UTILIZATION OF SOLID STATE FERMENTED PALM KERNEL CAKE AS SUBSTITUTE FOR SOYABEAN MEAL IN THE DIETS OF BROILER CHICKENS

BY

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B. AGRIC (ANIMAL SCIENCE) BENIN, 2010

DEPARTMENT OF ANIMAL SCIENCE
FACULTY OF AGRICULTURE
UNIVERSITY OF BENIN
BENIN CITY, NIGERIA

DECEMBER, 2022

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A THESIS WRITTEN IN THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, UNIVERSITY OF BENIN, BENIN CITY, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTERS OF ANIMAL SCIENCE (M.Sc.) IN ANIMAL SCIENCE

DECEMBER, 2022

CERTIFICATION

This is to certify that this Research work "Utilization of Solid State Fermented Palm Kernel Cake as substitute for Soya bean meal in the diets of Broiler chickens" was carried out by **Ebikeseye Joy KEGBE (Miss)** with Matriculation Number **PG/AGR0501472** of the Department of Animal Science, Faculty of Agriculture, University of Benin, Benin City, Nigeria.

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M.Sc. Animal Science

December, 2022

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Signed…………………...…

Date………………………..

Department of Animal Science

Faculty of Agriculture

University of Benin, Benin City, Nigeria

DEDICATION

This Project work is dedicated to God Almighty for His grace in completing this Work and to my loving Husband (Pastor Jeremiah Owofio), and children **(**Joshua and John) for their relentless support during the course of the study.

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ABSTRACT

The price fluctuation and limited availability of soya bean meal as a major protein feedstuff for broiler chickens have been constraints in monogastric animal production in Nigeria. Palm kernel cake has been widely used as a protein source in replacing conventional protein sources at different levels. However, the use of palm kernel cake in poultry diets has been limited due to its low quality (low protein and high fibre contents vis-à-vis dryness, grittiness and texture). The objective of this study was therefore to evaluate the effect of solid state fermentation using white rot fungus (*Pleurotus sajor caju*) on the nutritive value of palm kernel cake (PKC) as a substitute for soyabean meal (SBM) protein in the diets of finisher broiler chickens.

Palm kernel cake was sterilized for 6 hours and inoculated with *P. sajor caju* spore suspension, sun-dried and homogenized after full colonization before incorporation into the poultry feed. Proximate composition and some mineral contents of PKC and fermented PKC were determined before diets formulation. Five dietary treatments containing 50% unfermented palm kernel cake at 0, 25, 50 and 75% levels of fermented palm kernel cake were formulated to replace soyabean meal in the diets of finisher broiler chickens. Ninety finisher broiler chickens were used to evaluate the performance, carcass characteristics, hematological indices and economy of feed conversion of test diets for 6 weeks in a completely randomized design (CRD). Feed and water were given *ad libitum*

The crude protein was significantly increased (P<0.05) by 50% after fermentation. The results of the performance indicated no significant (P>0.05) differences for the test diets when compared to the Control diet 2. The inclusion of Fermented Palm Kernel Cake FPKC up to 75% had no adverse effect on weight gain, feed intake, FCR and PER. Feed intake was highest on dietary treatment 5. FCR and PER were best in birds that were fed the control diet. The 50% and 75% FPKC diets significantly (P<0.05) increased lymphocytes and MCV respectively, FPKC replacement of SBM increased the blood globulin and glucose of the finisher broiler chickens. The live and defeathered weights of birds were highest in the Control while 75% FPKC diet gave the highest values for eviscerated weight, back cut, head and kidney (as percentage of live weight). The highest digestibility of protein was obtained in Treatment 3.The cost of raising the broiler chickens was also reduced as FPKC increased in the diets. It is thus concluded that solid state fermented PKC can be utilized as a substitute for SBM in the diets of broiler chickens up to 75%.

CHAPTER ONE

1.0 INTRODUCTION

Agro-industrial by-products (AIBPs) have in recent years become important feed components in poultry diets in Nigeria mainly due to the increased competition for the conventional ingredients with humans and the food industries (Iyayi and Davies, 2005; Oluwafemi, 2012). It has been reported that feed is the major cost associated with commercial poultry production. Hence, inclusion of non-conventional feed resource becomes of primordial importance in livestock production to maintain the productivity at a lower cost (Zanu *et al*., 2012).

Odunsi *et al.* (2002) highlighted the problems facing animal feeds and poultry production in the tropics; amongst which is poor feed quality and escalating prices of Soyabean meal as a major source of protein. Various studies have delved in to the area of grain substitution with agro-industrial byproducts (AIBPs), not directly used by man, in poultry diets. Palm Kernel Cake (PKC) is the resulting by-product from the extraction of oil from palm kernel (Olomu, 2011).

PKC is one alternative feed resource that can be used in poultry feeds, where it virtually has no competition between man and farm animals (Kperegbeyi and Ikperite, 2011). Agro-industrial by-products such as PKC could be used to spare conventional feed ingredients such as soyabean meal in poultry diets because of its low pricing and availability (Onuh *et al*., 2010). Many studies have been carried out on the nutritional value of PKC in monogastric animal feeding with more than two-thirds of which were carried out on various classes of poultry (Onuh *et al*., 2010).

According to Ezieshi and Olomu (2007), PKC supplies both protein and energy; however, it has high fibre content and it has been widely used in poultry diets as a protein source to replace conventional protein sources at different levels. It is expected that as the demand for animal products increases with increasing population and improvements in living standards, conventional feedstuffs are likely to be insufficient to sustain poultry production (Iyayi and Davies, 2005).

It is against this backdrop of high cost of the conventional vegetable sources of quality protein (Dairo and Fasuyi, 2007) and the dryness, grittiness of texture and the high crude fibre constraint of PKC that studies have recommended that the use of PKC in the poultry ration requires processing because of its low quality (Perez *et al*., 2002; Ezieshi and Olomu, 2008).

Poultry do not have fibre and manan enzyme in digestive tract. It is necessary for prior processing to improve the quality of PKC through biotechnology (Purwadaria and Haryati, 2003).

Fungal growth under solid state fermentations has been found to be more suitable for low technology applications and there is hardly any waste disposal at the end of the process because the whole product may be used directly in animal feeds (Marini *et al.,* 2005; Iluyemi *et al*., 2006).

The fermented feed ingredients under Solid State Fermentation (SSF) conditions have been found to be more suitable for low technology application, and there is hardly any waste disposal at the end because the whole product may be used directly in the animal feeds (Iluyemi *et al*., 2006). Apart from that, the SSF of PKC produces a product that contains high protein content and low hemicellulose and cellulose concentration. The levels of unsaturated fatty acids increase while saturated fatty acids decrease as a result of SSF of PKC using fungi as culturing agents (Iluyemi *et al*., 2006). The solid-state fermentation of PKC appears to increase the protein value and bioavailability of nutrients (Marini *et al*., 2005; A'dilah and Alimon, 2011), however the most suitable microorganisms for the treatment of PKC using this approach are yet to be identified (Ramin *et al*., 2011).

1.1 Justification of the Study

The price fluctuation of soyabean meal as a major protein feedstuff, the increased competition with man and industries for its use as well as its limited availability have been a major constraint militating against the increased production of valuable sources of animal protein (Animashaun *et al*., 2006; Boateng *et al*., 2008; Aya *et al*., 2010; Mirnawati *et al*., 2010).

Therefore, as the demand for animal products increase with increasing population, conventional feedstuffs are likely to be insufficient to sustain poultry production (Iyayi and Davies, 2005).

Studies have shown that the inclusion rate of Palm Kernel Cake in monogastrics diets is limited to about 20% - 30% (MPOPC, 2011; Olomu, 2011) as a result of its low quality, that is, low crude protein and high crude fibre contents.

Its use in poultry ration requires processing according to Perez *et al*. (2002). Thus processing of PKC through biotechnology will cause an improvement in its quality, by decreasing its fibre content and inturn upgrading its crude protein so that it can be used to replace the protein of soyabean meal in poultry diets (Purwadaria and Haryati, 2003; Mirnawati *et al*., 2010).

The SSF of PKC appears to increase the protein value and bioavailability of nutrients (Adi'lah and Alimon, 2011). It has been recently considered as the cheapest and most environmentally friendly biotechnology feature in the production of nutrient enriched livestock feeds (Dairo and Fasuyi, 2007; Bashir, *et al*., 2011). Therefore, it is necessary to harness the potential of solid state fermentation in improving the nutritive quality of PKC for growing broiler chickens.

1.2 Objective of the Study

The general objective is to evaluate the effect of solid state fermentation on the nutritive value of palm kernel cake (PKC) used as a substitute for soyabean meal protein in the diets of broiler chickens.

The specific objectives were to:

1. determine the proximate composition and some mineral contents of solid state fermented PKC.
2. examine the effects of partial replacement of soyabean meal with fermented PKC in broiler chickens diets on their performance.
3. determine the effect of the dietary treatments on some blood parameters and the carcass characteristics of broiler chickens.
4. determine the economy of feed conversion of the broiler chickens fed the test diets.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Palm Kernel Cake

PKC is an important solid by-product of the oil-palm industry and is obtained after the extraction of palm kernel oil from the kernel of the oil palm fruits (Olomu, 2011; Alimon and Wan Zahari, 2013). It is an agro industrial by-product that is produced locally and within the West Africa sub-region in sizeable quantities (Zanu *et al*., 2012).

The African oil palm (*Elaeis guineensis* Jacq.) is a native of West Africa. According to Ezieshi and Olomu (2007), a wide range of Palm Kernel Meal types exist depending on the processing method and type of palm kernel used.

2.2 Nutritional Composition of Palm Kernel Cake

The nutro-chemical properties of PKC vary depending on the source, the methodology of oil removal, the proportion of endocarp remaining and the efficiency of oil removed from the kernel (Olomu, 2007; Onuh *et al*., 2010). It is generally looked upon more as a source of protein though it supplies both protein and energy. As reported by Olomu (2011), palm kernel cake is 86.60% dry matter, protein 16-22%, crude fat 7.80%, crude fibre 17.50%. Alimon (2004); Dairo and Fasuyi (2007) and Nuzil Amri (2013) carried out researches and recorded similar nutrient contents, dry matter 88-94.5%, crude protein 14.5-20% and a crude fibre level of 13-20%. It is low in lysine, methionine, histidine and threonine. The fibre content of PKC (13%-20%) is believed to be responsible for its grittiness, dryness in texture and poor digestibility (Onwudike, 1986; Alimon, 2004; Olomu, 2011).

In a study conducted by Olomu and Ezieshi (2007), it was found that the composition of crude fibre (CF) of solvent extracted PKC was higher compared to mechanically extracted PKC due to the degree of oil extraction in which solvent extraction method provides a better oil efficiency, leaving PKC with higher CF content.

Table 1: Proximate Composition, Energy levels and some Amino acid contents of PKC

Nutrients (%)	Alimon[1]	Dairo and Fasuyi[2]	Olomu[3]
Dry matter	88.0-94.5	91.8	89.6
Crude protein (CP)	14.5-19.6	20	21.3
Crude fibre (CF)	13.0-20.0	-	17.5
Ether extract	5.0-8.0	15.47	7.8
Ash	3.0-12.0	-	0.4
Calcium	0.2-0.3	-	0.4
Total phosphorus	0.48.0.7	-	0.5
Metabolisable energy (Kcal/kg):		-	
poultry	1,554-1793		2,500
Digestible energy(kcal/kg):			
Pigs	-	-	2508
Fish	-	-	2594
Amino acids (g/l6g N):		-	
Lysine	-	-	3.2
Methionine	2.68	-	2.21
Histidine	1.75	-	1.92

Source: [1]Alimon (2004), [2]Dairo and Fasuyi (2007) and [3]Olomu (2011).

Besides that, 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 CF values (Onuh *et al*., 2010).The protein of palm kernel cake has poor amino acid balance as it is limiting in methionine, lysine, histidine, and threonine contents (Ezieshi and Olomu, 2007).

2.3 Palm Kernel Cake Utilization in Poultry

PKC is one alternative feed resource that can be used in poultry feeds, where it virtually has no competition between man and farm animals (Kperegbeyi and Ikperite, 2011). Agro Industrial By-Products (AIBPs) such as PKC could be used to spare maize and soyabean meal in poultry diets because of their low pricing and availability (Onuh *et al.*, 2010).

Many studies have been carried out on the nutritive value of PKC in monogastric animal feeding with more than two third of which were carried out on various classes of poultry (Oluwafemi, 2012). PKC supplies both protein and energy; however, it has high fibre content and it is reported to have a low metabolisable energy for poultry. There exists a wide variation in the optimum inclusion level of PKC in poultry rations. Olomu (2011) reported that its level of use should be restricted to maximum of 30% in the diets of layers and broilers and (30%-40%) in pullet diets.

Sundu *et al*. (2006) reported that broiler chickens can tolerate up to 20% PKC in their diets without affecting their growth performance and feed efficiency. Zanu *et al.* (2012) in a study stated that inclusion of PKC at 15% has no significant effect on hematological parameters assessed and it reduced feed cost. Non-ruminant animals such as poultry and swine have simple stomachs which limits the use of PKC in their rations due to low fibre digestive enzymic activity in their gastrointestinal tract (Jozefiak *et al*., 2004).

2.4 Solid State Fermentation (SSF)

Solid State Fermentation is generally the growth or cultivation of microorganisms under controlled conditions on moist solid substrate in the absence or near absence of free water (Pandey *et al.,* 2001); for production of desired products of interest (Bashir *et al.,* 2011).

It has become a method of preference for upgrading low quality lignocelluloses into feed involving efficient microbes as it stimulates the natural growth condition of most microorganisms especially fungi and the process can be handled in low operational cost (Iyayi and Davies, 2005; Iluyemi *et al*.,2006; Dairo and Fasuyi, 2007).

It is more environmentally friendly in relation to submerged liquid fermentation (SLF). Duchiron and Copinet (2011) also illustrated the use of solid state fermentation technique to produce animal feed as referenced in Figure 2.1.

Iluyemi *et al*. (2006) reported that fungal growth under solid state fermentation has been shown to be more suitable for low technology applications and there is hardly any waste disposal at the end of the process because the whole product may be used directly in animal feeds.

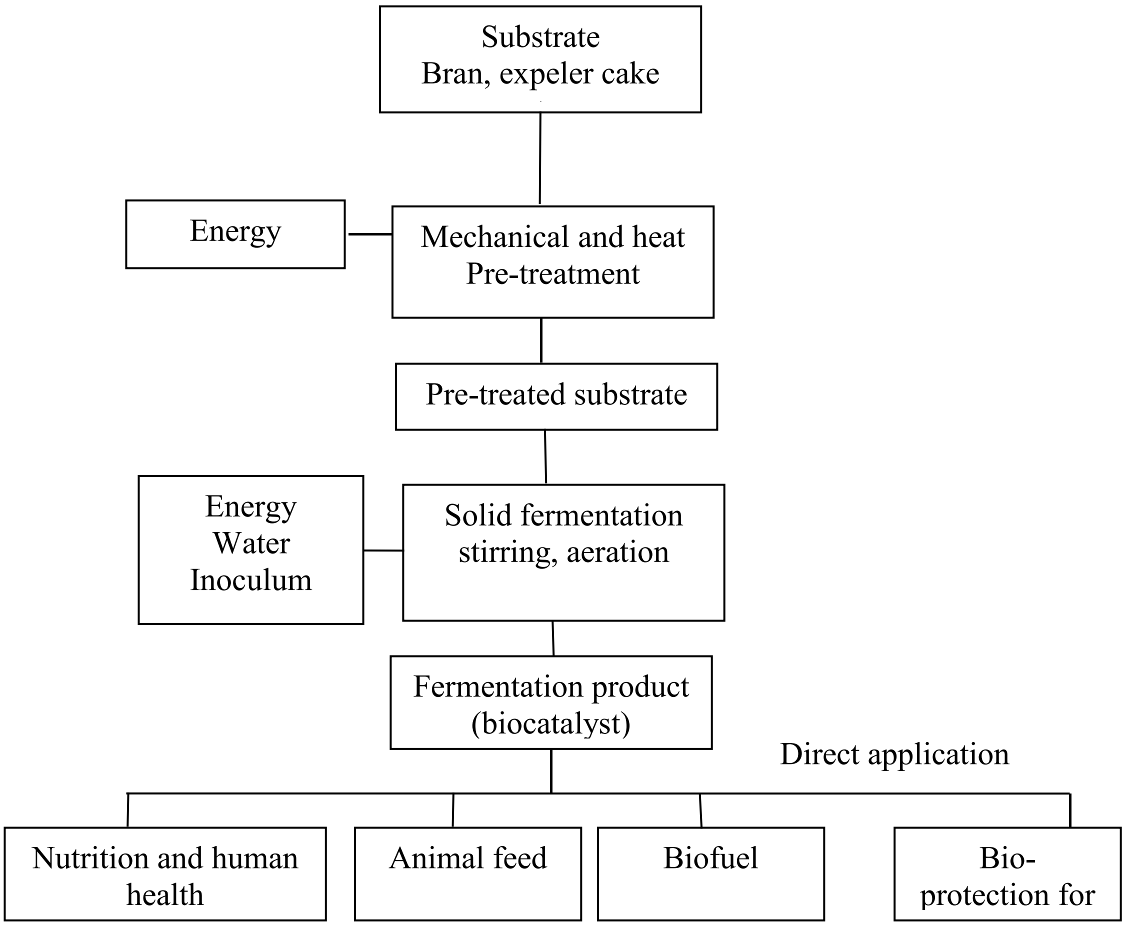

Figure 2. 1: Solid State Fermentation Technique and its Uses.
Source: Duchiron and Copinet (2011).

2.5 Effect of Solid State Fermentation on Nutritive Value of PKC

Current researches are focused on enhancing the nutrient content of PKC, and other AIBPs for poultry. This includes enzyme treatment and solid state fermentation of the PKC. The fermentation with *Aspergillus niger* was reported to increase the True Metabolisable Energy (TME) of PKC from 5.5MJ/kg to 8.1MJ/kg (Alimon, 2004; Akpodiete *et al.*, 2006; Ramin *et al.*, 2011). Begum and Alimon (2013) also carried out a study to improve the nutritive quality of rice straw through SSF using *Pleutorus sajor caju* which increased its protein content from 5.86% to 12.98%.The combined methods of chemical pre-treatment and SSF have been reported to better improve the nutritive value of PKC.

A comparison between fungi enzyme treated SSF of PKC with enzyme supplemented PKC was carried out by Ng (2004) and Lawal *et al*. (2010). Cellulose and hemicellulose components were significantly reduced in fungi enzyme treated SSF of PKC (biodegraded) compared with PKC supplemented with commercial enzyme, Roxazyme G2G (Table 2.2). A significant increase in CP, phosphorus and energy of SSF PKC was observed compared to that treated with Roxazyme G2G PKC. The enzyme complexes (enzyme produced through SSF of PKC with four different fungi, namely *Aspergillus niger, Trichoderma viride, Rhizopus stolonifer and Mucor mucedo*) produced were more efficacious in breaking down the cellulose and hemicellulose compared to Roxazyme G2G, an enzyme product specific for cereal-based diets (Lawal *et al*., 2010).

Table 2: Proximate composition (% dry matter) of raw and treated PKC

Ingredient	Moisture	Crude protein	Crude fat	Crude fibre	Ash	Nitrogen free extract
PKC	11.43	16.86	6.82	15.12	6.58	54.62
Enzyme-treated PKC	10.15	17.11	5.15	14.59.	5.4	57.75
Fermented PKC	6.67	31.27	3.36	14.51	11.34	39.52

Source: Ng (2004)

2.5.1 Effect of SSF on the Fibre content and Palatability of PKC

Mirnawati *et al.* (2010) researched the processing of PKC by *Aspergillus niger* which gave an improvement of protein by 52.04% and the decreased crude fibre by 42.03%.In a similar study, Iyayi and Aderolu (2004) by employing polysaccharidase producing *Trichoderma viride*, reported that crude fibre in BDG and PKC was reduced by 40% and 36.5% respectively when the Agro industrial by-products (AIBs) were inoculated with the fungus for 14 days. The ability of enzymes to degrade fibre has also been reported by other works. The increased digestibility of crude fibre observed in the study was an indication of the breakdown of the nonstarch polysaccharides by the enzyme during SSF in the BDG and PKC.

Feed consumption did not differ significantly due to fermentation, the PKC had a scent and flavor that was favorable to livestock. Fermentation can alter the unfavoured flavor to become favorable. In addition to the production of preferred flavor and palatability, vitamins B1, B2 and B12 and minerals are also increased after fermentation (Murugesan *et al*., 2005).

Fermented materials have a better quality, a higher digestibility and can eliminate toxic compounds and increase the content of vitamins and minerals.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental location

This research was carried out at the Farm Project Unit of the University of Benin, Ugbowo Campus, Benin City, Edo State, Nigeria. The Farm Project is located between latitude 6^{o} 20^{1} 0.32'' North and 5^{o} 36^{1} 0.53" East of the equator (Google earth, 2019).

3.2 Experimental phases:

The research was conducted in two phases.

First, solid state fermentation was carried out on PKC using white rot fungus (*Pleurotus sp. Sajor caju*) to decrease its fibre and upgrade its protein quality. This phase also involved analysis for the mineral and proximate composition of the fermented PKC by the methods of (Marini *et al*., 2005; Begum and Alimon, 2013).

The second phase of the research involved carrying out feeding trials with experimental diets which constituted graded levels of the solid state fermented PKC. Soyabean meal (SBM) protein was then replaced partially with FPKC in the diets of broiler chickens. The feeding trial was conducted in a single stage; Experimental diets were formulated with the FPKC for Finisher broiler chickens (5-10 weeks).

3.2.1 Phase One

3.2.2 Solid State fermentation of PKC

The PKC that was used in this study was obtained from commercial sale points in Benin City, Edo State, Nigeria. It was ground into smaller particle sizes using a locally fabricated hammer mill. The moisture content of the ground PKC was increased from 12% to about 70% and bagged in transparent cellophane bags, sterilized in a steamer for 6 hours and then inoculated with the white rot fungus

(*Pleurotus sajor caju*) spore suspension. The Solid State Fermented PKC was produced using the established Solid State Fermentation (SSF) Technique (Abdul Rahman *et al*., 2005). The culture was incubated at 30^0C and the bags were left in a sterile location to aid full colonization, sun–dried and sieved for easy incorporation into the animal feeds (Pandey, 2003; Begum and Alimon, 2013). Proximate analysis of the Solid State Fermented PKC (FPKC) was carried out to determine its nutritional potentials using the AOAC (2011) method.

3.2.3 Proximate and Mineral Analysis

Proximate composition of the fermented PKC was determined according to standard methods described by the AOAC (2011). It was also analysed for some mineral contents. Calcium, Magnesium, Nitrogen and Sodium were determined by Atomic Absorption Spectroscopy (AAS), Phosphorus was determined by Ultra Violet Absorption as described by the AOAC (2016).

3.2.4 Phase Two

3.2.5 Dietary Formulation and Feeding Trial

The birds were fed commercially formulated feeds at the starter phase of this study.

The fermented PKC obtained from the solid state fermentation by *P. sajor-caju* was used in formulating the experimental diets that were used for the feeding trial.

In the diets, soyabean meal protein was replaced by the FPKC in the finisher diets as follows;

Diet 1 - 50%PKC

Diet 2 - 0% FPKC

Diet 3 - 25% FPKC

Diet 4 - 50% FPKC

Diet 5 - 75% FPKC

Other ingredients that made up the diets were Maize, Wheat offal, Bone meal, Limestone, common Salt, mineral-vitamin premix.

The diets each met up with the required crude protein (20%) and metabolisable energy (3000 kcal/kg) level for broiler finisher chickens.

Table 3: Feed Formulation table

Ingredients	1(50%) PKC	2(0.00%) FPKC	3(25 %) FPKC	4(50%) FPKC	5(75%) FPKC
Maize (white)	50.90	50.90	50.90	50.90	50.90
Wheat offal	17. 05	17.05	17.05	17.05	17.05
Groundnut Cake	18.00	18.00	18.00	18.00	18.00
Palm Kernel Cake (PKC)	5.04	0.00	0.00	0.00	0.00
Fermented PKC	0.00	0.00	2.52	5.04	7.56
Soyabean meal	5.04	10.08	7.56	5.04	2.52
Bone meal	2.00	2.00	2.00	2.00	2.00
Lime stone	1.24	1.24	1.24	1.24	1.24
*Mineral/Vitamin premix	0.15	0.15	0.15	0.15	0.15
Common Salt	0.35	0.35	0.35	0.35	0.35
	100	100	100	100	100
Calculated composition:					
Metabolizable energy Kcal/Kg diet	2967.90	2968.00	2987.57	3009.26	3030.96
Crude protein (%)	19.06	20.46	20.02	19.59	19.17
Methionine +Cysteine (%)	0.62	0.70	0.57	0.60	0.65
Lysine (%)	1.01	1.00	1.10	1.05	1.06
Calcium (%)	1.00	1.00	1.01	1.03	1.04
Phosphorous (%)	0.65	0.70	0.60	0.66	0.71
+ Cost/ Kg diet (₦)	95.80	124.00	99.40	96.00	92.60

*mineral/vitamin premix contained per kg diet: Vitamin A, 10,000-15,000 i.u; Vitamin D; 2000-3000 i.u, Vitamin E, 5-20 I.U; Viatmin K, 2.2-3.0 mg; thiamine, 1.5-2.0 mg; riboflavin,5.5 mg; niacin, 23 mg; calcium pantothenate, 10 mg; pyridoxine, 2 mg; choline chloride, 120-150 mg; folic acid, 1 mg; Vitamin B_{12}, 0.01 mg; manganese, 56-80 mg; zinc, 50 mg; copper, 10-20 mg; iron, 20 mg; iodine, 0.4-1 mg; cobalt, 0.6-1.25mg.

+1 US $ =₦350 (At time of study)

3.2.6 Diets for Finisher Experiment

Diet 1 (negative Control diet for finisher phase) 50% SBM was replaced with unfermented PKC.

Diet 2 (Control Diet), Diet 3 had 25% of its SBM replaced by FPKC, Diet 4 had 50% of its SBM replaced with FPKC and Diet 5 had 75% of its SBM replaced by FPKC. The birds were 4 weeks old when the feeding trial started, and was terminated when the birds were 10 weeks old. The duration of the experiment was for a period of 6 weeks with after one week of adjustment. They were fed the experimental diets and given water *ad libitum*. The birds were reared on deep litter system. During the first four weeks, the open sided portions of the pens were covered with plastic sheets and adequate heat provided for brooding purpose. The birds on arrival were subjected to anti-stress vitamins and antibiotics for prophylactic treatment. They were randomly assigned to the five dietary treatments such that there were three replications per treatment. The birds were subjected to the standard vaccination schedule for broiler chickens.

- Vaccination against new castle disease at day old and 6 weeks of age.
- Vaccination against Infections Bursal disease (Gumboro) at 2 and 4 weeks of age.
- Vaccination against coccidiosis at intervals of 2-3 weeks.

3.3 Experimental Design

The experiment was laid out using Completely Randomised Design (CRD). There were five Treatments; (Control Inclusive) with 18 birds per treatment and 6 birds per replicate making a total of 90 birds used for the study. The linear additive model for the CRD is expressed below.

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

Where Y_{ij} = the effect of the j^{th} observation in the i^{th} treatment

μ = general mean of the population

t_i = the effect of the i^{th} treatment where i = 1,2,3….t

e_{ij} = random error associated with the j^{th} observation in the i^{th} treatment

3.3.1 Data Collection for Feeding Trial

During the experiment, data were collected and the parameters that were measured include; feed consumption, live weight, weight gain, feed conversion ratio, protein efficiency ratio and carcass characteristics.

3.3.1.1 Weight gain

Weight gain/bird was determined by the difference between initial and finial live weights, average daily weight gain was derived by dividing the weekly weight gain by seven.

3.3.1.2 Feed consumption

Daily feed intake was determined by subtracting the left over feed from the known quantity of diets supplied daily. The weekly as well as total feeds consumed were also estimated.

3.3.1.3 Feed Conversion Ratio (FCR):

$$FCR = \frac{\text{Feed consumed (g)}}{\text{Weight gain (g)}}$$

3.3.1.4 Feed conversion efficiency

Weight gain per unit of feed consumed.

FCE = (weight gain/feed consumed).

3.3.1.5 Protein Efficiency Ratio (PER)

This is the expression of the weight gain by the broiler chicken per unit of protein consumed PER = weight gain (g)/protein intake (g).

3.3.1.6 Economy of feed conversion

This was determined by using prevailing prices of ingredient/feed within the experiment period (July to October, 2018).

3.3.1.7 Carcass percentage

One bird per replicate, making three birds per treatment were slaughtered and the size, weight of eviscerated and dressed carcass as well as dressing percentage were determined.

3.3.1.8 Blood Parameters

Blood sample were collected from each treatment and parameters such as packed cell volume (PCV), total red blood cell count (RBC), white blood cell count (WBC), haemoglobin concentration (HBC), blood glucose, total plasma protein, globulin and albumin of serum were all measured at the end of the experiment and records were taken for analysis using automated electrometric cell counters.

3.4 Chemical Analysis

The fermented PKC and compounded feeds were analysed every two weeks during the 6 weeks experimental period. Faecal samples from the digestibility study were also analysed using methods described by AOAC (2011).

3.5 Statistical Analysis

Data collected from the feeding trial and chemical analysis were subjected to analysis of variance (GenStat 2013 12^{th} Edition Statistical Package) and differences between the means were separated using Duncan's Multiple Range Test (Duncan, 1955).

CHAPTER FOUR

4.0 RESULTS

4.1 Determination of Proximate and Some Mineral Compositions of PKC and Fermented PKC

The results of the proximate and some mineral compositions of PKC and fermented PKC used for the phase one of the study are presented in Table 4.

The Results revealed that PKC has 21.00% Crude protein, 11.94% crude fibre, 7.23% ether extract, 1.19% Ash and 47.24% Nitrogen free extract. Mineral analysis result showed that the PKC had 0.111% calcium, and 0.017% phosphorus.

Also, the results for the fermented PKC showed 31.50% Crude Protein, 11.68% Crude fibre, 7.67% ether extract, 1.16% Ash and 31.97% Nitrogen free extract. Mineral Analysis of Fermented PKC showed 0.1145% Calcium and 0.0175% Phosphorus.

The percentages of Crude protein and Ether extract of PKC were higher with the Solid State Fermentation (SSF) while others were unaffected.

Phosphorus, Magnesium, Sodium and Potassium also increased with SSF while percentage of Calcium was lower with fermentation.

Table 4: Proximate and some Mineral Compositions of SBM, PKC and fermented PKC

Nutrient	SBM (%)	PKC (%)	FPKC (%)
Dry matter	90.70	88.60	83.98
Crude protein	48.50	21.00	31.50
Crude fibre	4.10	11.94	11.68
Ether extract	1.50	7.23	7.67
Ash	8.00	1.19	1.16
Nitrogen free extract	28.6o	47.24	31.97
Moisture	9.30	11.40	16.02
<u>Minerals (%):</u>			
Calcium	0.2800	0.1117	0.1145
Phosphorous	0.6200	0.0174	0.0175
Magnesium	0.2800	0.0251	0.0384
Sodium	0.0180	0.0071	0.0075
Potassium	1.9000	0.1737	0.1852

On dry matter (DM) basis

4.2 Study Two: Determination of Proximate and some mineral compositions of FPKC-included diets

4.2.1 Finisher phase

The results of proximate and some mineral compositions of the FPKC- included diets are shown in Table 5

The results of the proximate analysis of FPKC included diets showed no significant (P>0.05) difference in all the diets. The Ash content of Diet 3(25.00% FPKC) was significantly (P<0.05) lower than the values for Diets 4(50.00% FPKC) and 5(75.00% FPKC) but similar to the values for Diets 1(50.00%) and 2 (0.00% FPKC).

Diet 4 also recorded the lowest Crude fibre, which was not significantly (P>0.05) different from other values.

Results of mineral compositions for the FPKC-included diets showed significant (P<0.05) differences for all the five experimental diets in respect of Calcium, Potassium, Magnesium and Sodium.

Phosphorus composition indicated that only Diet 2 (Control diet) was significantly (P<0.05) lower than other Diets.

Diet 5(75.00% FPKC) also recorded highest percentages of all the minerals that were analyzed for in all the diets but had the same Phosphorus value with Diet 4 (50.00% FPKC). The results indicated an increase in the nutrient composition of the Diets with SSF.

Table 5: Proximate and some Mineral Compositions of PKC and fermented PKC -Included diets

Proximate Composition	Diet (% Inclusion of FPKC)					
	1(50.0)PKC	**2(0.00%)**	**3(25.00%)**	**4(50.00%)**	**5(75.00%)**	**SEM**
Dry matter	89.67	88.67	87.67	89.00	87.67	1.54
Crude protein	19.80	21.92	23.05	20.90	21.04	1.43
Crude fibre	4.94	4.97	5.047	4.933	7.00	0.69
Ether extract	8.16	7.44	7.56	10.36	7.23	1.34
Ash	7.67[ab]	7.67[ab]	5.82[b]	9.37[a]	10.00[a]	1.03
Nitrogen free extract	45.58	46.66	46.18	42.77	42.39	3.08
<u>Minerals (%)</u>						
Calcium	0.0875[e]	0.0914[d]	0.0995[c]	0.1083[b]	0.1124[a]	0.00
Phosphorus	0.0174[a]	0.0173[b]	0.0174[a]	0.0175[a]	0.0175[a]	0.00
Potassium	0.1588[d]	0.1773[c]	0.1894[b]	0.1920[e]	0.1998 [a]	0.00
Magnesium	0.0267[e]	0.0278[e]	0.0315[c]	0.0363[b]	0.0437[a]	0.00
Sodium	0.0067[e]	0.0073[d]	0.0081[c]	0.0083[b]	0.0091[a]	0.00

[a, b, c, d, e] Means within the same row with different superscripts are significantly (P<0.05) different.
SEM: Standard Error of Mean.

4.2.2 Study Two: Effect of feeding on performance of Broiler chickens fed diets containing graded levels of fermented PKC (First 2-weeks)

The responses of the Broiler chickens fed diets containing PKC and FPKC during the First two weeks of the finisher phase is presented in Table 6**.**

The initial weights of birds were significantly (P<0.05) different from each other

Results obtained showed significant (P<0.05) differences for the weight gain in grams/bird/week.

Diets 1(192.80g), 2(197.30g) and 3(197.30g) were not significantly (P>0.05) different from each other; but was significantly (P<0.05) different from Diets 4(158.3g) and 5(152.80g). The lowest weight gain was recorded in Diet 5(152.80g) while the highest was obtained in the Control diet 2(197.30g). The daily weight gain of birds were not significantly (P>0.05) different from each other while Feed intake was increased with inclusion of FPKC.

Feed intake was highest in Diet 5(658.20g), but was not significantly (P>0.05) different from all other diets. The lowest Feed intake was recorded in Diet 1(650.60g). Feed Conversion ratio in the Control diet 2(3.32), FPKC included Diets 3(3.43), 4(4.11) and 5(4.31) were not significantly (P>0.05) different.

Table 6: Effect of Feeding on Performance of Broiler Chickens fed diets containing graded levels of fermented PKC of Finisher phase (First 2 weeks)

Parameters	Diet (% inclusion of FPKC)					
	1(50.00) PKC	**2 (0.00)**	**3(25.00)**	**4(50.00)**	**5 (75.00)**	**SEM**
Initial weight (g/bird)	653.30^{a}	591.60^{b}	611.10^{ab}	605.60^{ab}	633.30^{ab}	14.49
Final weight (g/bird)	846.10^{a}	788.90^{b}	802.60^{b}	763.90^{c}	786.10^{c}	7.11
Weight gain (g/bird/week)	192.80^{a}	197.30^{a}	191.50^{a}	158.30^{ab}	152.80^{b}	12.38
Weight gain (g/bird/day)	29.54	28.18	27.37	23.87	19.83	8.06
Feed intake (g/bird/week)	650.60	656.80	656.90	651.70	658.20	8.37
Feed intake (g/bird/day)	92.94	93.83	93.84	93.10	94.02	1.19
Feed conversion Ratio	3.37^{b}	3.32^{ab}	3.43^{ab}	4.11^{ab}	4.31^{a}	0.40

$^{a, b, c}$ Means within the same row with different superscripts are significantly ($P<0.05$) different.
SEM: Standard Error of mean.

4.2.3 Effect of feeding on Performance of Broiler chickens fed diets containing graded levels of fermented PKC (Second 2 weeks) of finisher phase

The response of Broiler chickens fed diets containing FPKC during the second two-weeks of the Finisher phase are presented in Table 7

The results showed no significant (P>0.05) differences among birds fed the different diets in respect of weight gain, though birds fed FPKC included Diet 3(194.5g)/bird/week gave the highest weight gain while the lowest was obtained in the negative Control diet 1(145.6g)/bird/week. The final weight of birds fed Diet 4 (1189.0g)/bird was similar to the Control diet 2 (1166.7g). Weight gain in grams/bird/day was significantly (P<0.05) highest in FPKC Diet 5(35.69g) when compared with others.

There was no significant (P>0.05) difference in feed intake across the diets.

Feed conversion ratio was not significantly (P>0.05) affected by the Treatments. Diet 3(3.43) with FPKC was not significantly (P>0.05) different from the Control diet 2(3.32) in this phase of the study.

4.2.4 Effect of feeding on Performance of Broiler Chickens fed diets containing graded levels of fermented PKC Finisher phase (Third 2-weeks)

The response of broiler chickens fed diets containing FPKC during the third two-weeks of the finisher phase are presented in Table 8

The result showed that there was no significant (P>0.05) differences in the weight gain among diets.

There was also no significant (P>0.05) differences in feed intake. The highest feed intake was obtained in diet 5(1066g) in grams/bird/week. Daily feed intake was significantly (P<0.05) different in the control diet 2(148.7g).

Furthermore, the feed conversion ratio obtained for Diet 5(2.95) was significantly lower than that of the Control diet 1(3.02).

Table 7: Effect of Feeding on Performance of Broiler Chickens fed diets containing graded levels of fermented PKC at the Finisher phase (Second 2 weeks)

Parameters	Diet (% inclusion of FPKC)					
	1(50.0) PKC	**2 (0.00)**	**3(25.00)**	**4(50.00)**	**5 (75.00)**	**SEM**
Initial weight (g/bird)	1008.30	986.10	1002.80	1010.70	1055.00	69.90
Final weight (g/bird)	1153.90^{b}	1166.7^{ab}	1197.30^{a}	1189.0^{ab}	1225.00^{a}	17.91
Weight gain (g/bird/week)	145.60	180.60	194.50	178.30	170.00	30.90
Weight gain (g/bird/day)	20.79^{c}	26.50^{b}	27.74^{b}	32.14^{ab}	35.69^{a}	2.04
Feed intake (g/bird/week)	846.10	815.30	817.90	817.90	839.70	9.77
Feed intake (g/bird/day)	120.90	116.50	116.80	116.80	127.70	1.39
Feed Conversion Ratio	5.81	4.51	4.21	4.58	4.93	2.94

$^{a, b, c}$ Means within the same row with different superscripts are significantly (P<0.05) different.

SEM: Standard Error of Mean.

Table 8: Effect of Feeding on Performance of Broiler Chickens fed diets containing graded levels of fermented PKC at the finisher phase (Third 2 weeks)

Parameters	Diet (% inclusion of FPKC)					
	1(50.0) PKC	**2 (0.00)**	**3(25.00)**	**4(50.00)**	**5 (75.00)**	**SEM**
Initial weight (g/bird)	1420^{b}	1500^{c}	1561^{a}	1617^{a}	1536^{ab}	8.79
Final weight (g/bird)	1708.0	1844.5	1864.3	1920.3	1897	62.1
Weight gain (g/bird/week)	288.00	344.50	303.30	330.60	361.10	73.5
Weight gain (g/bird/day)	41.14	58.71	43.33	47.22	51.59	9.15
Feed intake (g/bird/week)	1044	1041	1031	1056	1066	13.23
Feed intake (g/bird/day)	149.10^{a}	148.70^{b}	147.30^{ab}	150.80^{a}	152.30^{a}	1.316
Feed Conversion Ratio	3.63	3.02	3.39	3.19	2.95	2.89

[a, b, c] Means within the same row with different superscripts are significantlly (P<0.05) different.
SEM: Standard Error of Mean.

4.2.5 Effect of feeding on performance of Broiler Chickens fed diets containing graded levels of FPKC at the Finisher Phase (week 5-10)

Response of Broiler Chickens fed diets containing FPKC during the finisher phase is presented in Table 9**.** There was no significant (P>0.05) difference in weight gain among birds fed the different diets, however the Control diet 2(268.5g) recorded high weight gain. The results showed that there was no significant (P>0.05) difference in both feed intake and feed conversion ratio of the birds.

High Feed intake was obtained in birds fed Diet 5(850.8g) compared to the control diet 2(784.1g). The Control diet 2(2.92) recorded low Feed conversion ratio. The inclusion of FPKC did not affect the Protein Efficiency Ratio (PER) when compared with the Control diet. However the cost of feed per kg weight gain was considerably reduced with FPKC diets up to 25%.

The Results indicated that there were no significant (P>0.05) differences in weight gain, feed intake, feed conversion and protein efficiency ratios for all the Treatments. However Protein efficiency ratio steadily decreased with increasing level of FPKC in the diets.

Table 9: Effect of Feeding on Performance of Broiler Chickens fed diets containing graded levels of FPKC for the Finisher Phase (Weeks 5-10)

	Diet (% inclusion of FPKC)					
Parameters	**1(50.0) PKC**	**2 (0.00)**	**3(25.00)**	**4(50.00)**	**5 (75.00)**	**SEM**
Initial weight (g/bird)	1027	1026	1052	1029	998	27.90
Final weight (g/bird)	1231.60	1294.50	1297.40	1269.70	1235.00	24.80
Weight gain (g/bird/week)	204.60	268.50	245.40	240.70	237.00	23.50
Weight gain (g/bird/day)	29.22	38.35	35.05	34.38	33.85	3.20
Feed intake (g/bird/week)	849.60	784.10	837.90	845.00	850.80	21.68
Feed intake (g/bird/day)	121.40	112.00	119.70	120.70	120.10	3.67
Feed Conversion Ratio	4.15	2.92	3.41	3.51	3.58	1.97
Protein Efficiency Ratio	0.011	0.015	0.014	0.013	0.013	0.001
Cost of feed (₦/kg)	95.80	124.00	99.40	96.00	92.60	28.00
Cost of feed (₦/kg wt.gain)	397.57	362.08	383.95	336.96	331.51	31.11
Cost savings (₦/kg wt.gain)	35.47	0.00	23.13	25.12	30.57	5.56

SEM: Standard Error of Mean.

1 US $ =₦350 (At time of study)

4.2.6 Hematological Indices of Broiler Chickens (Finisher phase)

The result of hematological indices of Broiler chickens fed diets containing fermented PKC are presented in Table 10. Results showed that there were no significant (P>0.05) differences in PCV, RBC, WBC and Platelets across all experimental dietary groups. The Control diet 2(20.07%) recorded the highest PCV. The HBV in the Control diet 2(16. 93g/dl) was significantly (P<0.05) higher than in any other diets. RBC in the FPKC included diets were similar in value to the control diet 2(2.737x10^6/ul). MCH was highest in Diet 1 (26.90pg). The result also showed that both WBC and Platelet were high in the control diet 2(17.800x10^3/ul) and 2(89.33$10^3$/ul) respectively. The MCH level was not significantly different in diet 3(21.03pg) and diet 5(22.40pg) but was significantly different (P<0.05) in diet 1(26.90pg).

There were no significant (P>0.05) differences in PCV, RBC, WBC, Lymphocytes and MCV when compared with the Control, while the inclusion of FPKC in the Diets recorded significant differences in HBV and MCH. The concentration of WBC was lower with inclusion of FPKC while Lymphocytes, Monocytes and MCV were increased.

Table 10: Effects of Diets on Hematological Indices of Broiler Chicken at the Finisher Phase (Weeks 5-10)

Parameters	Diet (% inclusion of FPKC)					SEM
	1(50.0) PKC	**2 (0.00)**	**3(25.00)**	**4(50.00)**	**5 (75.00)**	
PCV (%)	13.53	20.07	12.53	6.27	9.07	20.89
HBV (gldl)	10.90^{b}	16.93^{a}	10.67^{b}	10.30^{b}	10.80^{b}	1.27
RBC (10^6/ul)	0.85	2.74	2.61	2.49	2.71	0.88
WBC (10^3/ul)	7.33	17.80	4.90	6.27	5.50	5.42
Lymphocytes (%)	0.60	1.83	1.67	2.03	1.20	0.57
Monocytes (%)	0.40	1.20	1.00	1.17	1.27	0.39
Granulocytes (%)	97.33	96.97	97.23	96.80	97.47	0.44
MCV (fl)	71.67	76.20	67.30	80.23	82.07	4.76
MCH (pg)	26.90^{a}	24.37^{ab}	21.03^{bc}	20.77^{b}	22.40^{bc}	1.07
MCHC (g/dl)	31.80	33.47	29.70	31.73	32.33	2.69
Platetet (10^3/ul)	79.6	89.33	85.33	86.00	86.00	7.40

$^{a, b, c}$ Means within the same row with different superscripts are significantlly (P<0.05) different.
SEM: Standard Error of Mean.

PCV: Packed Cell Volume,

HBb: Haemoglobin,

RBC-Red Blood Cell

WBC: White Blood Cell,

MCV: Mean Corpuscular Volume,

MCH: Mean Corpuscular Haemoglobin

MCHC: Mean Corpuscular Haemoglobin concentration

4.2.7 Serum metabolites of broiler chickens (finisher phase)

The results of Serum metabolites of Broiler Chickens fed diets containing fermented PKC is presented in Table 11. The results showed no significance (P>0.05) differences in the volumes of Albumin, globulin, Total Protein and Blood glucose across the dietary groups. However, Albumin concentration in the control diet 2(2.067g/dl) was slightly lower than those of Diets 1(2.33g/dl), 3(2.133g/dl), 4(2.100g/dl) and 5(2.100g/dl).

Diets with FPKC recorded high concentration of Globulin, Albumin, Total protein and Blood glucose. The Results revealed a high concentration of the Serum metabolites with inclusion of 25% FPKC when compared to the Control diet 2.

Table 11: Effect of Diets on Serum Matabolites of Broiler Chickens (Finisher Phase)

Parameters	Diet (% inclusion of FPKC)					SEM
	1(50.0) PKC	**2 (0.00)**	**3(25.00)**	**4(50.00)**	**5 (75.00)**	
Albumin (g/dl)	2.13	2.07	2.13	2.10	2.10	0.15
Globulin (g/dl)	2.60	2.97	3.33	2.77	2.467	0.73
Total protein (g/dl)	4.73	5.03	5.46	4.86	4.56	0.43
Blood glucose (mg/dl)	175.00	197.00	201.70	211.70	191.30	10.75

SEM: Standard Error of Mean.

4.2.8 Effect of diets on carcass characteristics (finisher phase)

The results of the effects of diets on Carcass characteristics of Broiler chickens fed fermented PKC are presented in Tables 12 and 13. The results revealed that there was no significant (P>0.05) difference in the Live weight of birds that were fed the experimental diets. Live weight was high in the control diet 2(2150g), followed closely by diet 5(2117g) and least in the negative control diet 1(1833g). The eviscerated weight was however high in diet 5(76.67%). The results showed no significant (P>0.05) differences in Live weight, eviscerated weight, breast cut, Kidney, Lungs, Spleen, thighs and wings, however percentage of the head in diet 5(2.93%) was significantly (P<0.05) higher than the ones in diets 2(2.43%) and 4(2.33%). Heart size of diet 5(0.41%) was not significantly different from the control diet 2(0.37%). Liver was significantly (P<0.05) different in diet 1(3.16%) but control diet 2(2.27%), diet 3(2.13%), 4(2.15%) and 5(2.30%) were not significantly different from each other.

Neck in the control diet 2(4.417%) was not different from diet 3(4.40%)

The right shank length of diets 3(15.67cm) and 5(16.10cm) were significantly (P<0.05) different from other dietary group in the experiment. The inclusion of FPKC in the Diets recorded a steady increase in the percentages of Breast cut, drum stick, gizzard, head, heart, spleen, thighs and wings while those of the Back cut, lungs and neck were not affected.

Table 12: Effects of Diets on Carcass Characteristics at the Finisher Phase (Week 5-10)

	Diet (% inclusion of FPKC)					
Parameters	**1(50.0) PKC**	**2 (0.00)**	**3(25.00)**	**4(50.00)**	**5 (75.00)**	**SEM**
Live weight (g)	1833	2150	1887	1900	2117	0.1502
Defeathered weight (PLW)	93.67	94.49	97.14	93.00	90.69	0.14
Eviscerated weight (PLW)	79.11	75.21	72.44	72.63	76.67	0.13
Back cut (PLW)	1.75	2.07	1.87	1.81	1.98	2.25
Breast Cut (PLW)	19.59	20.20	18.36	20.24	18.65	0.87
Left Drum Stick (PLW)	5.29	5.61	5.84	5.49	5.40	0.16
Right Drum stick (PLW)	5.46	5.54	5.63	5.43	5.55	0.18
Gizzard (% of LW)	1.96	1.78	1.80	1.81	1.69	0.15
Head (% of LW)	2.55^{ab}	2.43^{b}	2.69^{ab}	2.33^{b}	2.93^{a}	0.14
Heart (% of LW)	0.39^{ab}	0.37^{b}	0.46^{a}	0.34^{b}	0.41^{ab}	0.03
Kidney (% of LW)	0.19	0.23	0.15	0.28	0.32	0.07
Liver (% of LW)	3.16^{a}	2.27^{b}	2.13^{b}	2.15^{b}	2.30^{b}	0.20

a, b, means within the same row with different superscripts are significant (P<0.05) different.
SEM: Standard Error of mean.

PLW: Percentage of Live weight

LW: Live weight

Table 13: Effects of Diets on Carcass Characteristics Cont'd (Finisher Phase)

Parameters	Diet (% inclusion of FPKC)					SEM
	1(50.0) PKC	2 (0.00)	3(25.00)	4(50.00)	5 (75.00)	
Kiolin layer (% of LW)	0.23	0.19	0.34	0.17	0.19	0.09
Left lung (% of LW)	0.26	0.27	0.28	0.23	0.24	0.03
Right lung (% of LW)	0.27	0.26	0.25	0.24	0.30	0.02
Neck (% of LW)	4.29^{ab}	4.42^{a}	4.40^{a}	3.70^{a}	4.31^{ab}	0.20
Neck length (cm)	12.93	13.97	13.90	13.33	12.20	0.63
Left shank (% of LW)	1.58	1.95	2.19	1.99	1.95	0.21
Right shank (% of LW)	2.02	1.96	2.22	1.95	1.98	0.17
Left (L) shank length (cm)	21.40	15.17	15.10	15.43	15.67	3.08
Right shank length (cm)	14.67^{b}	14.87^{b}	15.67^{ab}	14.77^{b}	16.10^{a}	0.36
Spleen (% of LW)	0.12	0.12	0.09	0.08	0.11	0.02
Left thigh (% of LW)	4.84	5.33	3.89	4.90	5.29	0.56
Right thigh (% of LW)	5.36	5.02	5.37	5.01	5.30	0.39
Left wing (% of LW)	4.11	3.37	4.28	4.15	4.27	0.26
Right wing (% of LW)	4.11	4.32	4.31	4.04	4.38	0.37

[a,b,] means within the same row with different superscripts are significantly ($P<0.05$) different.

SEM: Standard Error of mean.

PLW: Percentage of Live weight

LW: Live weight

4.2.9 Nutrients Retention of Broiler Chickens (Finisher phase)

The nutrient retention of Broiler chickens fed diets containing graded levels of fermented PKC in the finisher phase are presented in Table 14. However, diet 3(71.73%) showed the highest digestibility followed closely by diet 5(62.89%). Protein digestibility and fibre digestibility were also highest in diet 3(59.00% and 43.12%) respectively which was slightly higher than those for diet 5(28.85%) and diet 1(25.00%). The results revealed that the Protein digestibility of the Diets were 45%, 39%, 59%, 28% and 49% respectively while the Fibre digestibility obtained were 25%, 4.55%, 43.12%, 7.65% and 28.85% respectively for the Diets 1, 2, 3, 4 and 5. Diet 3 was significantly ($P<0.05$) different from other diets in protein digestibility and also gave the highest fibre digestibility across all the Treatments. Digestibility improved with inclusion of FPKC in the diets.

Table 14: Effects of Diets on Nutrient Retention (Finisher Phase)

Parameters	Diet (% inclusion of FPKC)					SEM
	1(50.0) PKC	**2 (0.00)**	**3(25.00)**	**4(50.00)**	**5 (75.00)**	
Proximate Composition of Diets (%):						
Dry matter	52.44	43.68	54.24	61.18	49.48	5.24
Crude protein	13.80	14.00	13.50	17.71	14.33	1.08
Crude fibre	3.82	4.98	4.55	4.22	6.64	2.10
Ether extract	7.05	10.05	5.30	15.00	14.35	1.28
Ash	5.00	5.00	5.00	5.00	5.50	1.52
Digestibility (%):						
Diet digestibility	49.02^{a}	58.14^{a}	71.73^{b}	40.31^{a}	62.89^{ab}	4.22
Protein digestibility	45.00^{ab}	39.00^{a}	59.00^{b}	28.00^{a}	49.00^{ab}	5.88
Fibre digestibility	25.00	4.55	43.12	7.65	28.85	2.91

a, b, means within the same row with different superscripts are significantly ($P<0.05$) different
SEM: Standard Error of mean.

CHAPTER FIVE

5.0 DISCUSSION

The results obtained for proximate composition of the solid state fermented PKC showed a 50% increase in crude protein from 21% to 31.50% which is in agreement with the report of Ng (2004). Mirnawati *et al*. (2010) and Begum and Alimon (2013) also reported a similar increase in the protein content of Rice straw through SSF using the same fungus (*Pleurotus Sajor Caju*) that was used in this experiment. This increase could be attributed to the reduction in biomass after fermentation, which resulted in the utilization of the carbon content by the fungus (Marini *et al.,* 2008). However the crude fibre content was slightly increased by 6%.The result is significantly different from the value reported by Iyayi and Aderolu (2004) where it was found that *Trichoderma viride* reduced crude fibre gotten from this study when compared to the finding of other authors could be attributed to differences in the type of fungus that was used, variations in duration of inoculation and incubation as well as the rate of colonization and incubation in the substrate.

Lawal *et al*. (2010) reported a significant increase in the mineral contents of solid stated fermented PKC with four different fungi especially the Phosphorus and Calcium contents which is similar to the result obtained in this study.

The proximate composition of FPKC-included diets showed a general improvement in nutritive value of the diets compared to sole-soyabean meal and untreated PKC diets, this result is in agreement with the report of (Sahri *et al*., 2013).

The average weight gained by birds steadily decreased with increased feed intake and feed conversion ratios using the formulated diets containing 0, 25, 50 and 75% FPKC during the first two weeks of the feed trial. However there was no significant (P>0.05) difference in the average feed intake.

The results of the third and fourth weeks of feed trial showed highest average weight gain at 25% level of FPKC inclusion. Feed intake was least in the control diet while the feed conversion ratio increased with FPKC replacement with 75% level FPKC inclusion was lowest in the diet while average weight gain and feed intake improved with % inclusion of FPKC in the last two weeks of the study.

The performance of birds on feed trial as per weight gain was significantly ($P<0.05$) reduced as average feed intake increased with inclusion of FPKC. The increase in feed intake could be attributed to the palatability.

However, the FCR value which is the most sensitive factor in assessing performance significantly increased, an indication of poor feed utilization due to high crude fibre content. This agrees with the report of Iyayi and Davies (2005). The diet containing 25% inclusion of FPKC gave the best as regards FCR.

The carcass characteristics of birds on the various dietary treatments showed no significant ($P>0.05$) differences in the live weight of the birds fed the different diets. The live weights of birds in Treatments 4 and 5 were higher than those reported by Esiegwu *et al*. (2016). The defeathered and eviscerated weights of birds that were fed FPKC included diets were not significantly affected, a similar report was given by Iyayi and Davies (2005).

However, in contrast, the head, heart, liver, neck and the length of the right shank (expressed as percentage of live weight) were significantly ($P<0.05$) affected by the inclusion of FPKC.

The head of birds in the Control diet and those of 50% FPKC were not different. The heart size was increased by FPKC diets except in Treatment 4(50% FPKC)

The range of value for heart, liver, breast cut, neck, kidney, head and gizzard observed in this study resemble those reported by Esiegwu *et al*. (2016).

It is interesting to note that breast cut in birds fed 50% FPKC (Treatment 4) was slightly higher than those in the Control diet, an indication that nutrients required for tissue synthesis were quite sufficient and proteins were adequately metabolized (Mathew *et al*., 2010). The weight of the liver in Treatments 3 and 4 decreased compared to the Control diet, this also supports the findings of Akinmutimi (2011) that decrease in the size of the liver is an indication of reduction in its activities.

The findings in this study showed that SSF of PKC with *P. Sajor Caju* resulted in enhanced digestibility and diminished the effects of the fibre content on the guts of the birds.

Chiang *et al*. (2010) reported an apparent protein digestibility range of 62-64, the protein digestibility in this study was slightly lower than the report of the above author but was comparable to findings of Aremu *et al*. (2016).

The enhanced digestibility was observed in diets that contained 75% FPKC and 25%FPKC respectively. The hematological responses of the birds fed the Control diet and FPKC included diets were not significantly (P> 0.05) different and were not influenced by the FPKC inclusion levels in the diet (Obun, 2007) reported a similar observation in a feed trial with fermented locust bean meal.

The HBV and MCH values in the birds fed the Control Diet 2 were significantly (P< 0.05) higher than that in birds fed FPKC-based diets. This generally indicates the good quality of FPKC to replace soyabean meal since haemocrit, erythrocytes and hemoglobin are known to correlate positively with protein quality and protein level (Oyelala *et al*., 2004). Therefore, FPKC inclusion in the diets had no adverse effect on haematological indices that were measured in this study. The PCV and RBC values decreased with inclusion of FPKC, and were also lower than the Physiological range of 22-35% as stated by Onyishi *et al*. (2017).

These lower values could be due to nutrient conditions, environmental factors and fasting (Etim *et al*., 2014). However, the HBV, RBC, WBC and Monocytes reported in this study are consistent with the report of Olusiyi *et al*. (2017) where the Serum biochemistry variables were significantly (P>0.05) affected. Chickens fed FPKC based diets at 25% and 50% recorded higher contents of Albumin and Blood glucose.

Globulin level was only higher than the Soyabean meal based diet in 25% FPKC inclusion level which is similar to the report of Zeng *et al*. (2012) where *Lactobacillus* fermented Rape seed meal was used to replace Soya bean meal in the diets of broiler chickens. Total protein however decreased with FPKC inclusion, the closest value of Total Protein to the Control diet was observed in birds that were fed 50% FPKC diet.

The inclusion of FPKC in the diets of finisher broiler chickens significantly reduced the cost of feed per kg of weight gained. The diet with unfermented PKC was the most expensive; therefore FPKC diets reduced the cost of production with a range of ₦23.13 to ₦30.57 per weight gain which was similar to the report of Onyishi *et al*. (2019).

The results implied that replacing soya bean meal protein with fermented PKC can reduce cost of production of broiler chickens (finishers).

The cost (₦) per kg feed decreased as FCR increased and the cost (₦) of feed per kg weight gain of birds fed on all FPKC-based diets were significantly lower than the Control. This result therefore agrees with the report of Olajide (2012) but contrasts the report of Esiegwu *et al*. (2016).

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

Solid state fermentation of Palm Kernel Cake (PKC) with *Pleurotus sajor caju* was carried out at the Mushroom Research Centre which significantly improved the Crude Protein content of the PKC for finisher broiler chickens. The fermented PKC was used to partially replace soyabean meal in the diets of finisher broiler chickens up to 75%. The utilization of fermented PKC had no adverse effect on the growth performance, carcass characteristics and blood metabolites of the finisher Broiler chickens.

6.2 Conclusion

Based on the results of this study, it can be concluded that:

1. solid state fermentation of PKC with *Pleurotus sajor caju* can improve the proximate composition of PKC especially the crude protein content as well as some mineral contents.
2. including fermented PKC in the diets of broiler chickens (finishers) up to 75% had no adverse effect on weight gain and feed intake, feed conversion ratio increased with increasing inclusion of FPKC.
3. inclusion of fermented PKC as a partial replacement of soyabean meal up to 75% did not adversely affect serum metabolites and hematological characteristics, the carcass characteristics were also significantly improved.
4. protein digestibility was improved at 25% inclusion of FPKC and the cost of raising broiler chickens was reduced by 25% with the inclusion of FPKC in the diets of broiler chickens.

6.3. Recommendations

As a result of the findings obtained in this study, it can be recommended that:

1. solid state fermentation of PKC can greatly improve its nutritional quality to replace soyabean meal in the diets of broiler chickens (finishers) with no adverse effect on performance, carcass value and blood parameters while saving cost of production.
2. further studies should be conducted with other filamentous fungi to ferment PKC for suitability in the replacement of soyabean meal in the diets of broiler chickens.
3. utilization of Fermented PKC in the starting phase of broiler chickens should be researched.

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