c}	1.93^{c}	3.33^{ab}	1.01	111.66^{f}	59.85^{b}	24.33^{d}	1.93^{ab}	0.98^{b}	0.41^{c}
D6	0	0.5	4.50^{a}	2.43^{ab}	3.60^{a}	1.10	133.35^{ab}	64.67^{a}	36.33^{a}	2.07^{a}	1.18^{ab}	0.56^{a}
D7	25	0.5	4.33^{ab}	2.30^{abc}	3.17^{bc}	1.17	129.68^{abcd}	60.67^{ab}	32.00^{bc}	2.03^{a}	1.13^{ab}	0.53^{ab}
D8	50	0.5	4.14^{abc}	2.26^{abc}	2.87^{cd}	1.00	132.00^{abc}	61.66^{ab}	31.67^{bc}	1.88^{ab}	1.20^{ab}	0.51^{ab}
D9	75	0.5	3.93^{bc}	2.27^{bc}	2.95^{cd}	1.13	134.68^{a}	59.65^{b}	31.00^{bc}	1.83^{ab}	1.14^{ab}	0.52^{ab}
D10	100	0.5	4.00^{bc}	2.10^{abc}	2.73^{d}	1.00	126.67^{cde}	61.00^{ab}	28.33^{cd}	1.73^{b}	1.31^{a}	0.46^{bc}
SEM			0.967	0.075	0.062	0.080	1.354	0.949	0.856	0.047	0.047	0.018
P-VALUE												
PKC			0.0005	0.0126	0.0001	0.0978	0.0473	0.0056	0.0001	0.0138	0.7979	0.0003
ENZYME			0.1019	0.1458	0.8516	0.0551	0.0001	0.4141	0.0712	0.2346	0.5571	0.0843
PKCE			0.0001	0.0001	0.0001	0.0257	0.0001	0.04446	0.0001	0.0020	0.0040	0.0003

^{a,b,c,d,e,f} Mean values having different superscripts were significantly (P<0.05) different within columns

AST- Aspartate Aminotramsferase, ALT- Alanine Aminotransferase, PKC-Palm Kernel Cake, SEM- Standard Error of the Mean,. D1- 0% PKC, D2- 25% PKC, D3- 50% PKC, D4- 75% PKC, D5- 100% PKC, D6- 0% PKCE, D7- 25% PKCE, D8-50% PKCE, D9- 75% PKCE, D10- 100%PKCE, PKCE- Interaction of Palm Kernel Cake and Enzyme

4.48 Main effect of palm kernel cake and enzyme supplementation on the nutrient digestibility of broiler chickens (0-21days).

The effect of PKC and enzyme on the nutrient digestibility of broiler chickens fed the experimental diets (Table 62). Crude Proetein (CP) was highest ($P<0.05$) for the control diet fed birds with a value of 72.51% and lowest ($P<0.05$) with a value of 62.87% for birds on 100% inclusion of PKC in their diet. A similar trend of significance ($P>0.05$) was observed for the ether extract (EE), Crude Fibre (CF) and Ash parameters with highest ($P<0.05$) values of 75.47%, 83.33% and 82.04% respectively found for the control diet fed birds. Addition of the multi-carbohydrase showed ($P<0.05$) values only for CP and EE with the higher ($P<0.05$) values of 68.97% and 71.23% respectively found for birds on the enzyme supplemented diets.

Table 62: Effect of PKC on the nutrient digestibility of broiler chickens (0-21 days)

Diet No	PKC	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	Ash (%)
1	0	72.51[a]	75.47[a]	83.33[a]	82.04[a]
2	25	69.77[ab]	72.35[b]	79.71[b]	78.50[b]
3	50	67.66[bc]	69.73[bc]	77.08[bc]	76.74[c]
4	75	65.08[cd]	67.24[c]	74.82[cd]	75.75[c]
5	100	62.87[d]	64.14[d]	72.34[d]	74.01[d]
SEM		0.664	0.725	0.736	0.367
P-Value		0.0001	0.0001	0.0001	0.0001
	Added Enzyme				
	Without (-)	66.18[b]	68.25[b]	75.97	77.37
	With (+)	68.97[a]	71.32[a]	78.95	77.45
SEM		1.395	1.535	1.490	0.040
P-Value		0.0398	0.0499	0.0516	0.9361

[a,b,c,d] Mean values having different superscripts were significantly (P<0.05) different within columns
PKC- Palm Kernel Cake, SEM- Standard Error of Mean

4.49 Interaction effects of palm kernel cake and enzyme supplementation on the nutrient digestibility of broiler chickens (0-21days).

The interaction effect of PKC and multi-enzyme on the nutrient digestibility of the experimental birds in the starter phase (0-21 days) is presented in Table 63, where CP was highest ($P<0.05$) for birds on D6 (73.91%) and lowest ($P<0.05$) for birds on D5 (61.50%), this trend was similar to what was observed for EE which had the highest ($P<0.05$) value of 76.85% at D6 and the lowest ($P<0.05$) value of 63.10% at D5 and also similar for CF parameter. However, Ash was highest ($P<0.05$) at D1 and D7 (82.04% and 82.05% respectively) and lowest ($P<0.05$) at D5 (73.19%). Birds on enzyme supplemented diets had better utilization of the nutrients than their counterparts without enzyme.

Table 63: Interaction effect of PKC and enzyme on the nutrient digestibility of broiler chickens (0-21 days).

Diet No	PKC	Enzyme supplementation	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	Ash (%)
D1	0	0	71.10^{b}	74.09^{b}	82.61^{ab}	82.04^{a}
D2	25	0	68.04^{c}	70.49^{c}	78.09^{cd}	79.43^{b}
D3	50	0	66.35^{d}	67.89^{d}	75.99^{ef}	76.95^{cd}
D4	75	0	63.90^{e}	65.67^{e}	73.07^{g}	75.21^{de}
D5	100	0	61.50^{f}	63.10^{f}	70.07^{h}	73.19^{f}
D6	0	0.5	73.91^{a}	76.85^{a}	84.05^{a}	63.20^{b}
D7	25	0.5	71.51^{b}	74.21^{b}	81.32^{b}	82.05^{a}
D8	50	0.5	68.97^{c}	71.56^{c}	78.17^{c}	77.57^{bc}
D9	75	0.5	66.25^{d}	68.80^{d}	76.58^{de}	76.52^{cde}
D10	100	0.5	64.24^{e}	65.18^{e}	74.61^{fg}	74.84^{ef}
SEM			0.330	0.299	0.313	0.387
P-VALUE						
PKC			0.0001	0.0001	0.0001	0.0001
ENZYME			0.0398	0.0499	0.0516	0.9361
PKCE			0.0001	0.0001	0.0001	0.0001

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^{a,b,c,d,e,f,g,h} Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC- Palm Kernel Cake, SEM- Standard Error of Mean D1- 0% PKC, D2- 25% PKC, D3- 50% PKC, D4- 75% PKC, D5- 100% PKC, D6- 0% PKCE, D7- 25% PKCE, D8-50% PKCE, D9- 75% PKCE, D10- 100%PKCE, PKCE- Interaction of Palm Kernel Cake and Enzyme

4.50 Main effects of palm kernel cake and enzyme supplementation on the nutrient digestibility of broiler chickens (22-42days).

The result showing the effect of PKC and enzyme on the nutrient digestibility of broiler chickens between 22-42days is presented in table 64, where all parameters were significantly ($P<0.05$) influenced. CP had similar ($P>0.05$) values for all the treatments, except at 100% inclusion of PKC, which was ($P<0.05$) lowest with a value of 71.09%. Ether extract values had a different trend with the highest ($P<0.05$) value of 77.00 % observed at 0% inclusion level of PKC and the lowest ($P<0.05$) value of 70.87 % at 100% PKC inclusion, Crude Fibre also had a different trend, where the highest ($P<0.05$) fibre available for utilization was found in birds on 100% PKC (84.29%) and the lowest at 0% (75.32%). Ash values were also significantly ($P<0.05$) influenced by the inclusion of PKC such that ash values decreased ($P<0.05$) with an increasing level of PKC. Enzyme addition influenced ($P<0.05$) CP, EE and CF parameters. Values of CP and EE were higher ($P<0.05$) for enzyme supplemented diet fed birds, but CF had higher ($P<0.05$) values for the birds on diet without enzyme supplementation.

Table 64: Effect of PKC on the nutrient digestibility of broiler chickens (22-42 days)

Diet No	PKC	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	Ash (%)
1	0	74.82[a]	77.00[a]	75.32[c]	87.13[a]
2	25	74.78[a]	74.31[b]	79.31[bc]	84.89[b]
3	50	74.34[a]	73.03[bc]	81.06[ab]	83.58[b]
4	75	73.32[a]	72.05[bc]	82.92[ab]	81.68[c]
5	100	71.09[b]	70.87[c]	84.29[a]	80.63[c]
SEM		0.363	0.311	0.267	0.208
P-Value		0.0521	0.0001	0.0001	0.0001
	Added Enzyme				
	Without (-)	70.19[b]	72.42[b]	83.00[a]	84.22
	With (+)	77.15[a]	74.49[a]	78.16[b]	82.94
SEM		3.486	1.035	2.420	0.640
P-Value		0.0001	0.0197	0.0005	0.1666

[a,b,c] Mean values having different superscripts were significantly (P<0.05) different within columns

PKC- Palm Kernel Cake, SEM- Standard Error of Mean

4.51 Interaction effects of palm kernel cake and enzyme supplementation on the nutrient digestibility of broiler chickens (22-42days).

The interaction effect of PKC and enzyme on the nutrient digestibility of experimental birds (Table 65), showed that all parameters were significantly ($P<0.05$) influenced by the treatment diets. The highest ($P<0.05$) value for CP was found for birds on D8(78.45 %), while the lowest ($P<0.05$) was found for birds on D5 (66.38%). Ether extract value was highest ($P<0.05$) at D6 (77.81%), and had no specific trend for the rest of the treatments. CF and Ash values were also significantly influenced by the addition of PKC with their highest ($P<0.05$) values of 86.50% and 87.50% found at D5 and D1 respectively also, their difference ($P<0.05$) did not follow any definite pattern.

Table 65: Interaction effect of PKC and enzyme on the nutrient digestibility of broiler chickens (22-42days)

Diet No	PKC	Enzyme supplementation	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	Ash (%)
D1	0	0	73.91^{cd}	76.19^{ab}	76.75^{ef}	87.50^{a}
D2	25	0	71.95^{de}	73.02^{cd}	82.56^{c}	85.55^{bc}
D3	50	0	70.22^{ef}	71.53^{de}	83.89^{bc}	85.01^{c}
D4	75	0	68.49^{fg}	71.51^{de}	85.31^{ab}	82.23^{d}
D5	100	0	66.38^{g}	69.82^{e}	86.50^{a}	80.81^{de}
D6	0	0.5	75.73^{bc}	77.81^{a}	73.90^{g}	86.76^{ab}
D7	25	0.5	77.62^{ab}	75.60^{b}	76.07^{f}	84.22^{c}
D8	50	0.5	78.45^{a}	74.53^{bc}	78.24^{e}	82.14^{d}
D9	75	0.5	78.16^{ab}	72.60^{cd}	80.53^{d}	81.12^{de}
D10	100	0.5	75.80^{bc}	71.92^{de}	82.07^{cd}	80.46^{e}
SEM			0.514	0.440	0.378	0.294
P-VALUE						
PKC			0.0521	0.0001	0.0001	0.0001
ENZYME			0.0001	0.0197	0.0005	0.1666
PKCE			0.0001	0.0001	0.0001	0.0001

^{a,b,c,d,e,f,g} Mean values having different superscripts were significantly ($P<0.05$) different within columns

PKC- Palm Kernel Cake, SEM- Standard Error of Mean D1- 0% PKC, D2- 25% PKC, D3- 50% PKC, D4- 75% PKC, D5- 100% PKC, D6- 0% PKCE, D7- 25% PKCE, D8-50% PKCE, D9- 75% PKCE, D10- 100%PKCE, PKCE- Interaction of Palm Kernel Cake and Enzyme

CHAPTER FIVE

5.0 DISCUSSION

The nutritional evaluation of PKC has been reported (Nwokolo *et* a*l*., 1976, Hutagalung *et* a*l*., 1982, Yeong 1983 and Iluyemi *et* a*l*., 2006) and the documented research reports had varying chemical composition, which could be attributed to the source and also to the extent and method of oil removal (Rhule, 1996: Carvalho *et al*., 2005). Wide variability in the concentrations of Calcium and ether extract, were observed in this trial, and this is in agreement with the findings of Boateng *et al*. (2013) who reported higher ether extract values for expeller samples. Moisture content had low variability among the data analysed and this could be due to proper elimination of moisture from the samples before analysis was done. The chemical composition of SBM is also majorly influenced by heat treatment which is done before they can be fed to livestock (ASA, 1997) and this is because of the presence of several Anti-Nutritional Factors (ANFs) in variable amounts in the raw soybean grain which are heat labile (trypsin inhibitors, lectins, goitrogens, phytates) and heat stable (oligosaccharides) (Feng *et al*., 2007; Gharaghani *et al* ., 2008; Soetan and Oyewole 2009). These thermal processing of soybean has been acknowledged to be very successful in enhancing the nutritional value of SBM and in reducing these ANFs. However, these processes were affected by varied reports on the influence of temperature-time combinations on the ANFs and amino acid profile of the feedstuffs (Ari *et al*., 2012). These factors affected the results obtained in this study. In descending order of variability, from the most variable Calcium to crude fibre and ether extract. The low variability observed for CP indicates that the processing methods applied to remove the ANFs has not affected the CP content of the feedstuffs. The amino acid profile of the feedstuffs showed high variability for methionine and cystine for SBM and serine, glutamic acid and

proline for PKC. This wide variability compared with other amino acids is possibly because these particular amino acids are more affected by factors (or combination of factors) causing varaibilty in the chemical composition of PKC (Adebiyi, 2014). The variation in the amino acid profile of PKC was higher than for SBM and this could be due to various research conductied, which eliminated dearth of information on the methods of efficiently processing SBM to maintain good quality amino acid profile while eliminating the ANFs. Apart from the correlation between DM - EE, DM - ash and DM - calcium that were positively correlated, negative correlations that existed between DM - CP, DM - CF, DM - NFE and DM - phosphorus may be due to different analytical tools used and wider variation in chemical content. The negative correlation between Arginine- tryptophan and glutamic acid- tryptophan for PKC is possibly because most of these amino acids are affected by factors that cause variability in nutrient composition. SBM showed positive correlations among amino acid content except for alanine-histidine, arginine- histidine, arginine-methionine, aspartic acid-histidine, glycine-histidine, glutamic acid-histidine, glutamic acid- methionine and all histidine relationships (which indicates a resultant increase in one as a result of the other). However, histidine-methionine, isoleucine-tryptophan, leucine-methionine, methionine-tryptophan and methionine-valine which are negatively correlated indicated that an increase in one causes a reduction in the other, and humidity during drying of the feedstuffs before analysis is another factor that interferes with protein determination (and eventually amino acid profile). This is because excessive exposure to sunlight may enhance denaturation of protein. Also, the formation of insoluble lysine-carbohydrate moieties and partial destruction of cystine in oil seeds, animal protein meals and plant-based feedstuffs due to excessive heat treatment has been reported (Cromwell et al., 1993 and Cozannet et al., 2010).

The result obtained for the first experiment where broiler chickens were fed PKC based diets at 0, 7.5 and 15% with enzyme addition between 0-21days showed that the inclusion of PKC in the diets did not affect all the parameters analyzed for excluding feed cost. This result is in contrast with the findings of Ojewola and Ozuo (2006) who recorded better feed intake, daily weight gain and total weight gain when the PKC was substituted for SBM and fed to cockerels. The observed disparity in the result may be as a result of the different strain of birds used for the two experiments. However, the use of enzyme showed that all parameters observed (excluding initial weight) was affected with the final weight, weight gain and daily weight gain parameters having the best result when enzyme was administered to the diets of the experimental birds. This observed improvement may be attributed to the type of enzyme used. The functionality of PKC, a gritty feedstuff, which is highly fibrous could have been made utilizable by the multi-carbohydrate enzyme. The experimental birds also had lower and better feed intake and feed conversion ratio values for the birds with enzyme added to their diets, causing reduced feed intake and better conversion rate. This is buttressed by the result of Parakkasi (1983) and Tulung (1987) which stated that a high crude fibre ration can reduce the digestibility components and also that enzyme activities assist carbohydrate, protein and fat digestion, and such may have been the case with the diets not treated with enzyme. Feed cost was highest for birds on the control diet and this could be attributed to the high level of SBM in the diet of the experimental birds as compared with the other treatments. Enzyme addition also caused an increase in the price of feed, but the resultant cost per weight gained (CPWG) was reduced for birds on enzyme supplemented diets and this could have been as a result of the increased availability of nutrients for use by the animals.

The result for the interaction of PKC and enzyme shows that all the evaluated parameters affected birds fed both the enzyme supplemented and unsupplemented diets. However, birds fed diets with enzyme supplementation had higher values across board. The increased weight gain of birds on diets with enzyme supplementation may have been as a result of the better degradation of the nutrients composed in the feed by the enzyme releasing them to be more available for utilization in the area of growth accumulation as against the untreated diets. This better utilization was observed also with a resultant lower feed conversion ratio of the enzyme supplemented diets fed birds. This resulted in a reduction of the feed consumed by the birds. This may be due to the ability of the birds to meet their daily nutritional need with the available nutrient they ingested. An overall higher feed cost for birds on enzyme supplementation was observed but there was a reduction in the CPWG of those birds on the enzyme unsupplemented diets for both starter and finisher phases (0-21 days and 22-42 days respectively).

At the second phase (22-42days) of the experiment which, the initial weight was similar for birds on 0% and 15% PKC but it did not affect the final weight and weight gain parameters. This decrease in final weight as the value of PKC in the diet increased could be as a result of the highly fibrous nature of the experimental diet and this result is corroborated by the findings of McDonald *et al.,* (1995), who observed that lower weights of birds fed diets containing PKC could be attributed to the high content of fibre in the diet, this affected the weight gain and daily weight gain. Feed intake increased but it was not converted to meat as revealed by the FCR which was lowest ($P<0.05$) for birds on the control diet. The use of enzyme showed that birds on diets with enzyme supplementation had higher values for all parameters observed, (final weight, weight gain, daily weight

gain) and lower feed intake and FCR. This may be as a result of the multicarbohydrate enzyme used for this experiment. This result disagrees with the findings of Iji *et al.* (2003) and Pinheiro *et al.* (2004) who did not find any difference in the performance of chickens fed cellulose, protease and amylase supplemented diets and disagrees with the findings of Nikam *et al.* (2016) who stated that the use of NSPHE (Non Starch Polysaccharide Hydrolysing Enzyme) on PKC showed no significant difference in body weight at both starter and finisher phases even at 1X and 2X higher concentration. Abbas *et al.* (1998) found out that NSP enzyme supplemented fibrous diets improved growth rate of broilers. The interaction of PKC and enzyme for 22-42 days showed an overall better output for birds on enzyme supplemented diets. Final weight was highest for birds on the control diet with enzyme supplementation and could have been as a result of the absence of the test ingredient (PKC) with the influence of the multicarbohydrase resulting in the better utilization of the other feed ingredients used to compose the diet (Ezeishi and Olomu, 2004), where birds on control diet had the highest body weight gain. Improved weight gain observed in this experiment also buttressed the findings of Zanella *et al.* (1999), who investigated the effect of a commercial enzyme cocktail containing xylanase, protease and amylase on performance of broilers fed corn-soybean based diets and found that enzyme supplementation improved body weight gain. However, FCR values obtained by birds fed diets with enzyme supplementation also justifies the findings of Saleh *et al.*, (2003) that reported lower FCR in enzyme improved diet fed birds. A reduction in the cost of feed as PKC level increased was observed, although this was complemented with a corresponding increase in the CPWG with increasing PKC level and no reason could be attributed to this observation. Effect of enzyme was similar to what was observed at the 0-21 days, with an

increase in cost of enzyme supplemented diets and a decrease in their CPWG, this could be due to the use of enzyme.

Gabriel *et al.* (2003) has stated that the fibrous nature of dietary ingredients fed to poultry birds causes a modification of the upper and lower parts of the gastrointestinal tract (GIT). The increased villus height (VH) for the ileum and jejunum by the use of PKC may be an indication of the active workings of these segments of the small intestine on the utilization of the feed material as those on 7.5% had higher values for VH of ileum, duodenum and jejunum. The observed decrease in the VH of the birds on 15% inclusion may be justified by the findings of Moharrery and Mohammadpour (2005) and Kalmendal *et al.* (2011) who observed that the presence of high levels of fibre in poultry ration may lead to a decrease in the surface, width and height of the intestinal villi. Higher apical width at 7.5% and 15% PKC inclusion levels in the jejunum could be as a result of the increased activity of the jejunum in digestive function as the level of PKC increased. The increase in the base of the villus for duodenum and Lamina Propria Depth (LPD) which was influenced for all the segments of the small intestine and higher at 7.5% indicates that birds on this inclusion level in their diet had a wider space between each villus and indicated better nutrient absorption. However, the increase in the ratio of VH to LPD (VLR) was higher for ileum and duodenum at 7.5% and 15% PKC inclusion levels and thus supports the findings of Wageha *et al.* (2008) who discovered an increase when birds were fed with symbiotic supplemented diets. The intestinal mucosa architecture can reveal useful information on the function of the intestine, and with a combined effect on enzyme use, greater depth of its functions will be experienced, where VH was higher for birds on diets without enzyme supplementation for jejunum. This contradicts the findings of

Chichowski *et al*. (2007) who stated that addition of probiotics to broiler diets increased jejuna VH and Samli *et al*. (2007) ileal VH (though not significantly for ileum in this study). The interaction result shows that the ileum had higher result for all the parameters when birds were fed 7.5% PKC, this indicates a better absorption of the nutrients entrapped in the diet by the effect of the enzyme and this support the findings of Moeser *et al*. (2002) and Van Kempen *et al*. (2006) that NSP in corn and soybean meal negatively influenced nutrient digestibility and hence absorption as seen for the control diet fed birds. All parameters were influenced for duodenum but 15% PKCE had the highest values for VH, BW and VLR showing a better output of digestibility and increased absorption of nutrients, as enzyme causes a release of nutrients trapped in the cell wall (Adeola and Cowieson 2011). Jejunum also had a similar trend of significance but at 7.5% inclusion level. The increase in jejunum length could be because it worked more on processing the diet fed and enzyme was not able to influence it, this result is in agreement with the work done by Fafiolu *et al*. (2015) who found no effect in weight of GIT measured when birds were fed Palm Kernel Extraction By-Products. Blood serum metabolites and haematological parameters have often been associated with health indices and are of diagnostic significance in routine clinical evaluation of the state of health (Toghyani *et* al., 2010). Total proteins and Albumin results indicated better utilization of the protein in the diet (Fafiolu *et al*., 2013) by birds on the 0 % and 15 % PKC inclusion diets. An increased value of 119.02µ/L for Aspartate aminotransferase (AST) one of the liver enzymes could be an indication of liver diseases or incidence of salmonellosis during the experiment conducted by Fafiolu *et al*. (2013), and which was not the case in this present study. All the liver enzymes examined had decreased values for birds on diets with enzyme supplementation, which indicates that enzyme fed birds had reduced possibility of liver

infections and diseases. The interaction effect shows higher protein and albumin values across treatments for birds on enzyme supplemented diets (D4-D6), although all diets had values indicating better protein utilization. Serum uric acid of the experimental birds on 15% PKC increased with enzyme supplementation (D6), indicating that protein was not efficiently utilized by them and this supports the statement that serum uric acid is a function of protein quality fed to the animals, high levels indicates low protein efficiency utilization (Fafiolu, 2007). Creatinine which is a chemical waste molecule generated from muscle metabolism and which the kidney helps to maintain in a normal range (Utim *et al*., 2011) was highest at 15% PKC without enzyme supplementation (D3) indicating muscle wastage, but the lower values observed for birds on D5 indicated proper elimination of the waste products.

According to Saad (2010), any abnormality in the variation of haematological parameters are said to impair the primary physiological functions of the body. Packed Cell Volume (PCV), Haemoglobin (HB), Red Blood Cells (RBC) and Eosinophils (a differential of White Blood Cells) were all higher at 7.5% PKC inclusion level and were not within the normal range as indicated by Jain (1993) with PCV, HB and RBC. However, the birds had lower neutrophil, an indication that the immune status of the birds is low and incapable of performing their phagocytic functions. This may be due to stress caused by prevailing environmental factors. Only White Blood Cells (WBC) were higher for birds on enzyme supplemented diets, indicating an infection on the birds. Neutrophil which was lower and lymphocytes which had higher values were above the normal range of 20-40% reported by Heath and Olusanya (1985). Interaction of PKC and enzyme on heamatological indices showed highest value for WBC at 7.5% PKC with enzyme supplementation (D5). The

varying values obtained for other parameters are buttressed by the submission of Jain (1993) and Talebi *et al*. (2005) which stated that blood profile varied among breeds, ages, diets and clinical conditions of broiler chickens where diet is a factor of major concern. For carcass characteristics in this experiment, only drumstick was influenced by the use of PKC and this may be as a result of the quantity of PKC added to the experimental diet on a weight for weight basis, causing insignificant differences among the treatments. However, the carcass percentage or eviscerated weight of broiler chickens falls within the range (65-75%) published by Siregar (2001). The interaction result infers that the use of minute amount of PKC in this experiment did not affect live weight of the birds, and this contradicts the findings of Onwudike (1986), who discovered an increase in gizzard size and attributed it to the gritty nature of the feedstuff.

The nutrient digestibility of the experimental diets fed to the broiler chickens at 0-21 days revealed that the values for Crude Protein (CP), Ether Extract (EE), Fibre and Ash were affected by the inclusion of PKC, this is in contrast with the findings of Aya *et al*. (2013) who reported that the inclusion of 10% PKC in broiler starter diet led to a decrease in nutrient digestibility, while in this present study, the digestibility of birds on 15% PKC was higher for CP and EE values. The ash values evaluated was higher for birds on 7.5% PKC inclusion while fibre was better utilized by the birds on both 0% and 7.5% inclusion, and lowest when birds were fed 15% PKC based diet. The reduction in this nutrient digestibility could be attributed to the presence of high levels of Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), Insoluble fibres and NSPs in PKC as illustrated by Sulabo *et al*. (2013) and Son *et al*. (2014). The interactive use of PKC and enzyme however showed that fibre digestibility was highest for birds on D4, which may be

attributed to the presence of enzyme breaking down the high fibre component of the diet even without PKC inclusion. Ether extract and Ash results did not follow any particular trend of influence. Nutrient digestibility analysis carried out at the 42nd day of the experiment showed that CP, EE and Ash values were higher for birds fed the control diet than other levels of PKC inclusion, showing that much nutrient is available, and this supports of the findings of Degen *et al*. (2007) and Sulabo *et al*. (2013) which stated that the adverse effects of soluble fibres (NSPs), a major component of PKC is greater than the insoluble fibres in terms of nutrient digestibility. Fibre digestibility which was higher for birds on enzyme supplemented diets is in agreement with Brenes *et al*. (2002) who mentioned that diets supplemented with enzyme (0.1% Novozyme®) led to improved nutrient digestibility. In the second experiment, the result of the performance of broiler chickens fed the five levels of PKC inclusion (0, 25.50,75 and 100%) showed higher final weight and weight gain for birds on the control diet, than the other levels, and this can be attributed to the highly fibrous nature of the diet that increases the passage rate of digesta and may decrease nutrient absorption by the birds (Alshelmani *et al.,* 2016). The reduction in feed intake may be because of higher energy value of PKC based diets (Fafiolu *et al*., 2015) as birds generally eat to satisfy energy requirement and will reduce intake drastically as soon as this is satisfied (Ngi,1999). Although Sundu *et al*., (2005) stated that the bulk density and water holding capacity of PKC is 0.11g/cc higher than copral meal, and these two factors which are important affect feed intake (Kyriazakis and Emmans, 1995). According to Onwudike (1986), Ezieshi and Olomu (2004) and Sundu *et al*. (2005), feed intake of birds fed PKC diets is usually higher than for maize based diets, but the trend observed in this study was quite different, with the highest value for feed intake observed for the birds on the control diet, and they had the lowest and best FCR.

The influence of enzyme addition to PKC on final weight supported by the findings of Sundu *et al*. (2005) stated that body weight of birds fed 30% PKC increased (Panigrahi and Powell, 1991), and that inclusion of PKC up to 50% in diet was tolerated. The resultant effect was similar for weight gain and daily weight gain. Feed intake, however, followed no definite pattern. Ezieshi and Olomu, (2004) noted that feed intake slightly increased when 50% of maize was replaced with PKC or wheat offal. The addition of Non-Starch Polysaccharide (NSP) hydrolyzing enzyme seems to cause a little change in birds fed diets containing 75 and 100% PKC replacement for SBM. This support the result of Saleh *et al.* (2003), Song *et al*., (2010) and Mohammad *et al*. (2010) that FCR was improved with enzyme supplementation in the diets of broiler chickens. Cost of feed decreased with increasing level of PKC and this could be attributed to the cost of PKC which is lower than the cost of soybean being replaced. However, the lowest CPWG was observed at 50% inclusion of PKC, and this could be as a result of better digestibility and utilization of PKC supplemented in the diet at this level compared to the other levels, and this was similar to the trend observed for the 22-42 days phase of the experiment. The weight gain of birds on PKC based diets between 22-42days reduced as the level of PKC increased. This reduction in the weight may be as a result of the increased fibre content of the diet as PKC level increases, thereby causing the birds to utilize a reduced quantity of the nutrients in the diet leading to lower meat accretion. Reduced feed intake for birds on diet containing 100% PKC could be attributed to the gritty nature of the feed ingredient and the high level of supplementation for birds on this treatment, but the FCR of birds on the 0% PKC with enzyme supplementation was the lowest and this supports the findings of Aftab *et al*. (2006) who attributed reduction of FCR when palm kernel by products are being fed to broiler chickens to the higher protein of the diets since protein functions in

the accretion of meat by broilers. Birds on PKC diets supplemented with enzyme had higher final weight, weight gain and daily weight gain parameters than their counterpart without enzyme supplementation. This is supported by the result of Raghavan (1990) that inclusion of dietary enzymes in broiler diets increased weight gain, feed efficiency and reduced sticky droppings. Luz (2002) also stated that use of mannan degrading enzymes can support maximum growth of broilers. Feed intake values were lower only for birds on diets supplemented with enzyme, indicating that the use of enzyme resulted in a reduction in the feed consumed by the birds at those levels. Meanwhile, Sundu *et al*. (2005) stated that feed was efficiently utilized when mannan degrading enzyme was added to a 40% PKC formulated diet. The FCR reduced in enzyme fed birds as against the unsupplemented diet fed birds and this supports the findings of Narasimha *et al*. (2013a and 2013b) that FCR improved with the addition of NSP enzyme alone or in combination with probiotics. Narasimha *et al*., (2013b) also reported that supplemeting sub-optimal energy diets with NSP hydrolyzing enzyme with symbiotics and phytase improved FCR. The reduction in FCR however disagrees with the findings of Naqui and Nadeem (2004) where enzyme supplemented diets resulted in poor FCR but the level of inclusion was not considered. CPWG did not follow any specific pattern but was lowest at D10 and prevailing market prices of the feed ingredients may be a contributing factor to these observations. Inclusion of PKC in this experiment affected the villus height (VH) of the bird's jejunum, and was highest at 25% inclusion level and lowest at the control. This shows that the activity of the villi increased with the presence of the test ingredient used in this experiment and is supported by the findings of Caspary, (1992) that increase in the VH suggested an increased surface area capable of greater absorption of available nutrients. Apical width (AW) which was significantly influenced in the duodenum and

jejunum showed a fluctuating trend with PKC levels and no deducible reason could be given for this observation. Wenk (2001) and Chen *et al*. (2014) reported that long-term feeding of high rations of dietary fibre could alter the physiological and anatomical characteristics of the GIT of pigs. Basal Width (BW) which describes how wide the base of the villus is shows high absorptive capacity as this parameter was found to be significant in the jejunum especially, for control diet fed birds. Lamina Propria Depth (LPD) and ratio of Villus height to LPD (VLR) were significant only for duodenum showing the depth of the crypts between villi and the relationship between the heights the villi and crypt depth, this supports the findings of Wageha *et al*. (2008) who discovered an increase for birds fed with symbiotic supplemented diet. Enzyme effect was only noticed on VH of the ileum, AW of duodenum, BW of ileum and duodenum and VLR of ileum. In all, values were higher for enzyme fed birds than for others. This shows better utilization of the feed at those parts of the gastro intestinal tract when enzyme supplemented diets were fed to the birds. Higher villus height for birds on enzyme supplemented diets in this study supports the result of Samli *et al*. (2007) that addition of probiotics to broiler diets increased ileal villus height, this increase was also noticed for the interaction result of PKC and enzyme. The increased VH also supported the findings of Pulske *et al*. (1996), where increased intestinal VH was reported after addition of *Bacilus subtillis* in association with prebiotics. BW and VLR that were also significantly affected for the interaction in the ileum were higher for enzyme fed birds than the other group and this support the result of the first experiment where PKC was fed at 0, 7.5 and 15 % on a weight for weight basis and with enzyme supplementation. Coarse fibre stimulates normal gizzard development and this improves functionality of the small intestine through better flow regulation and this possibly affects response to dietary

manipulations like use of enzyme, prebiotics or probiotics. The width of the villi (apical and basal) were highest at D10 promoting the effect of enzyme addition on the morphology of the intestine even at higher levels of PKC inclusion. LPD was highest at D4, showing that the depth of the space between the villi at 75% PKC without enzyme was achieved at 25% PKC inclusion with enzyme, giving a wider surface area for absorption between the villus or on the floor of the small intestine. The jejunal villus height was higher with enzyme supplementation and goes along with the result of Chichowski *et al*. (2007) that addition of probiotics containing enterococcus faecium micro-organisms to broiler diets increased the jejunum villus height, and according to Amat *et al*. (1996), it is assumed that increased VH is paralleled by an increased digestive and absorptive function of the intestine due to increased absorptive surface area, expression of brush border enzymes and nutrient transport systems. The base of the villus had varying values and was widest at the control diet without enzyme supplementation. Meanwhile the ratio of villus height to the depth of the crypt was greatly increased at D5 showing wide relationship between the height of the villus and the distance between each villi.

The viscosity of the digesta obtained from the ileum was influenced at the 50, 60 and 100 RPM with the highest values at 100% PKC and with values reducing as the level of PKC inclusion increased across board, this may be related to the increase in the level of NSPs with increasing levels of PKC and this goes along with the statement of Choct *et al.* (1998) that NSPs can bind large amounts of water and as a result, the viscosity of fluids in the digestive tract is increased. The effect of enzyme was only noticed at 50 and 100 RPM, with the lowest value observed for the enzyme supplemented diet fed birds. This

reduction observed relative to their counterpart may have resulted from a decrease in the NSP content of the diet by the multi-carbohydrate enzyme, which causes a reduction in the bounding of NSP to water and causing lower values for viscosity. The reduction in the viscosity by enzyme supplemented diet fed birds is in accordance with the findings of Hastings (1946) and Allen *et al*. (1995) who observed that enzyme addition to monogastric animal's feed reduced viscosity of ingesta in the intestine and showed a marked improvement on the various morphological effects of feeding fibrous materials to non-ruminant animals and also by Choct (2006) that exogenous enzyme degrade cell wall components such as soluble fibre. Also, inclusion of PKC with mannan enzyme was said to have caused a decrease in digesta viscosity of birds by 3-4% according to Sundu *et al*. (2005). This finding negates the result of Osofowora *et al*. (2013) that at 60RPM and 100RPM, there were no difference among the mean values for ileal digesta viscosity of broilers fed diets containing fungi-biodegraded and enzyme supplemented malted sorghum sprouts. This observed variation may have been as a result of the different test ingredients used for both experiments. Live weight increased for birds on enzyme supplemented diets and birds on 25% PKC inclusion (D7) had similar values for the control diet fed birds, indicating that the use of PKC up to this level would not adversely affect carcass yield. Packed cell volume (PCV) ranged between 24.25%-34.76% for the various inclusion levels of the test ingredients used in this experiment, and this falls within the normal range of 22-35% reported by Jain (1993) but lower than that of Mirtuka and Rawnsley (1997) who reported 25-45%. This range indicates a good health status of the blood cells via a good supply of Iron, Vitamin B12 and folic acid in the animal's body. The normal value of PCV obtained in this study indicates an increase in the availability of protein, energy and degradation of ANFs (Akinola and Etuk, 2015) which

according to Cary *et al*. (2002) improves broiler performance. Haemoglobin values were within the normal range of 7-13g/dL as reported by Jain (1993), Banjerjee (2009) and is in accordance with the findings of Madubike and Ekeyen (2006) (8.6-10.7g/dL) and Afolabi *et al*. (2010) and Nkwocha *et al*. (2014) (11.26-13.1g/dL), all showing that birds are healthy, this is supported by Adejumo (2004), who stated that heamatological traits, especially PCV and haemoglobin were correlated with the nutritional status of the animal. RBC was highest at the control and lowest for 100% PKC fed birds. This is similar to the range of 2.13-3.57($x10^{12/L}$) stated by Akinola and Etuk (2015), and Ikhimioya *et al*. (2000) who stated that their result implies that bone marrow of the birds were functioning normally. WBC and its differentials were not influenced by the use of PKC and this is in support of the result of Siegel (1995) that it indicates the birds were not stressed during the experiment by nutritional or environmental factors since WBC responses are considered as better indications of chronic stress. Enzyme effect was only affected for RBC and Neutrophil. However, neutrophil value was lower for both enzyme supplemented and unsupplemented diet fed birds and this could be an indication of lower immunity for the birds. RBC was within the range of 2.50-3.50 ($x10^{12/L}$) given by Jain (1993). The interaction effect showed higher values for PCV, HB, RBC and Neutrophil. According to Longe and Fagbenro (1990), Onifade, (1993) and Onifade, (1997), blood parameters have been reported to be lowered by high inclusion of fibrous ingredients which leads to inferior feed quality. PCV, HB and RBC were higher for birds on the control diet and reduced as the PKC level reduced for both supplemented and unsupplemented diet, but with higher values for enzyme supplemented diet fed birds. Ritchie *et al*. (1994) stated that percentages of PCV, RBC and mean value of haemoglobin concentration determine healthy conditions in chicken and thus indicating that birds on

enzyme supplemented diets were healthier. The non-significant effect on the white blood cell differentials is an indication that the percentages of blood volume taken up by the red blood cell were not altered. Although, the dietary treatments did not induce any significant effect on immune related parameters measured in this study, no deleterious impact was also detected as a result of enzyme addition to the diet on blood parameters. It has been reported however, that bacterial and viral diseases affect the number of white corpuscles and the percentages of the various types in healthy animal (Mohammad and Oloyede, 2009, Tewe and Egbunike, 1992, Post *et al*., 2007 and Wendy and Jean, 1992). The serum proteins evaluated in this study were useful indicators to the impairment in the functional capacity of the liver and kidney. Uric acid, which is a major nitrogen-containing metabolic product of protein catabolism was reduced and this indicates normal functioning of the urea cycle thus rulling out renal dysfunction which also indicates increase in serum uric acid content is attributable to impairment in the urea cycle (Yakubu *et al*., 2003). Variations observed for total protein (TP), Albumin and uric acid in this study aligns with Bolu *et al*. (2011) who observed similar result but disagrees with the same author as liver enzymes (AST and ALT) were found to be influenced. Interaction effect of PKC and enzyme showed variation in serum TP, Albumin, Globulin, uric acid, glucose albumin:globulin, the liver enzymes and AST:ALT. Elagib *et al*. (2012) found that sex, genetic differences, age differences, serum profile, environmental and physiological conditions also have significant effect on serum profile of chickens. Differences in AST are indications of pathological change and elevated level implies that the liver is not functioning properly and some liver cells may be damaged. The nutrient digestibility result at the starter phase for both main and interaction effect, showed a decrease in most of the parameters as the level of PKC inclusion increased and this is in

consonance with the findings of Parakkasi (1983) and Tulung (1987) which found out that a ration which is high in Crude Fibre can reduce the digestible components and also reduce the enzyme activities that assist Carbohydrate, protein and fat to be easily digested, however the use of enzyme indicated an increase in nutrient utilization for CP and EE compared to the other counterpart without enzyme supplementation and this goes in line with the findings of Sekoni *et al*. (2008) that enzyme treatment of PKM increased retention of vital nutrients and Metabolizable energy. At the second phase (22-42 days), the birds had values of CP, EE and Ash decreasing as the level of PKC increased, and this low nutrient retention of PKC diets can be attributed to CF levels of the ingredients (Ezieshi and Olomu, 2004). Enzyme effect was higher for enzyme supplemented diets for the CP and EE parameters, indicating that the better availability and utilization by the animals fed those diets. Interaction between PKC and enzyme showed that digestibility of the nutrients for the enzyme supplemented diets was higher for CP and EE and varied for CF and Ash, and this could be in line with the observation of Yaakugh *et al*. (1994) that the digestibility of a diet is inversely related to its fibre content.

5.1 Conclusions

- There were different levels of variations in the data collected as indicated by the co-efficient of variation, showing that Calcium variability is the highest among data collected for PKC and SBM.
- The amino acid content of the feed ingredients varies widely with Arginine taking the lead for PKC and Methionine for SBM.
- Better final weight was achieved when the diet of birds supplemented with PKC at 7.5% and 15% has enzyme included into it.
- Feed cost was higher for control diet fed birds and lower for birds on 15% inclusion of PKC giving a reduction in the cost of finishing the broilers,
- At the 22-42 days phase, birds on 15% PKC gave lower final weight, weight gain and feed cost and higher feed intake, FCR and CPWG
- Enzyme inclusion resulted in birds with better performance, but at the interaction level of PKC and enzyme, birds on enzyme included diets had overall better output but with a higher feed cost.
- Ileum and duodenum had higher villus height (VH) at 7.5%, but birds on 15% had a greater basal width (BW) for duodenum.
- Enzyme addition caused a reduction in LPD in the ileum, but the apex was wider in the duodenum for enzyme supplemented diet fed birds.
- For ileum and duodenum, the height of the villi was greater at these sites for birds on the unsupplemented diets.
- Only jejunum length was affected by the use of enzyme.

- The inclusion of PKC in the diet of the experimental birds affected Total Proteins (TP), Albumin and Aspartate Aminotransferase (AST), while enzyme addition only affected the liver enzymes with higher values for birds without supplementation.
- Serum chemistry of the birds had values in close range with each other and was within normal range reported.
- Heamatological indices of the birds also varied across the treatments, but the birds on 7.5% PKC inclusion had better values, however the increased value of WBC confirmed that the birds were challenged during the experiment.
- For carcass characteristics, only drumstick was affected by PKC inclusion, while head, shank and back were highest for diets without enzyme supplementation.
- Nutrient digestibility results showed better utilization of nutrient by birds on 15% PKC inclusion especially for CP and EE.
- Crude fibre was also well utilized at D4 (0% PKCE), but the mineral content was better used by birds on D2 and D5 for 0-21 days.
- At the 22-42 days phase, the control diet fed birds better utilized CP, EE and Ash while CF was highest at 7.5%.
- The result of experiment two where PKC was used at 0, 25, 50, 75 and 100% inclusion levels on a protein for protein basis indicated higher FW, WG and DWG for control fed birds. The poorest result was for birds on 100% inclusion of PKC, while birds at 25 % and 50 % had similar values.

- Enzyme supplemented diet was better for interactive effect at 0-21 days with control diet fed birds having the best values. 50% PKC diet fed birds without enzyme addition had the overall best result for FCR
- At the 22-42 days period, the feed cost was lowest for birds on 100% PKC but with a resultant increase in CPWG however, 25% inclusion had the best overall result at this phase for performance. The cummulative effect of PKC and enzyme showed that birds on D6 had the best result with the highest live weight and best FCR, and CPWG was best for birds on D10.
- For good gut performance in the ileum, the use of enzyme increased its efficiency, and the best result was observed at 50 % PKC inclusion with enzyme supplementation (D8), and jejunum also had a good result for birds on D8.
- The effect of PKC and enzyme on ileal digesta viscosity shows that control diet fed birds, had the best value of viscosity at 50RPM and 100RPM, and the interaction result shows better result for enzyme fed birds particularly at D7 (25 % PKCE).
- The microbiota of the gastro intestinal tract showed that *Coliform spp* was greatest for birds on 25 % PKC while the fungi *Saccharomyces spp* was highest at 100% inclusion.
- Carcass result showed that birds on control diet and at D2 (25 % PKC) had the highest live weight, but the overall best result was found for birds on D6.
- The heamatological parameters indicated a good state of health for birds on all treatments, with those on the control diet having the overall best result, especially for those with enzyme supplementation.

- The serum chemistry results also indicated that birds on 0 % and 25 % had good health status, for both enzyme supplemented and unsupplemented diets.
- The utilization of nutrients was higher for enzyme supplemented diet fed birds than for their unsupplemented counter-parts for CP and EE, birds on D6 had the best digestibility result for the 0-21 days period of the experiment, and a different trend was followed for 22-42 days with CP digestibility being highest at D8, EE at D6, CF at D5 and Ash at D1.
- Generally, it could be observed that the experiment carried out using PKC on a protein for protein basis yielded better results than when PKC was used on a weight for weight basis.

5.2 Reccommendations

Experiment One

- For optimum performance, PKC should be substituted at 15% inclusion level on a weight for weight basis at 0-21 days, and use of enzyme should be adopted for better output at the 22-42 days.
- Best result for gut morphology can be achieved when birds are fed 7.5% for ileum and jejunum, and the use of enzyme improved efficiency of the gastro intestinal tract for duodenum.
- Ileum and duodenum also supported the use of 7.5 % PKC with enzyme addition at D5 while jejunum was best at D6 (15% PKCE).
- For good health status using serum parameters, PKC should be used at 15 % but with the addition of enzyme output would be even better at that level, and for heamatological parameters, 7.5% PKC had best output.

- The best carcass output would be realized if PKC was not included in the diet at all, but it would be better with enzyme addition, and to achieve great digestibility, PKC should be included upto 15 % at the 0-21 days period, but at 7.5 % for the 22-42 days period.

Experiemt Two

- The performance of birds at this phase shows that PKC could be used up to 50 % to achieve good performance and even better with an inclusion of the multi-carbohydrase used in this experiment in the 0-21 days period,
- A similar recommendation could be given for the 22-42 days period as they showed similar trend of results.
- For gut morphology, the inclusion of PKC could be up to 75% but should be supplemented with enzyme to achieve maximum output for ileum, duodenum and jejunum.
- Enzyme addition is strongly recommended if reduced viscosity is the target of any experiment using PKC for better passage time that will enhance better nutrient utilization.
- In order to achieve good carcass yield, PKC inclusion must be less than 50% with or without enzyme addition.
- Heamatological and serum indices could be better when the multi-carbohydrase is added to the diet of birds containing PKC upto 50 %.
- Nutrients would be better utilized if birds are not fed beyond 25 % PKC with enzyme addition for both 0-21 and 22-42 days of trials.

- The replacement of PKC in the diet of broiler chickens should be on a protein for protein basis as it yields better output for the experimental birds and more efficiently with the use of multi-carbohydrate enzymes that could effectively make the trapped nutrients available for the animals.

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