COMPARATIVE RESPONSE OF JAPANESE QUAILS FED PALM KERNEL MEAL AND BREWER'S DRIED GRAIN BASED DIETS SUPPLEMENTED WITH *Maxigrain® enzyme*

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NIGERIA.

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NOVEMBER, 2012

DECLARATION

I declare that the work in this thesis entitled "Comparative response of Japanese Quails fed Palm Kernel Meal and Brewer's Dried Grain based diets supplemented with Maxigrain® Enzyme" has been performed by me in the Department of Animal Science under the supervision of Professor (Mrs) A.A. Sekoni and Professor T.S.B. Tegbe.

The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any University.

…….. ……

MAKINDE, OLAYINKA JOHN **DATE**

CERTIFICATION

This thesis entitled "Comparative response of Japanese Quails fed Palm Kernel Meal and Brewer's Dried Grain based diets supplemented with Maxigrain® Enzyme" by **MAKINDE, OLAYINKA JOHN** meets the regulation governing the award of the degree of Master of Science of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This project work is dedicated to the Glory of Almighty God for what He has done, He's doing and what He is about to do in my life; and to my caring parents, Engr. & Mrs. Stephen. Ade Makinde for their support throughout the period this research lasted.

ABSTRACT

Two experiments were conducted to evaluate the growth and egg laying performances of Japanese quails (*Coturnix coturnix japonica*) fed diets containing Brewer's dried grain (BDG) and Palm kernel meal (PKM). In the first experiment, 540 unsexed two week old quail chicks with an average initial weight of 38.00g were raised in cages for 28 days using 3x3 factorial in a completely randomized experimental design. The birds were assigned to nine dietary treatment groups of 60 quail chicks each with three replicates of 20 birds per pen. The diets were formulated to be isonitrogenous (25%CP). Water and feed were offered *ad libitum.* The result of the experiment showed that average daily weight gain of quails fed control diet was similar ($P>0.05$) to those of quails fed diets containing 15%BDG+0%PKM and those fed 15%PKM+0%BDG but was significantly higher ($P<0.05$) than those on other diets. Feed intake of quails increased with increased BDG and PKM levels across the treatments. Quails fed diet containing 30%BDG+30%PKM consumed significantly ($P<0.05$) higher feed compared to those fed the control and other diets. The efficiency of feed utilization revealed a downward trend as dietary levels of BDG and PKM increased. There were significant differences ($P<0.05$) in the carcass parameters measured except for dressing percentage, thigh, liver, intestinal weight and wings which were not significantly affected ($P>0.05$) by the levels of BDG and PKM fed in the diet. Also, there were significant ($P<0.05$) differences in the nutrient digestibility across the treatment groups with control diet significantly higher than all other dietary groups. In the second feeding trial, 270 females (point of lay) were used to study the effect of BDG and PKM based diets on egg production parameters. They were fed nine dietary treatments which were formulated to be isonitrogenous (22%CP) and iso-caloric (2700kcal/kgME). The result of the egg quality characteristics showed no significant ($P>0.05$) difference across the treatments when compared with the control. However, significant differences ($P<0.05$) were observed in the egg production parameters measured. Hen-day egg production, hen-house egg production and peak egg production of quails fed diets containing 15%PKM+0%BDG, 30%PKM+0%BDG, 15%BD G+0%PKM and 30%BDG+0%PKM were similar ($P>0.05$) to the control but significantly ($P<0.05$) higher than all other dietary groups. Thus, utilization of BDG and PKM in quails' diet at 15% inclusion level during grower phase and at 30% inclusion level during the egg laying phase resulted in enhanced growth and egg production performance at the least cost.

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CHAPTER ONE

1.0 INTRODUCTION

Quail is a small migratory bird of Asian and European origin. It belongs to the species *galliformes.* Though there are several domesticated species of quails, only two are popular, these are *Cortunix cortunix* species and *Colinue virjinianus* (Bobwhite quail) which are kept for dual purposes (meat and eggs) and meat, respectively (Thear, 1987; Anon, 1991).

According to Cooper (1989), quail has the potential to serve as an excellent and cheap source of animal protein. Other unique characteristics and advantages of quail over other species of poultry include early attainment of sexual maturity, short generation interval (Anon, 1991), attaining market weight of 150-180g between 5-6 weeks of age and a high rate of egg production of between 180-250 eggs per year (Shwartz and Allen, 1981; Garwood and Diehl, 1987).

Furthermore, quails require less floor space, about 8-10 adult quails can be reared in a space meant for one adult chicken (Haruna *et al*., 1997). They have less feed requirement and require 20-25g of feed per day. Quail meat and egg are of high quality protein with low cholesterol content thereby making it a choice product for hypertension-prone individuals (Haruna *et al*., 1997 and Olubamiwa *et al*., 1999).

Research efforts over the years had attempted to increase the use of cheap agro industrial by-products like wheat offal, rice bran, brewer's dried grain, palm kernel meal and maize milling by-products due to high cost of conventional feedstuffs (Onwudike, 1988). Palm kernel meal (PKM) is one agro industrial by-product that is cheap and readily available. It is aflatoxin free (Sundu *et al*., 2005) and has considerable potential as a carbohydrate and protein source. Similarly, Brewer's dried grain (BDG) is the residue obtained from the production of beer from barley or other grains in a mixture. It is an agro-industrial by-product of the brewing industry and is abundant in many parts of Nigeria. Brewer's dried grains was reported by McDonald *et al*, (1998) to contain about 700-760g water/kg when wet and about 100g water/kg when dry. Same researchers reported its energy value as 2710kcal/kg ME and a crude protein content of 25.3%. They also described BDG as an excellent source of B-vitamins and trace minerals and a potential substrate for the production of microbial protein during fermentation.

Most agro-industrial by-products contain high fibre which are poorly digested by monogastric animals. The use of feed enzyme has progressed a great deal over the past twenty years with respect to efficacy and matching activities with their target substrates. For example, β-glucanases and xylanases for degradation of the β-glucans and arabinoxylans in barley, oats, wheat, rye and triticale have proven efficacy in enhancing the nutritive value of these grains for poultry. The inclusion of microbial phytase to improve the utilization of organic phosphorus is another good example (Onwudike, 1988).

The advent and use of commercial feed enzymes in livestock feeding has opened a new horizon for the use of hitherto waste feedstuff. Atteh (2001) reported 56% and 26% increase in apparent metabolizable energy (AME) of wheat offal and BDG, respectively when diets were supplemented with xylanase enzyme.

With the availability of feed enzymes to improve feed digestibility, there is need to evaluate the feeding value of PKM and BDG supplemented with M*axigrain*® enzyme in quail diets. Therefore, the aim of this study is to compare the dietary effects of M*axigrain*® *enzyme* (a multi enzyme compound of β-glucanase, xylanase, cellulase, phytase) on PKM and BDG based diets fed to quails.

1.1 Research hypotheses

This study was designed to evaluate the following hypothesis:

H_o: There is no significant difference in the performance of quails fed diets containing graded levels of BDG with Maxigrain® enzyme.

H_A: There is significant difference in the performance of quails fed diets containing graded levels of BDG with Maxigrain® enzyme.

H_o: There is no significant difference in the performance of quails fed diets containing graded levels of PKM with Maxigrain® enzyme.

H_A: There is significant difference in the performance of quails fed diets containing graded levels of PKM with Maxigrain® enzyme.

1.2 Objectives of the study

This study was designed to achieve the following objectives:

i. To compare the dietary effects of Maxigrain® enzyme in PKM and BDG based diets on the growth performance of quail chicks.
ii. To compare the dietary effects of Maxigrain® enzyme in PKM and BDG based diets on the egg production parameters of quail hens.
iii. To compare the dietary effects of Maxigrain® enzyme in PKM and BDG based diets on the nutrient digestibility of quail chicks.
iv. To compare the dietary effects of Maxigrain® enzyme in PKM and BDG based diets on the carcass characteristics of quail chicks.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The use of agro-industrial by- products in poultry nutrition

In this decade, human consumption of meat and eggs of poultry has increased. This has resulted in increased need for feed ingredients. Thus, there is great need for alternative feedstuffs, which are not competitive with human foods and can be successfully included in poultry diets to replace the commonly used ingredients.

More recently, the growth of animal feed industry has allowed considerable use of industrial by-products, many of which have some inherent limitations such as high fibre and low energy contents, high bulkiness, low density, low availability of amino acids and anti-nutritive factors (Ishibashi and Ohta, 2000). However, these limitations may be overcome by chemical, physical and biological maneuvering processes, by lowering the amount to be included in diets or by supplementing with the limiting amino acids such as lysine and methionine.

The use of industrial by-products internationally has continued to be of interest to feed manufacturers and poultry nutritionists, and many are being put to use as feed ingredients. The most prominent by-products of plant origin in use today as enumerated by Bello (1984) are mainly of oil seed cake or meals and brewing wastes. The main oil seeds used in farming systems in Nigeria include oil-palm nuts and kernels, cotton seeds, sesame seeds, bambaranuts, groundnuts, melon seeds, coconuts, peanuts, rubber seeds and, increasingly so, soybeans and sunflower seeds. These can be served in their full-fat or partly expressed forms as both energy and protein sources for extensive and intensive poultry systems. It is feasible to include 5 percent full-fat palm kernels and up to 10 percent solvent- or expeller-extracted palm kernel meal (PKM) in broiler starter diets and 15 percent of any of these three forms in broiler finisher diets (Nwokolo, Bragg and Saben, 1997). Successful utilization of PKM in diets of broilers, layers and growers and chicks have been documented severally in literature (Onwudike, 1986; Onifade and Babatunde, 1998; Sundu *et al.,*2005; Akpodiete *et al*., 2006).

Vantsawa *et al*. (2007) reported that maize offal (*dusa*) is a by-product obtained by dehulling maize grain containing the testa, aleurone layer, reasonable quantities of broken endosperm and most of the germ of the grain using the locally fabricated machines. These authors also reported

that large quantities of maize offal are produced in Nigeria since this cereal grain feature prominently in human diets in many parts of Nigeria. This by-product has been successfully fed to finishing broiler chickens at 10% level of inclusion and 40% level of inclusion in broiler starter diets in the presence of 200mg/kg Roxaxyme enzyme, (Onu *et al*., 2006), 100% of *dusa* replaced maize in the diets of egg-type chicks and equal proportion of maize and maize offal could be fed to pullets without adverse effect on performance (Vantsawa *et al*., 2008).

Dogari (1985) replaced 10, 20, 30 and 40% of the maize with sorghum beer residue in the diet of 0-5 week old broiler chickens and reported an insignificant difference in weight gain, feed consumption and feed efficiency when up to 40% of maize was replaced by sorghum beer residue. However, at 20% level of maize replacement with sorghum beer residue in the diet of 6-9 week old broiler chickens, weight gain and feed efficiency were significantly depressed. He observed that age of the bird is an important factor in the practical consideration of the use of sorghum beer residue when weight gains are considered. He suggested that it is practicable to replace up to 40% of the maize in the diet of young chicks of between 0-5weeks and 15% of maize in the diet of older birds (6-9 weeks).

Tyokpat (1999) observed a significant reduction in feed consumption and weight gain without any significant effect in feed efficiency when 30% of re-fermented spent sorghum mash was incorporated in the broiler finisher diet, replacing about 75% of the protein source.

2.2 By-products of the brewing industry

In the brewing process according to McDonald *et al.* (1998), barley is soaked first for about six days and allowed to germinate. During this time, a complete enzyme system is developed for hydrolyzing starch to dextrin and maltose. This first stage is known as the malting process in which the conversion of starch to maltose and other sugars is said to be completed.

After germination just before mashing, the germinated grain (malt) is dried carefully so as not to in-activate the enzymes. The sprouts are removed and are sold as malt culms. The dried malt is crushed and small amount of other cereals (maize or rice) could still be added. Water is sprayed on the mixture and the temperature of the mash increased to about 65°C. The mashing process provides the enzymes with suitable condition for the conversion of proteins and starch to dextrin, maltose and small amount of other sugars. At the completion of the mashing process, the sugary

liquid or 'wort' is drained off, leaving brewers grains as residue, which is sold wet or dried as feedstuff for farm animal(s).

The sugary liquid (wort) is boiled with hops, which gives it a characteristic flavor and aroma. The hops are filtered off and after drying are sold as spent hops. The wort is fermented in an open vessel with yeast for a number of days, during which most of the sugars are converted to alcohol and carbon-di-oxide. The yeast is filtered off, dried and sold as brewers' yeast. The by-products obtained from entire brewing process are malt culms, brewer's grains, spent hops and brewers' yeast.

The main by-products of brewing industries in Nigeria as reported by Bello (1984) which becomes available for livestock and poultry feeding are brewers dried grains and brewers dried yeast. However, with increasing local brewing, another by-products of considerable importance to poultry nutrition is the dried spent sorghum mash which is a residue arising from local brewing of "Burukutu" and "Pito" (Dogari, 1985).

2.2.1 Brewers' dried grains (BDG)

Bello (1984) and McDonald *et al.* (1998) defined BDG as dried extracted residue of barley malt, alone or in mixture with other cereals resulting from the manufacture of wort. The fresh brewers' grains contain about 700-760g water/ kg (Mowat, 1990) and may be given to cattle, sheep and horses in this fresh state or preserved as silage alternatively. The wet product could be dried to about 100g of water/kg and sold as dried brewers' grains. Brewers' grains are reported to have an exposed storage life of about 4-5 days in warm or hot environment and up to 8days in cold weather or periods (Mowat, 1990). Lilly *et al.* (1990) have shown through laboratory and pilot scale studies that wet brewers' grains could be stabilized by incorporating 30% beet molasses and 0.3% potassium sorbate in cooled containers.

Lopez and Pascual (1991) reported that BDG could be produced by oven-drying the wet material at temperature ranges of 80-200^{0}C with minimal losses in the dry matter of the materials. They however observed that oven-drying the grains beyond 3-6 minutes resulted in significant dry matter losses of 18% and therefore concluded that temperature of 100-120°C and oven-drying time of 6 minutes had no adverse effects on the nutrient composition of the dried grains.

2.2.2 Nutrient composition of brewers' dried grains (BDG)

Bello (1984) showed that BDG contained 18-20% crude protein, 6.0% oil, 20.0% fibre, 0.2%Ca, 0.05%P, 0.4%methionine, 50%TDN and 1960kcal ME/kg. Lufadeju (1986) reported the chemical composition of BDG (in g/100g) as; 92.5%dry matter, 3.6% nitrogen, 33.33% acid detergent fibre and 4.6% ash. Almquist (1992) reported that BDG was fairly rich in essential amino acids, with; 0.9% lysine. 0.4% phenylalanine, 1.0% threonine and 1.6% valine. In another study, Oluokun and Olalokun (1995) reported values of 19.78% Crude fibre, 21.65% Crude protein, 7.25% Ether extract, 3.45% Ash, and 47.87% Nitrogen free extract. The nutrient composition of BDG varies from a grain source to another, and method of brewing (Oluokun and Olalokun, 1995). Uchegbu and Udedibie (1998) reported the proximate composition of BDG (maize/sorghum based) as 28.25% Crude protein, 13.12% Crude fibre, 6.70% Ether extract, 7.36% Total ash, 44.57% Nitrogen free extract and 4.23 kcal/g gross energy. Church and Pond (1988) reported the composition of dehydrated BDG as 92% DM, 25.3% CP, 15% CF, 0.29% Ca, 0.52% P, and 2080 kcal/kg of ME. They further gave the amino acid composition as; 1.30% arginine, 0.50% histidine, 1.50% isoleucine, 2.30% leucine, 0.90% lysine, 0.40% methionine, 1.30% phenylalanine, 0.90% threonine, 0.40% tryptophan, 1.20% tyrosine and 1.60% valine. Perry (1990) reported that although the protein content of BDG was high (about 20-30%) it does not contain a good balance of amino acids. Jensen *et al.*(1996) noted that as a result of the conversion or utilization of the starch in the original cereal grains, low metabolizable energy values are associated with the use of BDG in monogastric animals. These workers further noted that the other nutrient components were concentrated, namely: protein, fibre, vitamins, fatty acids and minerals.

2.2.3 Effects of brewer's dried grains on the performance of Poultry

Nelson (1984) reported that 50% replacement of maize with BDG and 5% palm oil supplementation in a broiler starter diet supported satisfactory weight gain, feed consumption and efficiency of feed conversion, while a finisher ration containing 25% replacement of maize with BDG plus 5% palm oil supplement supported optimum weight gain, feed consumption and efficiency of feed utilization. Lopez and Carmona (1991) evaluated BDG at levels of 10, 20, 30 and 40% in broiler diets and reported insignificant differences in average weight gains and feed conversion ratios with up to 20% inclusion level. The above researchers also observed that the

feed intake and dressing percentage of birds were also not significantly affected up to this level. They however observed that when 20% or more of BDG were used, there was significant reduction in abdominal fat pad and meat tissue fat and none in bone tissue fat content, while the digestive tract weighed significantly more. White *et al.* (1989) in a study used BDG from local breweries utilizing sorghum, maize or millets and fed 0, 25 and 40% BDG to laying birds noticed a non-significant differences in egg production parameters at BDG inclusion of 25% while at 40% level, egg weights and production rates fell drastically.

Onwudike (1991) tested BDG at 0, 10, 20, 30 and 40% levels in layer diets. The result indicated that the use of BDG at levels up to 30% resulted in highest feed intake, hen-day production and egg weights. Lopez and Pascual (1991) evaluated spent grains at 0, 15, 30, 45, 60 and 90% levels and indicated that the diet with up to 30% BDG were comparable to the control and adequate for laying hens. The 45% BDG diet was acceptable, but there was a loss in body weight and a drop in eggshell quality. The 60 and 90% BDG diets caused a significant drop in egg production, body weight, egg shell quality and the 90% BDG inclusion eventually led to an inhibition of egg laying.

2.3 Feeding value of Palm Kernel Meal (PKM)

Nutritionally, PKM contains moderate amounts of protein and carbohydrate. Crude protein of PKM ranges from 14 to 21% (Sundu *et al*., 2005). Table 2.1 shows the nutrient composition and physical characteristics of PKM, while Table 2.2 shows the amino acid composition and availability, exceeding 85%, except for valine and glycine. Examination of the physical characteristics of PKM reveals that its bulk density is quite high compared to copra meal (coconut) their respective values are 0.67 and 0.56g/cm^3. Although PKM and copra meal have some common properties in carbohydrate composition, their water holding capacity differs greatly. PKM water holding capacity is half the water holding capacity of copra meal (Sundu *et al.*, 2005).These two physical characteristics bulk density and water holding capacity are important as they affect feed intake (Kyriazakis and Emmans, 1995).

2.4 PKM protein and amino acids

Methionine and lysine are the two most essential amino acids to be considered when using PKM because only about 30% and 50% respectively of these amino acids requirement of young chicks was met by PKM. 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 methionine in palm kernel meal coupled with the low availability of methionine implied that supplementary methionine from other sources were needed when using palm kernel meal as a basal diet. However, palm kernel meal 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.*(2004) that the nutritional requirements for arginine, methionine and lysine were interrelated. Since the rate of arginine to lysine was very high (4:1) and as a consequence of high arginine and low lysine content, the inclusion of palm kernel meal 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 birds. 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 32^0C. The requirement for lysine is increased as levels of arginine increased (Chamruspollert *et al.,* 2004). This justified the importance of considering methionine and lysine when PKM is used in large quantities.

Table 2.1: Nutrient content and Physical characteristics of palm kernel meal

Fractions	Composition	References
Dry matter (%)	94	(1)
Crude protein (%)	14-21	(1) (2) (3)
Gross Energy (Kcal/kg)	4998	(1)
Crude fibre (%)	21-23	(1) (4)
Lipids (%)	8-17	(1) (4)
Ash (%)	3-6	(1) (4)
Bulk density (unmodified)(g/cm^3)	0.67	(1)
Bulk density (0.5mm) (g/cm^3)	0.57	(1)
WHC (1.0mm) (g/water/g feed)	2.82	(1)
WHC (0.5mm) (g/water/g feed)	2.93	(1)

WHC: water holding capacity, (1) Sundu *et al.*(2005). (2) Nwokolo *et al.*(1976). (3) Onwudike, (1986). (4) Sue, (2001).

Table 2.2: Amino acid composition and availability of palm kernel meal

Amino acids	Composition (%)			Availability (%)	0-3weeks of broiler
	(A)	(B)	(C)	(B)	Requirements (D)
Arginine*	2.18	2.68	2.40	93.2	1.25
Cystine	0.20	-	-	-	(Cys+Meth) 0.90
Glycine	0.82	0.91	0.84	63.3	(Glycine+Serine) 1.25
Histidine*	0.29	0.41	0.34	90.1	0.35
Isoleucine*	0.62	0.60	0.61	86.1	0.80
Leucine*	1.11	1.23	1.14	88.5	1.20
Lysine*	0.59	0.69	0.61	90.0	1.10
Methionine*	0.30	0.47	0.34	91.0	(Cys+Meth) 0.90
Phenylalanine*	0.73	0.82	0.74	90.5	(Phenyl+Tyrosine) 1.34
Threonine*	0.55	0.66	0.60	86.5	0.80
Tyrosine	0.38	0.58	0.47	85.0	(Phenyl+Tyrosine) 1.34
Serine	0.69	0.90	0.77	88.7	(Glycine+Serine) 1.25
Valine*	0.93	0.43	0.80	68.4	0.90
Tryptophan*	0.17	-	0.19	-	0.20

* Essential amino acids: (A): Yeong, (1980); (B) Nwokolo *et al*. (1976); (C) Hutagalung, (1980); (D) NRC, (1994).

2.5 Carbohydrate and energy content of PKM

A detailed description of the carbohydrate fraction of PKM has been reported by Knudsen (1997). This author reported that the total carbohydrate of PKM excluding lignin was 50%, of which only 2.4% was of low molecular weight and 1.1% was starch, while 42% is in the form of non –starch polysaccharides (NSPs). This means that 81% of PKM carbohydrate is in form of NSPs. Of the total NSPs present in PKM, the main form is an insoluble non-cellulose polysaccharide accounting for 33.6% of the dry matter. The main sugars in the soluble non-cellulose polysaccharide were mannose and galactose while the sugars in the insoluble non-cellulose polysaccharide were mannose and glucose (Knudsen,1997). The high amount of lignin (13.6%) in PKM, due possibly to the contamination with nut shell (Knudsen,1997) makes this feedstuff gritty and fibrous. Fractionation of PKM based on its proximate analysis revealed that 49% of the dry matter of PKM was in the form of nitrogen free extract (Sue, 2001 and Sundu *et al*., 2004).

It has been shown that 78% of the NSPs is linear mannan with very low galactose substitution, 12% cellulose, 3% glucoronoxylans and 3% arabinoxylans (Dusterhoff and Voragen, 1992). It also contains small amount of galactomannan (Daud and Jarvis, 1992; Dusterhoff and Voragen, 1992; Knudsen, 1997). This type of mannan units are characterized as hard and water insoluble (Warren, 1996). Most palm kernel meal mannan units are extremely hard, highly crystalline and water insoluble (Aspinal, 1970). However, Dusterhoft and Voragen (1992) reported that about 66% of palm kernel meal mannan could be solubilized by sequential extraction with alkali and sodium chloride. The metabolizable energy of palm kernel meal varies and ranged from 2591 kcal/kg (Chin, 2002) to 3959 kcal/kg (Sundu *et al*., 2005). This was due to the fact that the oil content of palm kernel meal varied due to differences in oil extraction process. The higher metabolizable energy values were due to higher residual oil content in the palm kernel meal after the oil extraction by expeller machinery (O'Mara *et al*., 1999).

2.6 Evaluation of the effects of PKM on poultry performance

Research on the use of PKM to establish its feeding value and the maximum inclusion rate in broiler diets has been a major concern in PKM producing countries. Early recommendations on the use of PKM indicated that 20% could be given to broilers without any negative effects on the

performance of birds (Yeong, 1980; Hutagalung, 1980). Onwudike (1986) investigated the possible inclusion of PKM in broiler starter and finisher diets and reported that 28% and 35% respectively could be fed without any ill effect. Later reports suggested that diets containing 40% PKM could be fed to broilers when methionine and lysine were added (Panigrahi and Powell, 1991 and Sundu *et al*., 2004). The different recommendations were due to the source and quality of PKM as these varied widely as shown in Table 2.2 (Nwokolo *et al*., 1976; Yeong, 1980). Panigrahi and Powell (1991) and Sundu *et al*., (2004) formulated balanced diets with the inclusion of methionine and lysine. This indicated that the difference in recommended levels as observed by Yeong (1980) and Hutagalung (1980) could not be from the PKM per se, but from the deficient nutrient in the diet. Amino acids and metabolizable energy are the two important nutrients in diet formulation particularly for diets containing a high fibre ingredient. The feed intake of birds fed a PKM based diet is usually higher than for a maize based diet (Onwudike, 1986; Esiehi and Olomu, 2004; Sundu *et al*., 2005). This was adduced to its faster rate of passage in the digestive tract (Onifade and Babatunde, 1998), high bulk density and its low water holding capacity. Sundu *et al*.(2005) compared the bulk of many poultry feedstuffs and found that the bulk density and water holding capacity of PKM were 0.57g/m^3 and 2.93 water/g feed respectively. These values were very close to the values of bulk density and water holding capacity believed to impair feed intake (Sundu *et al*., 2005). This phenomenon indicates that PKM has potential benefit for poultry provided that the diet consumed can be digested and made available for the birds. Panigrahi and Powell (1991) reported that the inclusion of up to 50% PKM in a diet was tolerated provided that the birds were kept up to 7 weeks of age. Although body weight and weight gain of birds were not affected but digestibility of the diet was impaired. Onifade and Babatunde (1998) and Sundu *et al.* (2005) reported that increased levels of inclusion of PKM decreased feed digestibility, apparent nitrogen retention and apparent calcium retention. This was an indication that a high proportion of PKM nitrogen or protein was located inside cell walls. The water intake of birds fed PKM based diets also increased (Panigrahi and Powell, 1991) and there was increased moisture content of the excreta (Onifade and Babatunde, 1998). The decreased digestibility was a pointer to the fact that broiler chickens have a limited ability to digest dietary fibre, such as α-mannan, because of the absence of any mannan degrading enzymes in the digestive tract of birds. Accordingly, one possible way to ameliorate this problem is to formulate the diet based on digestive nutrients such as amino acid and metabolizable energy

with enzyme application to improve PKM digestibility and to reduce the moisture content of excreta.

2.7 Effect of dietary PKM on Poultry Health

There has been increased interest in PKM over the last five years due to its efficacy in improving the immune system of broilers. Many current findings suggested that PKM could replace commercial manno-oligo-saccharide as a prebiotic to improve chicken health and immunity (Allen *et al*., 1997 and Fernandez *et al.,* 2002).

Poultry diets contain a wide variety of readily digestible carbohydrates such as starch, sugars and oligosaccharides and non-starch polysaccharides (NSPs). Numerous studies on the role of indigestible carbohydrates in digestive tract of chickens over the last two decades have improved our understanding of the role and fate of these carbohydrates. This is now an era when carbohydrates in poultry diets are not only recognized as a source of energy but also has beneficial effects on chicken gut health. Studies in this area is expected to increase in the nearest future as the use of antibiotics in the European Union and North America has been banned over concerns of antibiotics resistance and residues in food products (Philips *et al*., 2004).

Oligosaccharides have been substances of choice to replace antibiotics, due to their capacity to block the colonization of pathogenic bacteria in the intestines of broilers. Among oligosaccharides, fructo-oligosaccharides (Waldroup *et al*., 1993) and manno- oligosaccharide (Fernandez *et al*., 2000) have been of great interest. The efficacy of mannose based carbohydrates, either as manno-oligosaccharide (MOS) (Lyons, 2002) or mannose (Oyofo *et al*., 1989) to improve the immune system of animals has been well accepted. Commercially, the product "BioMos" which is extracted from yeast has been marketed with efficacious effects in 92% of all the animal studies (Lyons, 2002). Allen *et al.*(1997) pioneered research into the use of PKM as a source of mannose based carbohydrates. Since then, several authors reported the success of using PKM to improve the immune system of broilers (Fernandez *et al*., 2000 and 2002). β-mannan in PKM has been reported to have similar properties to the mannan from yeast to increase immunity. Allen *et al.*(1997) reported that the addition of 25g PKM/kg diet reduced the degree of *Salmonella* colonization in the intestinal tract of broilers consuming feed which was inoculated with Sa*lmonella kedeugou*, or *Salmonella enteritidis.* The birds became free of

infection by three weeks of age while birds fed the unsupplemented diet remained infected. The effectiveness of the use of PKM in broiler diets to protect against colonization with *Salmonella* increased to the same level as the use of commercial mannan oligosaccharide (MOS) (Fernandez *et al*., 2000).

In viral disease, PKM appeared to work well. Zulkifli *et al.* (2003) conducted research on Newcastle disease anti-body titre of broiler chickens fed PKM based diets and found that Newcastle disease antibody titre of birds fed PKM diets remained constant throughout a week period of heat stress while broilers fed the control diet had a large reduction in antibody titre.

The mechanism of improvement in the immune system of birds due to the consumption of PKM is still unclear. It may be through several modes of action in which mannose based carbohydrates either β-mannan or MOS, in the PKM are fermented in the caeca due to indigestibility of this fraction. This has beneficial effects in promoting the growth of desirable bacteria. This mode of action is based on the fact that mannose based carbohydrate in PKM increased the growth of non-pathogenic bacteria, such as *Bifidio bacterium spp* (Fernandez *et al*., 2002). One of the products of fermentation in the caeca is an increased concentration of lactic acid (Wang and Gibson, 1993; Okumura *et al*., 1994) and this prevents the growth of pathogenic species such as Salmonellae. The ability of PKM to reduce the population of pathogenic bacteria in the gut has been found in four-week old broiler chickens (Fernandez *et al*., 2002).

Another possible mechanism of action is that dietary MOS from PKM may attract micro organism away from the intestinal binding sites. Mannan-oloigosaccharides have been reported to have receptor sites for the fimbriae of *E.coli* and *Salmonella spp* which resulted in elimination of these particular bacteria as the digesta flows out (Spring *et al.,* 2000). Accordingly, colonization of the microbes in that organ decreases and thus the birds are less susceptible to these organisms.

2.8 Fibre in monogastric nutrition

The digestibility of a feed ingredient is closely related to its chemical composition. The fibre fraction of a feed has the greatest influence on its digestibility and both the amount and chemical composition of the fibre are important (McDonald *et al.,*1998).

High fibre basal diets according to Yaakugh (1986) are normally fluffy and carry a low proportion of nutrients per unit volume rather than per unit weight. He affirmed that substituting high fibre feeds (on weight for weight basis) would generally result in reduced nutrient intake by animals and higher fibre levels in the diets. Industrial by-products of plant origin (especially those of milling and brewing industries) are marked with a high level of crude fibre, which limits their use in monogastric nutrition. In ruminants, the large microbial population residing in the rumen contains enzymes capable of hydrolyzing the fibrous materials present in the cell walls, particularly those associated with the leaf and stem portion of the plant and outer bran layer of seeds. Non ruminant animals (horse, pigs and human) utilize some of these fibrous feeds to a small extent by virtue of the presence of similar microbial population residing in the colon and cecum (McDonald *et al.,* 1998).

Maisamari (1986) asserted that in the feeding of farm animals, it is important to know the fibre composition of various feeds since fibre of different origin is often digested differently and their nutritional value varies for different animal species.

2.8.1 The effect of fibre in pig nutrition

In feeding trials with pigs, Delic *et al.* (1997) evaluated BDG as a protein source where it constituted 10% of the diet and observed a better feed consumption per unit live weight gain. Improved live weight gains were recorded when lysine was added to the diets. More muscles were deposited per kilogram weight gain. The improved gains recorded on lysine supplementation revealed lysine inadequacy in BDG as a feed ingredient.

Kornegay (1993) fed BDG at 0, 25, and 50% levels to growing pigs and discovered an insignificant difference in feed requirement per unit gain. At 50% level, the average daily feed intake was depressed and there was no significant difference in average daily gains. Buthia *et al*. (1995) fed growing pigs with 0, 40, 50 and 60% levels of BDG and reported that up to 40% inclusion rate depressed gains with longer time to attain 60kg weight.

Dairo (1999) evaluated the effect of sorghum distillers waste (SDW) at 0, 10, 15 and 20% levels of inclusion on the performance of weaned pigs and observed the average daily feed consumption to be influenced signicantly. It was observed that pigs on 15% SDW had the highest feed intake, while those on 0% SDW had the lowest feed intake. Similarly, Mowat

(1990) observed that at growing and finishing phases, pigs on 0 and 10% SDW had the highest feed consumption. Higher inclusion levels of 20 and 30% SDW resulted in marked decrease in feed intake.

Research has also shown that higher levels of dietary fibre in pigs depress growth and increases feed intake significantly. Frank *et al*. (1984) fed 0, 7.5 and 15% corn cobs to growing pigs and reported linear decrease in average digestible energy intake.

2.8.2 Effect of fibre in poultry nutrition

Studies have been carried out to investigate various effects of fibre in poultry nutrition. Church and Pond (1988) have established the favorable effects of fibre inclusion in poultry diets. They stressed the need to incorporate fibre in concentrate mixtures to attain an amount of bulk in order to avoid the formation of dough-like mass in the stomach, which is not readily attacked by digestive enzymes. For the unfavorable effects of fibre in the diet, the authors revealed that fibrous feeds might decrease the digestibility of crude protein and ether extract. They claimed that increased bulkiness of the ration consequent to the inclusion of fodder might lead to a more imperfect contact between proteolytic enzymes and the basal feed. There is further possibility that the presence of the fibre may speed up the rate of passage of food through the simple stomach of monogastrics. The authors further stated that fibrous feeds may increase the output of nitrogenous material into the faeces thus causing a depression of the apparent digestibility and increased nitrogen excretion through ionic interaction matrix restriction and modification of filtration characteristics of the fibre components.

McDonald *et al.* (1998) stated that the crop by virtue of its physical similarity to the rumen of ruminants may have the potential for digestion of lower quality fibrous diets that are presently being fed to poultry. It was concluded that fibre aids digestion since it stimulates peristalsis and secretion as well as opening up concentrate feeds and bringing them into contact with digestive juices. Feed consumption and body weight gains especially in meat type birds decreased when birds were fed high fibre diets (Ndams, 1991).

2.9 Enzyme supplementation of poultry diets

The main goals of enzymes supplementation of poultry diets include:

1. To remove or destroy the anti-nutritive factors in some feed ingredients.
2. To enhance the overall digestibility of the feed to render certain nutrients biologically more available.
3. To reduce environmental pollution from animal excreta by reducing dry-matter excretion.
4. To allow the use of a wide range of ingredients without compromising bird performance and provide great flexibility in least –cost feed formulation.

To achieve these goals, enzymes must be able to withstand the processing of feed and resist the acidic conditions and proteolytic enzymes in the proventriculus and gizzard.

The feed industry formulates poultry diets on the basis of least cost. Under these circumstances, the price of cereal and the nutrient content will determine whether a cereal enters the computer formulation. With the introduction of enzymes, nutritionists are able to release more of the nutrients available in a particular cereal thereby making it more competitive with corn. Supplementation of feeds with enzymes could increase the energy available in wheat by 6-8%. Phytase use is reported to reduce phosphorus excretion by as much as 40% in broilers. When phytase was added to layer diets, egg production increased and positive effects on egg weight was observed (Simons and Versteegh, 1991).

The hidden benefits of using glycanases in birds fed viscous cereals include (a) reduction in output of manure containing large amounts of undigested nutrients, and (b) alleviation of problems associated with wet droppings, such as increased percentage of dirty eggs, increased gas production (i.e. ammonia) and increased flies and rodent populations in the shed. However, glycanase supplementation was not the answer to problems associated with phosphorus levels in pig and poultry manure. This has led to the development of phytase for use in monogastric animal diets. Phytase increases the digestibility of phytate from around 25% to 70% in poultry (Ravindran *et al*., 1999) and its use has been on the increase since the ban on the use of animal protein sources, such as meat and bone meal was introduced in the European Union. It is also understood that phytase can improve the digestibility of other nutrients as well as energy (Ravindran *et al*., 1999, 2000; Kornegay, 2001).

Cereal by-products, such as rice bran and brewers dried grain are important feed ingredients but their efficient use in monogastric diets is hindered by the presence of high levels of NSPs and phytate. Supplementing ducks diets with microbial phytase allowed rice bran to be used at high level (up to 60%) without detrimental effects, phosphorus excretion was reduced by 9.6%, and sufficient decrease in excretion of manganese, copper and zinc were also noted (Simons and Versteegh, 1991). Supplementary enzymes have found only limited practical use in animal nutrition until recently. The main reason was an unfavorable relationship between enzyme cost and their benefits. However, due to the advances in biotechnology leading to cheaper production costs, economical uses of enzymes in animal nutrition are now possible (Broz and Perrin-Voltz, 1994). There is increasing experimental evidence that specific enzyme complexes used as feed additives may offer a practical means of enhancing the nutritive quality of various low-energy cereals for poultry. Increasing interest in application of feed enzymes resulted in the development of specific preparations designed for particular feed.

2.10 Substrate structure and enzyme affinity

Matching an enzyme activity with a substrate does not guarantee the efficacy of the enzyme in degrading the substrate. Currently, most of the glycanases used in the poultry industry target the soluble carbohydrates in an endo-active manner, i.e. cleaving the molecules from the middle to reduce the molecular size with little or no monomeric sugars released (Bhat and Hazlewood, 2001). Substrate specificity depends largely on the source of the enzyme. Choct *et al*. (2004) reported three xylanases that have different substrate affinities. A xylanase derived from *Thermomyces lanuginosus,* significantly increased the soluble NSP content of the small intestinal digesta, but decreased its viscosity, whereas a xylanase derived from *Humicola insolens* markedly increased both the content of the soluble NSP in the small intestine as well as its digesta viscosity. This clearly demonstrated that the xylanase from *T. lanuginusos* had affinity for both soluble and insoluble arabinoxylans, e.g. whilst releasing soluble Non-starch polysaccharides (NSP) from the insoluble cell wall xylans, it also degraded them into smaller polymers, but that from the *H. insolens* had affinity for only the insoluble cell wall xylans. The third xylanase reported by the author was from *Aspergillus aculeatus,* which effectively degraded the soluble arabinoxylans, but had no effect on the insoluble fractions. The NSP degradation patterns appear to indicate that enzymes having affinity for both soluble and

insoluble NSP will be more efficacious. However, these differences, in general did not translate into apparent differences in bird performance despite some numerical trends.

Each grain of Maxigrain® contains cellulase (10,000 i.u.), Beta-glucanase (200 i.u.), Xylanase (10,000 i.u.), Phytase (2500 FTU).

Cellulase breaks down cell-wall for more energy and relocked nutrients. Xylanase and β-glucanase degrades non-starch polysaccharides in feeds. Phytase efficiently releases bound phosphorus from plant phytates and also liberates minerals and amino acids.

Benefits include:

• Optimisation of metabolizable energy and feed conversion efficiency (FCE).

• Increased use of low cost non- conventional feed ingredients.

• Reduction in requirement of di-calcium phosphate (DCP) or bone meal in feed.

• Significant improvement in better quality and dropping consistency of feces.

• Improvement in weight gain.

• Improvement in egg production and shell quality.

Monogastric animals do not have the endogenous enzymes to hydrolyse non-starch polysaccharides contained in fibrous feed materials, as a result of this, exogenous enzymes must be added into their diets to improve digestion.

2.11 Mechanism of exogenous enzyme actions

Enzyme action involves the formation of a complex between the enzymes and the substrate to be acted upon. The complex then undergoes breakdown yielding the products and the unchanged enzyme. The complexes are formed between the substrate or substrates and relatively few active centres on the enzymes (McDonald *et al*., 1983). It may be due partly through the mechanism of decreasing digesta viscosity (Dingle, 1995). Sundu *et al*. (2005) reported that the use of mannan degrading enzymes decreased jejuna digesta viscosity of birds fed palm kernel meal diet by 3-4%, and when mannan degrading enzymes were used in combination with a mixed enzyme

preparation (Maxigrain®), a greater reduction of about 27% was found in jejuna digesta viscosity.

Since the use of mannan degrading enzymes increased digestibility of dietary fibre, protein and lipid, that means that protein and lipid located inside cell walls contained mannan. So, when mannan is broken down by exogenous enzymes, the accessibility of endogenous protease and lipase to attack protein and lipid is enhanced. However, when a combination of enzymes containing mannan degrading enzymes and a multi-enzyme (Allzyme SSF) was used, dry matter digestibility and NDF digestibility were further increased. The increase in nutrient digestibilities in turn helped to increase the apparent metabolizable energy of a palm kernel meal diets. Importantly, the moisture content of faeces was drastically reduced by 16-23% when mannan degrading enzymes were included in palm kernel meal diets (Sundu *et al*., 2004). The above is beneficial for alleviating the problem of wet feces which is one of the main issues in the poultry industry today.

2.11.1 Responses of Broilers to enzyme supplementation

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 by increasing energy digestibility (Patridge and Wyatt, 1995; Ven der Klis *et al.,* 1995). Enzyme supplementation improves carbohydrate digestibility, reduces gut viscosity, and improves fat utilization (Almirall *et al*., 1995). The improvements from enzyme supplementation are varied because of the variability in the NSP content of wheat. Classen *et al*. (1995), Schutte *et al*. (1995) and Ver der Klis *et al*. (1995) reported improvement of 5-16%, 3.1-4.5%, and 4.5-12.4% respectively. The increase in available metabolizable energy with the use of enzymes is difficult to predict, as nutrient ratios, such as energy: protein, and other factors also play an important part in poultry feed formulations. The importance of energy compensation in feed formulation was demonstrated in a cost benefit study in Australia in 1991 (unpublished data). A wheat based diet was formulated with or without enzyme supplementation, 5% increase in apparent metabolisable energy (AME) was observed in the diets with enzyme supplementation. It also improved growth and feed efficiency, the cost per kilogram of birds produced in the enzyme-treated group was 1.3% lower than in the wheat-control group. Compensating for the additional energy further improved production characteristics and also reduced feed cost, giving a reduction in cost of feed per kilogram of

8.8% compared with the wheat control. Partridge and Wyatt (1995) cited similar benefits when allowances were made for the improvements in energy and amino acid digestibility. The problem in feed formulation is estimating the correct energy allowance for wheat-based diets. A conservative 5-6% upgrading of the AME of wheat is recommended for commercial situations. This allowance effectively improves the energy value of wheat to about 13800KJ/kg in a least cost matrix, bringing the value of a wheat-enzymes combination closer to that for maize and allowing the use of less supplementary energy. Amino acid adjustments may also be made, as enzyme supplementation also improves protein digestility (Bedford, 1992; Partridge and Wyatt, 1995). The digestibility of amino acids increased by 10% with added enzymes (Bedford, 1992; Ward, 1995). Responses to enzyme supplementation depend on age of birds, which is apparently related to both the type of gut microflora present and the physiology of the bird. Older birds, because of the enhanced fermentation capacity of the microflora in their intestines, have a greater capacity to deal with negative viscosity effects (Allen *et al*., 1995; Choct *et al*., 1995; VukicVranjes and Wenk, 1993).

The dry matter content of the litter of wheat or barley fed broiler chickens is improved (reduced sticky droppings) by adding enzymes to their diets (Wiedmer and Volker, 1989; Jansson *et al*., 1990; Mohammed, 1995). The improved litter condition reduced ammonia build up in pens and reduced the incidence of hock burns and breast blisters. Also, birds fed high- barley or high-wheat diets have been shown to have elevated intestinal weight which negatively affected the carcass yield. This negative effect is reduced after supplementation with the appropriate enzymes (Francesch *et al*., 1989; Jeroch and Danicke, 1993).

2.11.2 Responses of Laying hens and quails to enzyme supplementation

The response of laying hens and quails to enzyme-supplemented feeds are also well documented. Enzymes added to layer feed appear to have little effect on egg mass but improve efficiency of feed utilization (VukicVranjes and Wenk, 1993; Benabdeljelil and Arbaoui, 1994), energy utilization (Wyatt and Goodman, 1993; VukicVranjes and Wenk, 1993), and egg laying rate (Poultry International, 1996).

Wet litter arising from the use of barley and newly harvested wheat can result in an increased incidence of dirty egg shells and ammonia build up in poultry pens. Adding enzymes to both

wheat and barley-based diets has been shown to reduce the moisture content of fecal matter in layers (Marquardt *et al*., 1994), this means that barley can effectively be used if diets are supplemented with the appropriate enzymes.

Egg-yolk pigmentation should be considered if yellow maize is excluded from the diets. Wheat and barley contain very low levels of xanthophylls and if these grains are fed to layers, the yolk will be practically colorless. The diets therefore need to be supplemented with dietary carotenoids. The quantity required is well documented because of the extensive use of wheat and barley in the layer feed (Bird, 1994). Pigments are fat soluble compounds and are therefore less efficiently absorbed in the presence of highly viscous compounds such as those found in barley-based diets (Benabdeljelil and Arbaoui, 1994; Poultry International, 1996). Therefore, if barley and wheat-based diets are being supplemented with enzyme where yolk coloration is desired, appropriate pigments should be added.

2.11 Enzyme supplementation and improved poultry health

Morgan and Bedford (1995) reported that coccidiosis problems could be prevented by using enzymes. Birds fed wheat-based diets with and without enzyme (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 supplemented group, which also had a better lesion score. An increase in digesta passage rate and a reduction in excreta moisture were often noted when enzymes were added to poultry diets, which may be detrimental to the life cycle of the organism (Ravindran *et al*., 1999). In the study of Kornegay (2001), he observed a reduction in the moisture content of the excreta when glycanase was included in the diet.

Elevated levels of intact soluble NSPs detrimentally increased the activity of fermentative micro organisms in the small intestine. Enzyme (xylanase) supplementation largely eliminated fermentation in the small intestine and improved the performance of the birds.

2.13 Nutrient Requirement of Japanese Quails

Optimal growth and production like in other birds are determined by feeding well balanced rations. At chick stage between 0-5 weeks of age, quail chicks have been found to grow very

well on a ration containing 22-25% crude protein with 2800MEkcal per kg feed (Haruna *et al.,*1997).

There are several forms in which a balanced ration may be fed to quail such as mash, pellets or crumbs. In the tropics, as in the case of Nigeria, mash feeding system is being used. Feed is usually given *ad libitum.* Broiler starter or turkey starter ration containing between 24-28% crude protein is required during brooding as reported by Shim (2004). Local farmers may use broiler starter and layer diet for their growing and laying quails and supplement them with high protein ingredients, such as fishmeal, soyabean meal and skimmed milk. Haruna *et al.* (1997) reported further that fast early growth is achieved with high protein diets. Moreso, Japanese quails, which mature at 5-6 weeks of age respond favorably to higher dietary protein concentration.

Just prior to maturity, dietary requirements of quails are similar to that of chicken except for requirement of calcium (1.5%) and phosphorus (0.8%), (Shim, 2004). The bird will require approximately 25g of feed per head per day. However, Whyte *et al.*(2000) observed that feed intake increased with increase in protein level at energy level of 2800MEkcal/kg. Notwithstanding, they submitted that crude protein contents of the diets had no significant effect on the average feed consumption of the birds. In addition, they stated that feed intake per bird increased with age. Meanwhile, the requirement for specific nutrients has been well documented for this specie (Haruna *et al.,* 1997).

2.13.1 Energy Requirement of Japanese Quails

NRC (1994) recommended 2900 MEkcal/kg while Shim and Vohra (1984) suggested 2800 MEkcal/kg. Although, earlier findings had recommended an energy requirement of between 2600-2800 ME kcal/kg diet for starting and growing quails. Recent reports by Shrivastav and Johri (1994) showed that 2750 ME kcal/kg was adequate for both quail layers and breeders, whereas, Hardy (1981) reported faster growth at 3200 ME kcal/kg. Syed *et al.* (2000) reported optimum performance at 2800 ME kcal/kg. Furthermore, Soares *et al.* (2003) discovered that 2900 ME kcal/kg diet was efficient for growing and laying Japanese quails. According to Laseinde and Oluyemi (1997), feed consumption was significantly higher for lower energy diets. Haruna *et al.*(1997) suggested 2800 ME kcal/kg for growing quails in Nigeria.

2.13.2 Protein Requirement of Japanese Quails

The dietary protein requirements of Japanese quail are influenced by metabolizable energy content and the ingredients used to formulate the diets. In a study investigating the response of growth and carcass quality traits to dietary protein concentration, Mishra *et al.*(1988) found that diets containing 24% crude protein supplemented with methionine and lysine were as efficient as those with 27% protein for maximum growth performance. Haruna *et al.* (1997) submitted that quail performed better at 22% and 25% crude protein, however, it was reported that an attempt to reduce the protein level to 21% at third week depressed quail growth. It was also concluded that quail chicks grow very efficiently at minimum of 22% crude protein with a metabolizable energy of 2800 ME kcal/kg up till 6weeks of age. For breeders, a protein content of 20-22% CP has been recommended (Vohra, 1991) while Kumar *et al.*(1998) used and recommended 17% CP for laying Japanese quail.

Protein requirement, with or without dietary casein of different quail lines (meat line, egg line and white egg shell line) were also studied up to five weeks of age (Shrivastav and Panda, 1988). Result indicated that inclusion of casein reduced the dietary protein requirement of 24% in the white egg shell line whereas it significantly improved the body weight of the meat line, even at 27% dietary protein, suggesting that maintaining the quality of the dietary protein is more important than concentration alone in diet formulation. Igbasan and Guenter (1999) concluded that decreasing the dietary protein during the later part of egg laying cycle significantly improved egg production and feed utilization with negligible effect on egg weight and egg shell quality.

Whyte *et al.*(2000) showed that increased level of crude protein in diet had a significant effect on the average weight of adult quail birds. This finding agrees with the report of Okeke and Oluyemi (2003) who reported faster growth rates and higher reproductive ability in quail fed with higher levels of protein.

2.13.3 Vitamin Requirement of Japanese Quails

Housed quails are entirely dependent on the vitamins that are present in their compounded feed in the correct amount and proportion, for they have no access to the natural supply of these nutrients. Vitamins are only needed in small amounts and are needed by chickens to grow well (Martina, 1996). According to report from Mississipi State University (1997), vitamins are always added to feed in amounts that meet minimum dietary requirements. During period of stress caused by disease, shipping or sudden changes in the environment, it is recommended that vitamins and electrolytes be provided in the drinking water until the stress condition is corrected. The principal vitamin functions and requirement are as follows:

The principal feature of vitamin A is its functions in ensuring adequate growth and as a means of assisting in the bird's resistance to diseases. Vitamin A is essential for normal vision, egg production, and reproduction. NRC (1994) recommended 1650 IU per kg vitamin A for starting and growing birds and 3300 IU/kg for breeding quails.

A deficiency of vitamin E causes a disease of the nervous system in chicks known as "Crazy chick disease" (Encephalomalacia). Vitamin E is also essential to breeding stock for the good hatchability of their eggs (Shim *et al.,*1983). According to Shim (2004), the fertility and hatchability of quail eggs were severely depressed after the birds were fed a diet containing glucose and soyabean meal, but deficient in vitamin E for 20 weeks. It was found that encephalomalacia or muscular dystrophies were observed in quail fed vitamin E deficient diets for 35 weeks.

The B vitamins are well distributed in cereals and grains deficiencies are normally unlikely to occur. The main functions of vitamins are to assist the quail in achieving its optimum growth. According to Shim and Bocy (1988), breeding Japanese quail may have higher requirements for thiamin than breeding fowls which is reported to be 0.8mg thiamine/kg.

Vitamin D exists in two forms (D_2Ergocalciferol and D_3Cholecalciferol). Vitamin D can be synthesized in the skin of birds from precursors when the birds are exposed to the sun. However, when birds are kept under intensive condition, some forms of supplementation are essential and these can be provided by addition of fish-oils to the diet or by a dry synthetic preparation.

Synthetic Vitamin D should be given to birds in form of D_3 in food formulation because birds use D_3 more efficiently than D_2 (Shim and Bocy, 1988).

2.13.4 Mineral Requirement of Japanese Quails

Minerals are the inorganic elements remaining when feedstuff is burned. Calcium and phosphorus account for about 75% of the total mineral content of ash. Dozier and Bremwell (2002) and Laimingthanga *et al.*(1990) investigated the effects of dietary concentration of manganese in relation to that of calcium on growing performance of Japanese quails and reported 0.8% calcium and 60mg/kg manganese for optimum growth, feed efficiency, tibia weight, bone ash and serum calcium and phosphorus.

Meanwhile, Shrivastav and Shukla (1993) found that fertility was not related to dietary manganese or zinc concentration. According to findings from Mississippi State University (1997), chicks require high levels of minerals for proper bone formation and development.

2.13.5 Water Requirement of Japanese Quails

Water makes up the basic medium in the body for the transportation of nutrients, metabolic reactions, elimination of waste products, and to aid in maintenance of body temperature (Mack, 1989). Water is not often thought of as a nutrient itself, but it is indeed a very important one. According to Smith (2005), the function of water in the body of animals include; regulation of body temperature, transportation of nutrients and taking part in numerous chemical reactions in the body. Furthermore, water requirements (volume) of poultry are often crudely estimated by multiplying the amount of feed eaten by two. However, under hot conditions, animals drink substantially more water. Mississippi State University (1997) reported that many producers overlook the importance of providing clean, fresh water to their flocks, but that though not considered a nutrient by many producers, water is the most important nutrient for animals.

2.14 Environmental Temperature and Quail Growth

Ozbey *et al.* (2004) reported that high temperature affect live weight and growth performance of Japanese quail negatively. Moreover, they reduce carcass weight and output. This report is similar to the works of Poyraz *et al.* (1991), Okan (1999) and Ozbey and Ekmem (2000). It has been statistically demonstrated that high temperature (35^0C) decreased feed consumption and

capacity of benefiting from feed (Das *et al.,* 1990; Ozbey and Ekmem, 2000 and Ozbey *et al.,* 2004).

2.15 Adult Features of Japanese Quails

The adult male *cortunix* according to Shim (2004) weighs about 100-140 grams. The male birds can be identified readily by the rusty brown color feathers on the upper throat and lower breast region. Male Japanese quail also have a cloacae gland, a bulbous structure located at the upper edge of the vent. This gland secretes a white foamy material. This unique gland can be used to access the reproductive fitness of the male (Cheng *et al.,* 1985). The young males begin to crow at 5 to 6 weeks old. Generally, in their wild form, the birds are restless, nervous and timid but quite inquisitive (Hertrampf, 1987).

The adult female *Coturnix coturnix* according to Shim (2004) is slightly heavier than the male. An average female Japanese quail weighs from 120-160 grams. The body coloration of the female bird is similar to the male except that the feathers on the throat and upper breast are longer, pointed and lighter cinnamon. Also, the light tan breast feathers are characteristically black.

2.16 Eggs of Japanese Quails

Coturnix eggs are characterized by a variety of colour pattern. They range from snow white to completely brown. They are commonly tan and dark brown speckled or mottled brown with a chalky blue covering (Shim, 2004). The average egg from a mature female weighs about 10 grams. Das *et al.* (1990) compared the egg production efficiencies and percentage egg composition of domestic fowl, ducks and Japanese quail reported from practical farm experience that quail were at least equal to and possibly better than duck in this respect.

CHAPTER THREE

3.0 Materials and Methods

3.1 Experimental site

The study was conducted at the Poultry unit of Animal Science Department, Ahmadu Bello University, Zaria, Nigeria. It is located at latitude 11^0 9' 45'' N and longitude 7^0 38' 8''E, at an altitude of 610m above sea level (Ovimaps, 2012).

3.2 Sources of the Experimental Materials

The Brewer's dried grain and Palm kernel meal used in this study were obtained from Rebson feed-mill, Zaria, Kaduna State, Nigeria while the quail chicks were purchased from National Veterinary Research Institute (NVRI) Vom, Jos.

3.3 Determination of the chemical composition of feed ingredients used

Samples of the experimental diets were taken to Animal Science Biochemical Laboratory for proximate analysis using the methods described by A.O.A.C. (1990). The analysis was done to obtain the nutrient composition (dry matter, crude protein, ether extract, crude fibre, ash and nitrogen free extract) of the diets. Protein was determined by Kjedahl procedure, ether extract was determined by subjecting the samples to petroleum ether extraction at 60-80°C using the Soxhlet extraction apparatus. Dry matter was determined by oven drying the samples at 100°C over a 12-hour period. Crude fibre was determined by boiling the sample under reflux in weak sulphuric acid (0.255N H_2S04), then in weak sodium hydroxide (0.312N NaoH) for 1 hour. The residues which consist of cellulose, lignin and mineral matter was dried and weighed. The ash content was determined by igniting a weighed sample in a Muffle furnace at 600°C. The nitrogen free extract (NFE) was obtained by the difference after the percentages of the other fractions were subtracted from 100%. Gross Energy (GE) was determined by using the Ballistic Bomb Calorimeter (Model-I).

3.4 Experimental Design

Two 3 x 3 factorial trials in Completely Randomised Experimental Design (CRD) were conducted. There were nine treatments and three replications for each of the two experiments.

3.5 Diets for Experiment 1

Effects of feeding graded levels BDG and PKM based diets supplemented with Maxigrain® enzyme on the performance of quail birds (2-6weeks).

The diets for experiment 1 were as follows:

Diet 1 (Control) contained 0%BDG + 0%PKM

Diet 2 contained 0%BDG + 15%PKM

Diet 3 contained 0%BDG + 30%PKM

Diet 4 contained 15%BDG + 0%PKM

Diet 5 contained 15%BDG + 15%PKM

Diet 6 contained 15%BDG + 30%PKM

Diet 7 contained 30%BDG + 0%PKM

Diet 8 contained 30%BDG + 15%PKM and

Diet 9 contained 30%BDG + 30%PKM

The diets were formulated to be iso-nitrogenous (25% CP). The ingredient composition of the experimental diets is presented in Table 1.

Table 3.1: Percentage composition of Starter/Grower diets containing graded levels of BDG and PKM supplemented with Maxigrain® enzyme (2-6weeks).

	Dietary treatments								
Ingredients	1 0%BDG+ 0%PKM	2 0%BDG+ 15%PKM	3 0%BDG+ 30%PKM	4 15%BDG+ 0%PKM	5 15%BDG+ 15%PKM	6 15%BDG+ 30%PKM	7 30%BDG+ 0%PKM	8 30%BDG+ 15%PKM	9 30%BDG+ 30%PKM
Yellow Maize	52.76	37.75	30.25	40.30	30.25	22.75	30.25	22.75	15.25
Full fat soyabean	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Groundnut cake	27.79	27.79	20.29	25.24	20.29	12.79	20.29	12.79	5.29
Brewers dried grain	0.00	0.00	0.00	15.00	15.00	15.00	30.00	30.00	30.00
Palm kernel meal	0.00	15.00	30.00	0.00	15.00	30.00	0.00	15.00	30.00
Limestone	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Bonemeal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Maxigrain®	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total	100	100	100	100	100	100	100	100	100
Calculated Analyses									
ME(Kcal/kg)	2868	2898	2856	2893	2828	2801	2800	2801	2800
Crude protein (%)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Crude fibre (%)	4.81	4.48	4.64	4.60	4.79	5.95	4.94	6.10	7.26
Total P. (%)	0.85	0.82	0.85	0.83	0.80	0.81	0.81	0.80	0.82
Lysine (%)	1.11	1.15	1.11	1.17	1.15	1.17	1.10	1.17	1.15
Methionine (%)	0.55	0.54	0.55	0.54	0.57	0.59	0.53	0.57	0.55
Arginine (%)	1.30	1.81	1.92	1.32	1.85	1.95	1.45	1.38	1.98
Valine (%)	0.90	0.93	0.94	0.90	0.93	0.93	0.91	0.90	0.92
Lysine:Arg. Ratio	1:1	1:1	1:2	1:1	1:1	1:2	1:1	1:1	1:2
Ether extract (%)	5.30	5.35	5.30	5.25	5.48	5.57	5.40	5.37	5.45
Calcium (%)	1.47	1.40	1.47	1.48	1.35	1.29	1.35	1.40	1.41
Cost/kg of Diet (₦)	82.34	76.48	68.76	76.45	69.36	61.63	69.96	62.23	54.51

*Biomix premix provided per kg of diet: vit.A, 10,000i.u; vit,D3, 2000i.u; vit.E, 23mg; vit.K, 2mg; calcium pantothenate, 7.5mg; vit.B12,0.051mg; folic acid,0.75mg; sodium chloride,300mg;vit.B1,1.8mg;vit.B2,5mg; manganese,40mg; iron, 20mg; zinc, 30mg; copper, 3mg; iodine,1mg; cobalt,0.2mg;selenium,0.3mg.

Table 3.2: Nutrient Composition of Starter/Grower diets containing graded levels of BDG and PKM (2-6weeks)

Treatments	1	2	3	4	5	6	7	8	9
Parameters	0%BDG+ 0%PKM	0%BDG+ 15%PKM	0%BDG+ 30%PKM	15%BDG+ 0%PKM	15%BDG+ 15%PKM	15%BDG+ 30%PKM	30%BDG+ 0%PKM	30%BDG+ 15%PKM	30%BDG+ 30%PKM
Dry matter (%)	94.55	93.41	91.68	91.86	93.33	95.01	94.55	92.36	94.11
Crude Protein (%)	24.71	24.30	25.06	24.11	24.72	24.37	24.26	24.45	24.49
Crude fibre (%)	5.18	5.39	5.79	5.54	5.66	6.04	5.38	5.40	6.08
Ether extract(%)	6.01	5.86	6.19	6.08	5.56	5.81	5.94	6.02	5.73
Ash (%)	7.48	8.41	8.39	7.81	7.56	7.91	8.04	8.23	9.10
Nitrogen free extract (%)	56.62	56.04	54.57	56.46	56.50	55.87	56.38	55.90	54.60

3.6 Experimental Procedure for Experiment 1

Five hundred and forty (540) one-week-old quail chicks obtained from NVRI, Vom, Jos were used for this experiment. The birds were weighed and fed the control diet shown in Table 3.1 during a one-week adjustment period.

At two weeks of age, they were randomly assigned to nine treatment groups and fed nine isonitrogenous experimental diets formulated to contain 25% Crude protein. The treatments were replicated three times with twenty quail chicks per replicate pen. The birds were kept under standard management practices such as brooding, feeding etc required for quail production. Feed and water were supplied *ad-libitum* during the trial feeding period which lasted 28 days.

During the growth phase, the birds were weighed weekly and their performance characteristics monitored interms of average daily feed intake, average daily weight gain and feed conversion ratio.

3.7 Carcass evaluation.

At the end of the 4-week feeding trial, the birds were sexed and four male birds were selected from each pen based on their average weight, they were starved for 10hrs, weighed, slaughtered by 'Modified Kosher' method as described by Abe *et al*. (1996) and dressed at the Meat Products Laboratory, Animal Science Department, Ahmadu Bello University, Zaria. The breast, thigh, drumstick, wings, back, heart, liver, gizzard and intestines were removed and weighed individually and expressed as a percentage of dressed weight according to the procedures.

3.8 Digestibility Trial

During the last week of the Experiment 1, 4 birds were selected from each replicate pen making a total of twelve (12) birds per treatment. The birds were housed in metabolic cages to observe a week adjustment period before faecal collection period which lasted 7days. Trays were placed under each cage for total faecal collection. Water and feed were made available *ad libitum* throughout the 7-day trial period time. The droppings were collected daily, air-dried, weighed, pooled and then stored in a freezer for the 7-day period. The droppings were thawed, thoroughly mixed and samples obtained for laboratory analysis. The dried samples were assayed for proximate composition (Dry matter, Nitrogen, Ether extract, Crude fibre and Ash) in the Animal

Science Laboratory, Ahmadu Bello University, Zaria using the methods described by Association of Official Analytical Chemist (A.O.A.C, 1990). The digestibility coefficients were calculated using the equation below;

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

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

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

3.9 Experimental Diets for Experiment 2

Effect of feeding graded levels of BDG and PKM supplemented with Maxigrain® enzyme on egg production parameters of Japanese quail hens (6-20 weeks).

Nine quail layer diets were formulated such that

Diet 1 (Control) contained 0%BDG + 0%PKM

Diet 2 contained 0%BDG + 15%PKM

Diet 3 contained 0%BDG + 30%PKM

Diet 4 contained 15%BDG + 0%PKM

Diet 5 contained 15%BDG + 15%PKM

Diet 6 contained 15%BDG + 30%PKM

Diet 7 contained 30%BDG + 0%PKM

Diet 8 contained 30%BDG + 15%PKM

Diet 9 contained 30%BDG + 30%PKM

The diets were formulated to be iso-nitrogenous (22% CP). The ingredient composition of the experimental diets are presented in Table 3.3.

Table 3.3: Percentage composition of Quail Layer diets containing graded levels of BDG and PKM supplemented with Maxigrain® enzyme (6-20 weeks).

	Dietary treatments								
Ingredients	1 0%BDG+ 0%PKM	2 0%BDG+ 15%PKM	3 0%BDG+ 30%PKM	4 15%BDG+ 0%PKM	5 15%BDG+ 15%PKM	6 15%BDG+ 30%PKM	7 30%BDG+ 0%PKM	8 30%BDG+ 15%PKM	9 30%BDG+ 30%PKM
Yellow Maize	50.02	37.01	27.01	40.01	30.01	22.51	34.01	26.51	17.51
Full fat soyabean	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Groundnut cake	29.98	27.98	22.98	24.98	19.98	12.48	15.98	8.48	2.48
Brewers dried grain	0.00	0.00	0.00	15.00	15.00	15.00	30.00	30.00	30.00
Palm kernel meal	0.00	15.00	30.00	0.00	15.00	30.00	0.00	15.00	30.00
Limestone	5.10	5.10	5.10	5.10	5.10	5.10	5.10	5.10	5.10
Bonemeal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Maxigrain®	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total	100	100	100	100	100	100	100	100	100
Calculated Analyses									
ME(Kcal/kg)	2770	2778	2737	2777	2713	2700	2721	2700	2700
Crude protein (%)	22	22	22	22	22	22	22	22	22
Crude fibre (%)	3.09	4.32	4.51	4.43	4.62	5.79	4.73	5.89	7.06
Total P. (%)	0.85	0.82	0.85	0.83	0.80	0.81	0.81	0.80	0.82
Lysine (%)	1.01	1.05	1.00	1.01	1.01	1.10	1.10	1.00	1.05
Methionine (%)	0.55	0.54	0.55	0.54	0.57	0.53	0.53	0.57	0.55
Arginine (%)	1.30	1.81	1.92	1.32	1.85	1.95	1.45	1.38	1.98
Valine (%)	0.90	0.93	0.94	0.90	0.93	0.93	0.91	0.90	0.92
Lysine:Arg. ratio	1:1	1:1	1:2	1:1	1:1	1:2	1:1	1:1	1:2
Ether extract (%)	5.30	5.35	5.30	5.25	5.48	5.57	5.40	5.37	5.45
Calcium (%)	2.57	2.50	2.47	2.48	2.65	2.69	2.55	2.40	2.51
Cost/kg of Diet (₦)	79.57	73.26	66.16	73.10	66.01	58.28	65.60	57.88	50.53

*Biomix premix provide per kg of diet: vit.A, 10,000i.u; vit,D3, 2000i.u; vit.E, 23mg; vit.K, 2mg; calcium pantothenate, 7.5mg; vit.B12,0.051mg; folic acid,0.75mg; sodium chloride,300mg;vit.B1,1.8mg;vit.B2,5mg; manganese,40mg; iron, 20mg; zinc, 30mg; copper, 3mg; iodine,1mg; cobalt,0.2mg;selenium,0.3mg.

Table 3.4: Nutrient Composition of Quail Layer diets containing graded levels of BDG and PKM (6-20 weeks).

Treatments	1	2	3	4	5	6	7	8	9
Parameters	0%BDG+ 0%PKM	0%BDG+ 15%PKM	0%BDG+ 30%PKM	15%BDG+ 0%PKM	15%BDG+ 15%PKM	15%BDG+ 30%PKM	30%BDG+ 0%PKM	30%BDG+ 15%PKM	30%BDG+ 30%PKM
Dry matter (%)	93.35	92.46	92.58	94.71	93.41	92.61	93.82	92.98	95.21
Crude Protein (%)	22.17	21.75	22.06	22.11	21.50	22.37	21.34	21.40	21.82
Crude fibre (%)	3.69	4.57	4.71	4.43	4.89	5.79	4.80	5.92	7.06
Ether extract (%)	5.91	5.60	4.90	5.81	4.76	5.86	5.76	4.92	6.07
Ash (%)	8.14	8.00	8.17	7.92	7.76	8.71	7.67	8.08	8.89
Nitrogen free extract (%)	60.09	60.08	60.16	59.73	61.09	57.27	60.43	59.68	55.16

3.10 Procedure for Experiment 2

After the birds were sexed at the end of experiment 1 (i.e at 6 weeks of age), two hundred and seventy quail pullets were used for this experiment, the females were mixed up and placed on a common diet for one day. Thereafter, they were randomly allocated to nine dietary treatments with three replicates of ten birds per replicate group. The birds in each replicate group were weighed and the average initial weight recorded. Nine isonitrogenous experimental diets were formulated to contain 22%CP and 2700Kcal/kg ME respectively. The feed supplied were weighed and daily feed intake calculated. The birds were weighed at two-week intervals.

3.11 Measurement of egg quality parameters

Eggs were collected once daily (7.00am), counted, weighed and recorded per replicate pen. Internal egg quality parameters were also measured according to Haugh (1937) procedure. At every four weeks intervals, 8 eggs per replicate pen were sampled for internal egg quality assessment. The weight of each clean egg was taken using a Mettler balance of 0.01g sensitivity. Egg length and egg diameter were measured using a Vernier caliper. The eggs were carefully broken and the content poured into a tri-pod micrometer (Ames S-6428, U.S.A), with this, heights of yolk and thick albumen were measured. The yolk diameter was measured using a Vernier caliper. Thereafter, the yolk was separated after removal of the remaining albumen. The weight of the albumen was calculated by subtracting the weights of yolk and shell from the weight of whole egg. Thickness of the egg shell was obtained by average measurements of three areas blunt end, pointed and middle part of the egg using a micrometer screw guage (Mitutoyo Japan) as described by Amer (1972). The Haugh unit was calculated from the measured height of thick albumen and weight of egg using the following formula proposed by Haugh (1937).

$H.U = 100 \text{ Log } (H - 1.7W^{0.37} + 7.6)$

HU = Haugh unit

H = Albumen height

W = Egg weight.

The following parameters were also determined; initial weight, final weight, daily feed intake, cost of daily feed intake, cost of total feed intake, cost per dozen egg, profit over cost, cost

benefit ratio. Average egg production per quail per week, hen housed egg production (total egg production/bird), age at peak egg production and percentage egg production at peak.

3.12 Statistical Analysis

All the data generated were statistically analyzed using the General Linear Model procedure of Statistical Analysis System (SAS, 2008). Significant means were separated using Duncan Multiple Range Test (Steel and Torrie, 1988).

The statistical model used was:

$Y_{ijk} = \mu + B_i + P_j + (BP)_{ij} + E_{ijk}$

Y_{ijk} = Observation of K in level i^{th} of factor B and level j of factor P

μ = overall means

B_i = effect of level of ith of factor B (level of BDG)

P_j = effect of level of jth of factor P (level of PKM)

$(BP)_{ij}$ = effect of the interaction of ith of factor B with level j^{th} of factor P

E_{ijk} = random error with mean and variance

CHAPTER FOUR

4.0 Results

Table 4.1 shows the Nutrient composition of BDG and PKM analysed. The values derived from the proximate analyses for BDG (Dry matter 93.97%, Ether extract 8.91%, Crude fibre 39.20%, Crude protein 23.67%) were higher than that of PKM (Dry matter 93.04%, Ether extract 4.01%, Crude fibre 25.10%, Crude protein 17.45%) except for Ash (3.86%) and NFE (24.36%) which were lower when compared with that of PKM (4.98% Ash and 48.46%NFE).

Table 4.1 Nutrient composition of BDG and PKM analysed

	BDG	PKM
Dry matter (%)	93.97	93.04
Crude protein (%)	23.67	17.45
Crude Fibre (%)	39.20	25.10
Ether extract (%)	8.91	4.01
Ash (%)	3.86	4.98
Nitrogen Free Extract (%)	24.36	48.46

4.1 Main effects of feeding graded levels of BDG based diets on the performance characteristics of quail birds (2-6weeks).

Table 4.2 shows the performance of quail chicks fed three levels of BDG based diet. There were significant differences ($P<0.05$) in all the parameters measured except initial weight and first egg weight. Total weight gain for quails fed the control diet was similar ($P>0.05$) to those fed diet of 15%BDG but was significantly ($P<0.05$) higher than those of quails fed the 30%BDG diet. Birds on diet containing 30%BDG consumed significantly ($P<0.05$) more feed compared to those on 0%BDG. Daily feed intake of quails increased with increased level of BDG in the diet. The feed conversion ratio of quails fed diet of 30%BDG was significantly ($P<0.05$) poorer than those fed the control and 15%BDG diets which were similar. The age at first egg was significantly prolonged ($P<0.05$) for birds fed the diet with 30%BDG than those fed 15%BDG and the control diets. Age at first egg was observed to increase with increasing level of BDG in the diet.

Table 4.2 Main effects of feeding graded levels of BDG based diets on the performance characteristics of quail birds (2-6weeks).

Treatments Parameters	LEVELS OF BDG (%) 0%	 15%	 30%	 SEM
Initial weight(g/bird)	38.07	38.14	37.86	0.45
Final weight(g/bird)	133.49[a]	131.63[a]	115.74[b]	2.76
Total weight gain(g/bird)	95.42[a]	93.49[a]	77.88[b]	2.58
Daily weight gain(g/b/d)	3.41[a]	3.34[a]	2.78[b]	0.09
Total feed intake(g/bird)	579.63[b]	586.42[ab]	606.48[a]	14.67
Daily feed intake(g/b/d)	20.70[b]	20.94[ab]	21.66[a]	0.52
Feed conversion ratio	6.07[a]	6.27[a]	8.15[b]	0.41
Age at first egg (day)	39.44[a]	42.22[b]	44.33[c]	0.40
First egg weight(g)	10.11	10.18	10.13	0.14

[abc] Means with different superscripts within the same row are significantly($P<0.05$) different. SEM= Standard error of the means

4.2 Main effects of feeding graded levels of BDG based diets on the carcass characteristics of quail birds (2-6weeks).

Table 4.3 shows the results of carcass characteristics of quails fed graded levels of BDG based diets. There were no significant differences ($P>0.05$) in the values of parameters (dressing percentage, breast weight, thigh weight, wings weight, liver weight, heart weight and intestinal weight) measured except the live weight, carcass weight, back weight, gizzard and intestinal length which were significantly affected ($P<0.05$) by the levels of BDG in the diets. The live weight, carcass weight and back weight of quails fed the control diet were significantly ($P<0.05$) higher than those fed 30%BDG diet but those fed 15%BDG and 30%BDG were similar ($P>0.05$). These values decreased as the inclusion levels of BDG increased in the diets. The gizzard weight and intestinal length of quails on the control diet was significantly ($P<0.05$) lower than those fed 30%BDG diet but those on 15%BDG and 30%BDG were similar ($P>0.05$). The values obtained for gizzard weight and intestinal length were observed to increased as the inclusion levels of BDG increased in the diets.

Table 4.3 Main effects of feeding graded levels of BDG based diets on the carcass characteristics of quail birds (2-6weeks).

Parameters	LEVELS OF BDG (%) 0%	15%	30%	SEM
Live weight (g)	134.42[a]	125.74[b]	123.37[b]	4.19
Carcass weight (g)	87.70[a]	83.51[ab]	80.45[b]	2.85
Dressing (%)	65.24	66.41	65.21	1.35
Carcass cuts (%)				
Breast (%)	28.87	27.44	27.63	1.14
Thigh (%)	8.84	8.52	8.18	0.46
Back (%)	23.42[a]	21.93[ab]	20.34[b]	1.61
Wings (%)	7.71	7.24	7.67	0.30
Liver (%)	2.29	2.35	2.23	0.18
Organ weights (%)				
Gizzard (%)	3.59[b]	3.83[ab]	4.13[a]	0.18
Heart (%)	1.19	1.12	1.11	0.05
Intestinal weight (%)	5.67	5.51	5.86	0.44
Intestinal length (cm)	56.19[b]	57.07[ab]	62.70[a]	3.48

[ab] Means with different superscripts within the same row are significantly($P<0.05$) different. SEM= Standard error of the means.

4.3 Main effects of feeding graded levels of BDG based diets on the nutrient digestibility of quail birds (2-6weeks).

Table 4.4 shows the results of dry matter, crude fibre, crude protein, ether extract, ash and nitrogen free extract digestibilities by quails fed the experimental diets for 7days. There were significant differences ($P<0.05$) in all the coefficient of digestibilities measured. The dry matter digestibility was higher in quails fed the control diet and 15%BDG than those fed 30%BDG diet. The crude protein, crude fibre, ash and NFE digestibilities were significantly ($P<0.05$) higher in quails fed the control diet than those fed other dietary groups. Crude fibre digestibility decreased as the inclusion levels of BDG increased in the diets. The ether extract digestibility in the quails fed the control diet was similar to those fed diet 15%BDG but significantly ($P<0.05$) higher than those fed diet containing 30%BDG.

Table 4.4 Main effects of feeding graded levels of BDG based diets on the nutrient digestibility of quail birds (2-6weeks).

Parameters	LEVELS OF BDG (%) 0%	15%	30%	SEM
Dry matter (%)	82.98[a]	80.90[a]	75.48[b]	1.91
Crude protein (%)	71.69[a]	55.40[b]	57.20[b]	2.05
Crude fibre (%)	52.17[a]	47.70[b]	39.74[c]	1.74
Ether extract (%)	88.82[a]	86.65[ab]	84.48[b]	1.67
Ash (%)	51.95[a]	22.67[c]	31.72[b]	4.42
Nitrogen free extract(%)	70.24[a]	49.91[b]	52.38[b]	5.77

[abc] Means with different superscripts within the same row are significantly($P<0.05$) different. SEM= Standard error of the means.

4.4 Main effects of feeding graded levels of PKM based diets on the performance characteristics of quail birds (2-6weeks).

Table 4.5 shows the results of growth performance of quails fed three levels of PKM based diet. There were significant differences ($P<0.05$) in all the parameters measured except initial weight and first egg weight. Total weight gain for quails fed the control diet was similar ($P>0.05$) to those fed 15%PKM which were significantly ($P<0.05$) higher than those fed 30%PKM. Birds fed diet containing 30%PKM consumed significantly ($P<0.05$) more feed compared to those fed 15%PKM and the control diets. Daily feed intake increased with increased level of PKM in the diet. The feed conversion ratio of quails fed diets with 30%PKM was significantly ($P<0.05$) poorer than those fed the control and 15%PKM diet which were similar. The age at first egg was significantly prolonged ($P<0.05$) for birds fed the diet with 30%PKM compared to those fed 15%PKM and the control diets. In addition, there was a significant ($P<0.05$) difference between the control and 15%PKM diets. Age at first egg was also observed to increase with increasing levels of PKM in the diets.

Table 4.5 Main effects of feeding graded levels of PKM based diets on the performance characteristics of quail birds (2-6weeks).

Parameters	LEVELS OF PKM (%) 0%	15%	30%	SEM
Initial weight(g/bird)	38.10	37.90	38.06	0.45
Final weight(g/bird)	134.42[a]	130.63[a]	114.81[b]	2.76
Total weight gain(g/bird)	96.32[a]	92.73[a]	76.75[b]	2.58
Daily weight gain(g/b/d)	3.44[a]	3.31[a]	2.74[b]	0.09
Total feed intake(g/bird)	565.43[b]	582.72[b]	624.38[a]	14.67
Daily feed intake(g/b/d)	20.19[b]	20.81[b]	22.30[a]	0.52
Feed conversion ratio	5.87[a]	6.28[a]	8.45[b]	0.41
Age at first egg (day)	40.78[a]	41.78[b]	43.44[c]	0.40
First egg weight (g)	10.17	10.12	10.13	0.14

[abc] Means with different superscripts within the same row are significantly($P<0.05$) different. SEM= Standard error of the means.

4.5 Main effects of feeding graded levels of PKM based diets on the carcass characteristics of quail birds (2-6weeks).

Table 4.6 shows the results of carcass characteristics of quails fed graded levels of PKM based diets. There were significant differences ($P<0.05$) in the live weight, carcass weight, breast (%), back (%), gizzard (%) and heart (%). The live weight, carcass weight, breast, back and heart of quails on the control diet was significantly ($P<0.05$) higher than those fed 30%PKM while quails fed 15%PKM and 30%PKM were similar. The weight of gizzard increased as the inclusion level of PKM increased in the diets. The dressing percentage, percentage thigh, wings, liver, intestinal weight and length were not significantly ($P>0.05$) different.

Table 4.6 Main effects of feeding graded levels of PKM based diets on the carcass characteristics of quail birds (2-6weeks).

Parameters	LEVELS OF PKM (%) 0%	15%	30%	SEM
Live weight (g)	134.78[a]	126.72[b]	122.03[b]	4.19
Carcass weight (g)	88.81[a]	83.19[b]	79.65[b]	2.85
Dressing (%)	65.89	65.65	65.27	1.35
Carcass cuts (%)				
Breast (%)	29.32[a]	27.38[ab]	27.24[b]	1.14
Thigh (%)	8.66	8.43	8.46	0.46
Back (%)	23.22[a]	22.31[ab]	20.17[b]	1.61
Wings (%)	7.56	7.41	7.66	0.30
Liver (%)	2.37	2.32	2.18	0.18
Organs weights (%)				
Gizzard (%)	3.32[c]	3.72[b]	4.52[a]	0.18
Heart (%)	1.33[a]	1.05[b]	1.04[b]	0.05
Intestinal weight (%)	5.77	5.44	5.84	0.44
Intestinal length (cm)	57.84	58.46	59.67	3.48

[abc] Means with different superscripts within the same row are significantly($P<0.05$) different. SEM= Standard error of the means.

4.6 Main effects of feeding graded levels of PKM based diets on the nutrient digestibility of quail birds (2-6weeks).

Tables 4.7 shows the results of dry matter, crude fibre, crude protein, ether extract, ash and nitrogen free extract digestibility by quails fed the experimental diets for 7days. There were significant differences ($P<0.05$) in some of the coefficient of digestibilities measured except for the dry matter and ether extract which were not significantly ($P>0.05$) different. There were significant differences ($P<0.05$) in crude protein, crude fibre, ash and nitrogen free extract digestibilities with the quails fed control diet having similar values with those fed 15%PKM but was significantly ($P<0.05$) higher than those fed 30%PKM.

Table 4.7 Main effects of feeding graded levels of PKM based diets on the nutrient digestibility of quail birds (2-6weeks).

Parameters	LEVELS OF PKM (%) 0%	15%	30%	SEM
Dry matter (%)	81.57	78.70	79.07	1.91
Crude protein (%)	65.63[a]	62.60[a]	56.06[b]	2.05
Crude fibre (%)	38.48[a]	36.30[a]	26.82[b]	1.74
Ether extract (%)	86.72	87.05	86.18	1.67
Ash (%)	40.28[a]	37.75[a]	28.31[b]	4.42
Nitrogen free extract (%)	62.79[a]	61.19[a]	48.55[b]	5.77

[abc] Means with different superscripts within the same row are significantly($P<0.05$) different. SEM= Standard error of the means.

4.7 Effects of feeding graded levels of BDG and PKM based diets singly or combined on the performance characteristics of quail birds (2-6weeks).

Observations on the effect of feeding graded levels of BDG and PKM singly or combined on growth performance of the quail birds are shown on Table 4.8. Total weight gain of quails fed the control diet, 15%PKM and 15%BDG diets were similar and significantly better than other dietary groups. Total weight gain of birds fed diets 5 (15%PKM+15%BDG) and 7 (30%BDG) were also similar. Diet 9(30%BDG+30%PKM) had the least value for weight gain. Weight gain reduced with increased levels of BDG and PKM in the diets. Birds fed 30%BDG+30%PKM diet consumed significantly ($P<0.05$) more feed compared to those on other dietary groups. Feed intake of quails fed the control diet was similar to those of quails fed 15%BDG diet while the intake of quails fed 30%PKM diet was similar to those of quails fed 15%BDG +30%PKM diet. Also, the intake of quails fed 15%PKM diet was similar to those of quails fed 30%BDG diet and 30%BDG+15%PKM diets. The feed to gain ratio of quails fed diet 9 (30%BDG+30%PKM) was significantly ($P<0.05$) the highest among all the dietary treatments. Thus, the diet was poorly utilized for body weight gain compared to the control and other dietary treatments. Birds fed 15%BDG and 15%PKM diets were as efficient as the control diet interms of feed conversion ratio. These were significantly different ($P<0.05$) when compared to other diets. Birds fed 15%PKM, 15%BDG+15%PKM and 30%BDG diets were also similar interms of feed efficiency. Feed efficiency followed a downward trend as dietary levels of BDG and PKM increased. The age at first egg of quails fed control diet was significantly ($P<0.01$) better than those on other dietary treatment groups. Age at first egg of birds fed 15%BDG, 15%BDG+15%PKM, 15%BDG+30%PKM and 30%BDG were similar. Generally, age at first lay increased with increased levels of BDG and PKM in the diets.

Table 4.8. Effects of feeding graded levels of BDG and PKM based diets singly or combined on the performance characteristics of quail birds (2-6weeks).

Treatments Parameters	1 0%BDG+ 0%PKM	2 0%BDG+ 15%PKM	3 0%BDG+ 30%PKM	4 15%BDG+ 0%PKM	5 15%BDG+ 15%PKM	6 15%BDG+ 30%PKM	7 30%BDG+ 0%PKM	8 30%BDG+ 15%PKM	9 30%BDG+ 30%PKM	SEM
Initial weight (g/b)	38.44	37.47	38.30	37.87	38.18	38.36	38.00	38.05	37.53	0.49
Final weight (g/b)	140.59^{a}	138.96^{a}	125.92^{c}	139.04^{a}	131.48^{b}	120.37^{d}	129.62^{b}	119.44^{d}	98.15^{e}	1.59
Total weight gain(g/b)	102.15^{a}	101.49^{a}	87.62^{c}	101.17^{a}	93.29^{b}	82.00^{d}	91.62^{b}	81.40^{d}	60.61^{e}	1.49
DWG (g/b/d)	3.65^{a}	3.62^{a}	3.13^{c}	3.61^{a}	3.33^{b}	2.93^{d}	3.27^{b}	2.91^{d}	2.16^{e}	0.05
Total feed intake (g/b)	561.11^{fg}	594.45^{cd}	603.70^{bc}	548.15^{g}	574.07^{ef}	616.67^{b}	579.63^{de}	587.04^{cde}	652.78^{a}	8.47
DFI(g/b/d)	20.04^{fg}	21.23^{cd}	21.56^{bc}	19.58^{g}	20.50^{ef}	22.02^{b}	20.70^{de}	20.97^{cde}	23.31^{a}	0.30
FCR	5.49^{a}	5.86^{ab}	6.89^{de}	5.43^{a}	6.16^{bc}	7.54^{f}	6.33^{bc}	7.21^{f}	10.90^{g}	0.24
AAFE (day)	38.33^{a}	39.33^{b}	40.67^{c}	42.00^{d}	42.33^{d}	42.33^{d}	42.00^{d}	43.67^{e}	47.33^{f}	0.23
First egg weight(g)	10.20	10.17	9.97	10.13	10.13	10.27	10.16	10.17	10.17	0.16

^{abcdef} Means with different superscripts within the same row are significantly($P<0.05$) different. SEM= Standard error of the means. DWG=Daily weight gain. DFI=Daily feed intake. FCR=Feed conversion ratio. AAFE=Age at first egg.

4.8 Effects of feeding graded levels of BDG and PKM based diets singly or combined on the carcass characteristics of quail birds (2-6weeks).

Table 4.9 shows the results of effects of feeding graded levels of BDG and PKM based diets singly or combined on carcass characteristics of the experimental birds. There were significant differences ($P<0.05$) in values of some of the parameters measured except dressing percentage, thigh (%), liver (%), wings (%) and intestinal weight (%) which were not significantly affected ($P>0.05$) by the levels of BDG and PKM fed in the diets. There were significant ($P<0.05$) differences in the live weight, carcass weight, breast (%), back (%), wings (%), gizzard (%), heart(%) and in the length of intestine. The quails fed control diet had significantly ($P<0.05$) higher value for live and carcass weights. Quails fed 15%PKM, 30%PKM, 15%BDG, 15%BDG+15%PKM, 15%BDG+30%PKM, 30%BDG and 30%BDG+15%PKM were similar interms of carcass weight. The percentage breast of quails fed diets 15%PKM, 30%PKM, 15%BDG, 15%BDG+15%PKM, 15%BDG+30%PKM, 30%BDG and 30%BDG+30%PKM were similar ($P>0.05$). The weight of gizzard for quails fed control diet, 15%PKM, 30%PKM, 15%BDG, 15%BDG+15%PKM and 30%BDG were similar. Also, the percentage heart of quails fed the control diet was similar ($P>0.05$) to those of quails fed 15%BDG and 30%BDG diets but were significantly ($P<0.05$) higher than those fed other diets. The intestinal length of quails fed control diet was similar to those of quails fed other dietary treatments.

Table 4.9 Effects of feeding graded levels of BDG and PKM based diets singly or combined on the carcass characteristics of quail birds (2-6weeks).

Treatments Parameters	1 0%BDG+ 0%PKM	2 0%BDG+ 15%PKM	3 0%BDG+ 30%PKM	4 15%BDG+ 0%PKM	5 15%BDG+ 15%PKM	6 15%BDG+ 30%PKM	7 30%BDG+ 0%PKM	8 30%BDG+ 15%PKM	9 30%BDG+ 30%PKM	SEM
Live weight (g)	145.13^{a}	129.75^{b}	128.37^{b}	130.87^{b}	126.53^{b}	119.82^{c}	128.33^{b}	123.87^{bc}	117.90^{c}	5.19
Carcass weight (g)	92.60^{a}	85.38^{ab}	85.12^{ab}	85.63^{ab}	82.37^{bc}	79.52^{bc}	85.20^{ab}	81.82^{bc}	74.32^{c}	2.85
Dressing (%)	63.80	65.80	66.31	65.43	65.10	66.37	66.38	66.05	63.04	2.35
Carcass cuts (%)										
Breast (%)	30.78^{a}	28.42^{abc}	27.41^{abc}	27.40^{abc}	27.98^{abc}	26.93^{bc}	29.77^{ab}	25.75^{c}	27.37^{abc}	1.14
Thigh (%)	8.88	8.62	9.03	9.05	8.20	8.32	8.03	8.48	8.03	0.66
Back (%)	25.68^{a}	23.40^{ab}	21.18^{ab}	23.13^{ab}	23.00^{ab}	19.67^{b}	20.83^{ab}	20.52^{ab}	19.67^{b}	1.61
Wings (%)	7.68	7.43	8.02	7.15	7.17	7.40	7.83	7.62	7.57	0.45
Organ weights (%)										
Liver (%)	2.48	2.25	2.15	2.37	2.32	2.35	2.27	2.38	2.05	0.28
Gizzard (%)	3.25^{c}	3.68^{bc}	3.83^{bc}	3.30^{c}	3.53^{bc}	4.67^{a}	3.40^{bc}	3.95^{b}	5.05^{a}	0.35
Heart (%)	1.37^{a}	1.10^{b}	1.12^{b}	1.33^{a}	1.02^{b}	1.02^{b}	1.30^{a}	1.03^{b}	0.98^{b}	0.08
Intestinal weight (%)	5.68	5.35	5.98	5.65	5.25	5.65	5.97	5.72	5.88	0.44
Intestinal length (cm)	57.48^{ab}	57.83^{ab}	53.25^{b}	55.62^{b}	54.27^{b}	61.33^{a}	60.42^{ab}	63.27^{a}	64.42^{a}	3.58

^{abc} Means with different superscripts within the same row are significantly($P<0.05$) different. SEM= Standard error of the means..

4.9 Effects of feeding graded levels BDG and PKM based diets singly or combined on the nutrient digestibility of quail birds (2-6weeks).

Tables 4.10 shows the results of dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract digestibility by quails fed the experimental diets for 7days. There were significant differences ($P<0.05$) in all the coefficient of digestibilities measured. There were significant differences ($P<0.05$) in dry matter digestibility with the quails fed control having similar values with those fed 15%PKM, 30%PKM and 15%BDG+30%PKM diets but it was significantly ($P<0.05$) higher than those fed other dietary groups. The crude protein, crude fibre and ash digestibilities in quails fed the control diet were significantly ($P<0.05$) higher than those on other treatment groups. The crude protein digestibility of quails fed 30%PKM, 15%BDG and 15%BDG+15%PKM diets were similar. The crude fibre digestibility of quails fed 15%BDG+15%PKM, 15%BDG+30%PKM and 30%BDG+15%PKM diets were also similar. The ether extract digestibility was significantly ($P<0.05$) higher in quails fed 15%BDG+30%PKM diet but was similar to those fed the control and other dietary groups except 15%BDG and 30%BDG+30%PKM diets. The NFE digestibility in the quails fed the control diet was similar to those of quails fed 15%PKM diet. Quails fed 30%PKM, 15%BDG, 15%BDG+15%PKM, 15%BDG+30%PKM, 30%BDG and 30%BDG+15%PKM diets were also similar.

Table 4.10 Effects of feeding graded levels of BDG and PKM based diets singly or combined on the nutrient digestibility of quail birds (2-6weeks).

Treatments Parameters	1 0%BDG+ 0%PKM	2 0%BDG+ 15%PKM	3 0%BDG+ 30%PKM	4 15%BDG+ 0%PKM	5 15%BDG+ 15%PKM	6 15%BDG+ 30%PKM	7 30%BDG+ 0%PKM	8 30%BDG+ 15%PKM	9 30%BDG+ 30%PKM	SEM
Dry matter (%)	86.67^{a}	80.79^{abc}	81.47^{abc}	78.69^{bc}	78.99^{bc}	85.01^{ab}	79.36^{bc}	76.33^{cd}	70.74^{d}	1.91
Crude protein (%)	82.78^{a}	73.87^{b}	58.41^{cd}	52.60^{de}	52.71^{de}	60.89^{c}	61.51^{c}	61.22^{c}	48.88^{e}	2.05
Crude fibre (%)	64.93^{a}	52.82^{b}	38.74^{c}	32.51^{d}	26.71^{e}	23.87^{e}	18.00^{f}	23.37^{e}	17.85^{f}	1.74
Ether extract (%)	89.20^{ab}	89.29^{ab}	87.98^{ab}	84.24^{bc}	85.37^{abc}	90.34^{a}	86.72^{ab}	86.50^{ab}	80.21^{c}	1.67
Ash (%)	67.50^{a}	54.15^{b}	34.21^{cd}	22.98^{d}	21.37^{d}	23.66^{cd}	30.35^{cd}	37.74^{c}	27.06^{cd}	4.42
Nitrogen free extract (%)	83.18^{a}	75.16^{ab}	52.37^{cd}	47.98^{cd}	47.63^{cd}	54.12^{cd}	57.21^{bcd}	60.77^{bc}	40.17^{d}	5.77

^{abcdef} Means with different superscripts within the same row are significantly($P<0.05$) different. SEM= Standard error of the means.

4.10 Main effects of feeding graded levels of BDG based diets on the egg laying performance of quail layers (6-20weeks).

Observations on the egg production parameters of quail layers during the laying phase (6-20weeks, Table 4.11) revealed that there were no significant ($P<0.05$) differences in some of the parameters measured except for the feed intake, age at peak egg production, egg production at peak and the cost per dozen egg laid. The final body weight, hen house egg production, average egg weight and hen day production were not affected ($P>0.05$) by the dietary treatments. The age at peak production revealed that quails fed the control diet had similar age with quails fed 15%BDG diet which was lower ($P<0.05$) than those fed 30%BDG. Also, quails fed the control diet had the highest number of egg production at peak and cost per dozen egg laid than those fed other diets.

Table 4.11 Main effects of feeding graded levels of BDG based diets on the egg laying performance of quail layers (6-20weeks).

Parameters	LEVELS OF BDG (%) 0%	15%	30%	SEM
Initial weight (g)	150.35	150.46	150.22	1.50
Final weight (g)	190.46	190.13	183.62	6.12
Daily feed intake (g/bird)	20.94[c]	24.70[b]	26.66[a]	0.52
Total feed intake (g/bird)	2052.12[c]	2420.60[b]	2612.57[a]	51.38
Hen house egg production (%)	75.94	73.29	72.25	3.74
Average egg weight (g)	10.22	10.19	10.07	0.27
Hen day egg production (%)	75.94	73.29	72.25	3.74
Age at peak production (day)	63.11[a]	63.11[a]	65.00[b]	0.63
Egg production at peak (%)	91.00[a]	85.22[b]	81.00[b]	3.34
Cost/dozen egg (₦/dozen)	37.81[a]	33.70[b]	30.81[c]	0.03

[abc] Means with different superscripts within the same row are significantly($P<0.05$) different. SEM= Standard error of the means.

4.11 Main effects of feeding graded levels of BDG based diets on the egg quality of quail birds (6-20weeks).

Observations on the egg quality parameters of quail layers during the laying phase (6-20weeks, Table 4.12) revealed that there was no significant difference ($P>0.05$) in all the parameters (egg weight, egg length, albumen thickness, albumen weight, yolk thickness, yolk weight, shell thickness, shell weight, egg shape index and Haugh unit) measured across the treatment means. This shows that feeding graded levels of BDG in quails diet did not significantly affect the egg weight, albumen weight, shell weight and Haugh unit.

Table 4.12 Main effects of feeding graded levels of BDG based diets on the egg quality of quail birds (6-20weeks).

Parameters	LEVELS OF BDG (%) 0%	15%	30%	SEM
Egg weight(g)	10.22	10.19	10.07	0.37
Egg length (mm)	3.15	3.12	3.09	0.06
Egg breadth (mm)	2.46	2.44	2.44	0.03
Albumen thickness (mm)	0.39	0.40	0.36	0.04
Albumen weight(g)	5.03	4.84	5.01	0.18
Yolk thickness (mm)	0.88	0.82	0.86	0.04
Yolk weight(g)	3.11	3.26	3.11	0.12
Shell thickness (mm)	0.24	0.25	0.24	0.04
Shell weight(g)	1.42	1.42	1.44	0.04
Egg shape index (%)	78.01	78.08	78.87	1.02
Haugh unit (%)	70.05	70.11	69.94	0.27

SEM= Standard error of the means.

4.12 Main effects of feeding graded levels of PKM based diets on the egg laying performance of quail layers (6-20weeks).

Observations on the egg production parameters of quail layers during the laying phase (6-20weeks, Table 4.13) revealed that there were significant ($P<0.05$) differences in the parameters measured except for hen house egg production and hen day egg production. The final weight of quails fed the control diet was similar ($P>0.05$) to those of quails fed 15%PKM but was significantly higher than those on 30%PKM diets. Birds fed diet containing 30%PKM consumed significantly ($P<0.05$) more feed compared to those fed 15%PKM and the control diets. Daily feed intake increased with increased level of PKM in the diet. The age at peak production on the control diet was significantly reduced ($P<0.05$) compared to 15% and 30%PKM diets. Egg production (%) at peak for the control diet was better ($P<0.05$) compared to 15% and 30% PKM diets.

Table 4.13 Main effects of feeding graded levels of PKM based diets on the egg laying performance of quail layers (6-20weeks).

Parameters	LEVELS OF PKM (%) 0%	15%	30%	SEM
Initial weight (g)	150.36	150.35	150.33	1.50
Final weight (g)	194.33[a]	188.67[ab]	181.21[b]	6.12
Daily feed intake (g/bird)	21.19[c]	25.81[b]	27.30[a]	0.52
Total feed intake (g/bird)	2076.62[c]	2529.60[b]	2675.29[a]	51.38
Hen house egg production (%)	76.88	75.89	73.70	3.74
Average egg weight (g)	9.27[b]	10.43[a]	10.32[a]	0.27
Hen day egg production (%)	76.88	75.89	73.70	3.74
Age at peak production (day)	60.78[a]	62.22[b]	65.14[c]	0.63
Egg production at peak (%)	92.44[a]	84.11[b]	83.67[b]	3.34
Cost/dozen egg (~~N~~/dozen)	36.61[c]	33.95[b]	31.75[a]	0.03

[abc] Means with different superscripts within the same row are significantly($P<0.05$) different. SEM= Standard error of the means.

4.13 Main effects of feeding graded levels of PKM based diets on the egg quality of quail birds (6-20weeks).

Observations on the egg quality parameters of the quail layers during the laying phase (6-20weeks, Table 4.14) revealed that there were no significant differences ($P>0.05$) in all the parameters (egg weight, egg length, albumen thickness, albumen weight, yolk thickness, yolk weight, shell thickness, shell weight, egg shape index and Haugh unit) measured across the treatment means. This shows that feeding graded levels of PKM in quails diet did not significantly affect the egg weight, albumen weight, shell weight and Haugh unit.

Table 4.14 Main effects of feeding graded levels of PKM based diets on the egg quality of quail birds (6-20weeks).

Parameters	LEVELS OF PKM (%) 0%	15%	30%	SEM
Egg weight(g)	9.72	10.43	10.32	0.37
Egg length (mm)	3.06	3.16	3.14	0.06
Egg breadth (mm)	2.42	2.45	2.46	0.03
Albumen thickness (mm)	0.36	0.42	0.38	0.04
Albumen weight(g)	4.79	4.98	5.11	0.18
Yolk thickness (mm)	0.87	0.85	0.85	0.04
Yolk weight(g)	3.04	3.26	3.18	0.12
Shell thickness (mm)	0.24	0.23	0.25	0.04
Shell weight(g)	1.42	1.43	1.44	0.04
Egg shape index (%)	78.90	77.64	78.42	1.02
Haugh unit (%)	70.19	70.08	69.83	0.27

SEM= Standard error of the means.

4.14 Effects of feeding graded levels of BDG and PKM based diets singly or combined on the egg production performance of quail layers (6-20weeks).

Measurements on the egg production parameters of quail layers during the laying phase (6-20weeks, Table 4.15) revealed that there were significant ($P<0.05$) differences in all the parameters measured. The final body weight of quails fed the 15%BDG diet was significantly ($P<0.05$) higher than those of quails fed other dietary groups but 15%PKM and 15%BDG diets were similar ($P>0.05$). Feed intake was significantly ($P<0.05$) the highest for quails fed 15%BDG+30%PKM and 30%BDG+30%PKM diets compared to other diets. The values obtained for hen house egg production and hen day production were significantly ($P<0.05$) highest in quails fed 30%BDG diet and was similar to those fed the control, 15%PKM, 30%PKM and 15%BDG diets. Quails fed 15%BDG+15%PKM, 15%BDG+30%PKM, 30%BDG+15%PKM and 30%BDG+30%PKM diets also had similar ($P>0.05$) values for hen house egg production and hen day production. The age at peak production revealed that quails fed 15% and 30%BDG diets came to lay earlier than those on other dietary groups. Quails fed 30%BDG+30%PKM diet took significantly ($P<0.05$) longer time to attain peak production than those on other dietary groups. In addition, the value for egg production at peak was least ($P<0.05$) for quails fed 30%BDG+30%PKM diet while highest for quails fed diet 30%BDG. Egg production at peak for quails fed the control, 15%PKM, 30%PKM, 15%BDG, 15%BDG+15%PKM and 30%BDG were similar ($P>0.05$). Cost per dozen egg for quails fed 30%BDG+15%PKM and 30%BDG +30%PKM were similar, while quails fed the control diet had significantly ($P<0.05$) the highest cost per dozen egg than those fed other diets.

Table 4.15 Effects of feeding graded levels of BDG and PKM based diets singly or combined on the egg production performance of quail layers (6-20weeks).

Treatments Parameters	1 0%BDG+ 0%PKM	2 0%BDG+ 15%PKM	3 0%BDG+ 30%PKM	4 15%BDG+ 0%PKM	5 15%BDG+ 15%PKM	6 15%BDG+ 30%PKM	7 30%BDG+ 0%PKM	8 30%BDG+ 15%PKM	9 30%BDG+ 30%PKM	SEM
Initial weight(g)	150.47	150.25	150.34	150.42	150.56	150.40	150.20	150.25	150.23	0.87
Final weight(g)	182.73^{bc}	197.50^{ab}	191.13^{bc}	210.83^{a}	183.60^{bc}	175.97^{c}	189.43^{bc}	184.90^{bc}	176.53^{c}	6.12
DFI (g/bird)	25.04^{cd}	26.23^{bcd}	26.56^{bc}	24.58^{d}	25.50^{bcd}	27.56^{ab}	25.96^{bcd}	25.70^{bcd}	28.31^{a}	0.52
TFI (g/bird)	2453.92^{cd}	2570.54^{bcd}	2603.21^{bc}	2408.51^{d}	2499.33^{bcd}	2648.29^{ab}	2544.41^{bcd}	2518.93^{bcd}	2774.38^{a}	51.38
HHEP (%)	76.91^{ab}	79.44^{ab}	80.48^{ab}	79.93^{ab}	67.99^{c}	68.94^{c}	85.82^{a}	68.23^{c}	62.69^{c}	3.74
AEW (g)	9.63^{b}	10.42^{ab}	10.60^{a}	9.98^{ab}	10.60^{a}	9.98^{ab}	9.55^{b}	10.28^{ab}	10.37^{ab}	0.27
HDEP (%)	76.91^{ab}	79.44^{bc}	80.48^{ab}	79.93^{ab}	67.99^{c}	68.94^{c}	85.82^{a}	68.23^{c}	62.69^{c}	3.74
AAPP (days)	62.67^{b}	62.00^{b}	61.67^{b}	60.00^{a}	62.33^{b}	67.00^{d}	59.67^{a}	68.33^{e}	79.00^{f}	0.63
EPAP (%)	91.67^{a}	90.33^{a}	91.00^{a}	91.33^{a}	86.33^{ab}	78.00^{bc}	94.33^{a}	72.67^{cd}	67.00^{d}	4.34
Cost/dozen egg (₦)	39.85^{f}	38.43^{e}	35.15^{d}	35.93^{c}	33.67^{c}	31.50^{b}	34.06^{c}	29.75^{a}	28.61^{a}	0.58

^{abcdef}Means with different superscripts within the same row are significantly($P<0.05$) different. SEM= Standard error of the means. DFI= daily feed intake. TFI= total feed intake. HHEP=Hen housed egg production. AEW=average egg weight. HDEP= Hen day egg production. AAPP= Age at peak production. EPAP=Egg production at peak.

4.15 Effects of feeding graded levels of BDG and PKM based diets singly or combined on the egg quality of quail birds (6-20weeks).

Observations on the egg quality parameters of quail layers during the laying phase (6-20weeks, Table 4.16) revealed that there were no significant differences ($P>0.05$) in all the parameters (egg weight, egg length, albumen thickness, albumen weight, yolk thickness, yolk weight, shell thickness, shell weight, egg shape index and Haugh unit) measured across the treatment means. This shows that feeding graded levels of BDG and PKM singly or combined in quails diet did not significantly affect the egg weight, albumen weight, shell weight and Haugh unit.

Table 4.16 Effects of feeding graded levels of BDG and PKM based diets singly or combined on the egg quality of quail birds (6-20weeks).

Treatments Parameters	1 0%BDG+ 0%PKM	2 0%BDG+ 15%PKM	3 0%BDG+ 30%PKM	4 15%BDG+ 0%PKM	5 15%BDG+ 15%PKM	6 15%BDG+ 30%PKM	7 30%BDG+ 0%PKM	8 30%BDG+ 15%PKM	9 30%BDG+ 30%PKM	SEM
Egg weight(g)	9.63	10.42	10.45	9.98	10.45	9.98	9.55	10.28	10.37	0.47
Egg length (mm)	3.06	3.23	3.16	3.10	3.16	3.10	3.02	3.09	3.17	0.15
Egg breadth (mm)	2.43	2.44	2.50	2.42	2.45	2.43	2.30	2.47	2.46	0.10
Albumen thickness (mm)	0.40	0.39	0.39	0.34	0.45	0.40	0.33	0.42	0.33	0.07
Albumen weight(g)	4.83	5.00	5.27	4.70	4.83	5.00	4.83	5.12	5.07	0.38
Yolk thickness (mm)	0.90	0.85	0.89	0.83	0.82	0.81	0.87	0.87	0.85	0.05
Yolk weight(g)	2.97	3.23	3.13	3.22	3.35	3.20	2.93	3.18	3.22	0.19
Shell thickness (mm)	0.26	0.22	0.24	0.22	0.26	0.27	0.24	0.23	0.25	0.04
Shell weight(g)	1.43	1.35	1.48	1.47	1.42	1.38	1.35	1.49	1.45	0.08
Egg shape index (%)	79.25	75.53	79.25	78.17	77.64	78.43	79.28	79.76	77.58	2.22
Haugh unit (%)	70.64	69.85	69.65	69.77	70.20	70.35	70.15	70.20	69.49	1.27

SEM= Standard error of the means.

CHAPTER FIVE

5.0 Discussion

5.1 Effect of feeding graded levels of BDG and PKM based diets on the performance characteristics of quail birds (2-6weeks).

The result of the nutrient composition of BDG agrees with the report of Oluokun and Olalokun (1995) who reported that BDG contains 21.65%Crude protein, 19.78%Crude fibre, 7.25%Ether extract, 3.45%Ash and 47.87%Nitrogen free extract. Also, the values obtained on the nutrient composition of PKM agrees with the values of 14-21%Crude protein, 21-24%Crude fibre, 3-6%Ash, 3-8%Ether extract reported by Sundu *et al.* (2005) and Sue (2001).

The general increase in feed intake of birds across the treatment groups with increase in the dietary levels of BDG and PKM could be attributed to the increased crude fibre content of the diets. As the inclusion level of BDG and PKM increased, there was a concomitant reduction in the metabolizable energy value of the diets. Thus, quails had to increase their feed intake to satisfy their energy needs. In addition, the higher the PKM level, the higher the expected concentration of β-mannan which was reported to cause growth depression and increased feed conversion ratio (Dienick, 1989; Ariff Omer *et al.,* 1998). The result is in agreement with Dairo (1999), Nelson (1984), Esiehi and Olomu (2004) and Sundu *et al.*(2005) who observed significant increase in average daily feed intake and feed conversion ratio as the level of sorghum distillers waste inclusion increased in the diets. Timbrell (1992) had explained that there could be instances where enzyme treatment or supplementation add little value to particular ingredients or fail to result in improved performance.

Increase in daily feed intake observed as the dietary level of BDG and PKM increased in this study did not agree with the findings of Yaakugh *et al.*(1994) who observed a linear decrease in feed intake as the level of maize replaced by BDG increased. Also, Ndams (1991) observed that feed consumption and body weight gains especially in meat type birds decreased when birds were fed high fibre diets.

There was a reduction in daily weight gain of birds with increased BDG and PKM levels of inclusion. This revealed the superiority of the quality of the control diet which contained higher levels of maize and groundnut cake than other diets containing BDG and PKM. The reduction in

the daily weight gains of quails as the BDG and PKM inclusion levels increased was in agreement with the findings of Yaakugh *et al.*(1994) who observed a linear decrease in average daily weight gain as the level of maize replacement by BDG increased in the diet. The result also supported the reports of Arrif Omer *et al.* (1998) and McDonald *et al*. (1995) who observed that lower weights of birds fed PKM diets could be attributed to the high content of fibre that might have resulted from the diets which increased with increased percentage inclusion of PKM. This might have led to dilution of energy concentration of the diets and consequently reduced nutrient availability to the birds.

This was also confirmed by the higher values of feed to gain ratio obtained as the levels of BDG and PKM increased in the diets. Nelson (1984) observed that increased BDG levels above 30% led to increased feed intake and feed to gain ratio. Dairo (1999) also observed a significant increase in feed conversion ratio as levels of sorghum distillers waste inclusion increased. However, this did not agree with the findings of Yaakugh *et al.*(1994) who reported no significant difference in feed to gain ratio when BDG replaced 15, 30 and 45% maize in the diets of pigs.

The final live weights of quails on diets containing 15%BDG and 15%PKM were similar to those on the control diet. This suggests that the inclusion levels of BDG or PKM in quail diet at 15% with enzyme supplementation will support adequate live weight gain. This result is in agreement with Delic *et al.*(1997) who reported satisfactory result in live weight gain of pigs when 10% BDG was included in growing pigs' diet.

5.2 Effect of feeding graded levels of BDG and PKM based diets on the carcass characteristics of quail birds (2-6weeks).

The carcass evaluation of quail showed similar trend as that of the growth performance. The quails fed control diet had higher live weight and carcass weight compared to those on other diets. There was significant difference in the percentage breast, back, heart and gizzard but no trend was established. However, a trend was observed in the intestinal length (cm) which increased as the amount of BDG and PKM increased in the diets. The result agrees with the findings of Kandra *et al.* (1994) who observed that high fibre diets induced significant increase in the weight and size of the various sections of the digestive system in birds. The result is contrary to the findings of Dogari (1985) who observed a non-significant effect on intestinal

length when maize was replaced at different levels by sorghum beer residue in broiler chick diets. There was no effect of the diets on the % thigh, liver, wings and intestinal weight.

5.3 Effect of feeding graded levels of BDG and PKM based diets on the nutrient digestibility of quail birds (2-6weeks).

The effects of BDG and PKM on nutrient digestibility showed that protein retention of quails fed the control diet was similar to those fed 15%PKM and 15%BDG.This might have contributed to higher body weight observed in these two treatments. This agreed with the findings of Ariff Omer *et al.* (1998) who reported optimum PKM inclusion rate in poultry ration at 15%.

The dry matter digestibility of quails fed the control diet was similar to those fed 15%PKM, 30%PKM, and 15%BDG+30%PKM. The lowest dry matter digestibility coefficient observed for quails fed 30%BDG diet was as a result of high amount of non-starch polysaccharides in the high fibre diet which does not succumb to enzymes of animal origin (Iji *et al.,* 2001), making the diet less metabolized by quail's enzymes. The ash digestibility was significantly ($P<0.05$) higher in quails fed the control diet than those fed other diets. This contradicts the report of Ishibashi and Ohta (2000), who observed that phytase supplementation improved the utilization of chelated minerals and proteins.

There was significant difference in ether extract digestibility among all dietary treatments. Higher digestibility was noted in the diet containing 15%BDG and 15%PKM but was similar to the control. This is in agreement with Marquardt *et al.* (1994) who reported improvement in the body weight and feed conversion efficiency due to an increase in fat and protein digestibility. Increased fat digestibility is known to enhance the bioavailability of fat soluble vitamins. Langhout and Schutte (1995) reported that the chick performance and nutrient digestibility were affected by dietary endo-xylanasae in wheat and rye based diets and were also influenced by the type of fat in the diet.

The values obtained for crude fibre digestibility decreased as the amount of BDG and PKM increased in the diets. The lowest crude fibre digestibility observed in quails fed the diet containing 30%PKM may be due to high fibre content of the diet which in turn rendered the nutrients unavailable despite enzyme supplementation (Church and Pond, 1988; Onifade and Babatunde, 1998; Sundu *et al*., 2005), lack of endo-genous enzyme to digest feed, low enzyme

activity or low concentration and high fibre intake resulting in bulkiness of the GIT. Timbrell (1992) observed that there could be instances where enzyme treatment or supplementation adds little value to particular ingredients or even fails to result in improved performance. Of the NSPs in PKM, 78% is linear mannan, 12% cellulose, 3% glucoronoxylans and 3% arabinoxylans (Dusterhoff and Voragen, 1992). Since Maxigrain® contains cellulase, β-glucanase, xylanase and phytase, these enzymes are expected to act on cellulose, glucoronoxylans and arabinoxylans thereby increase crude fibre digestibility and subsequently increasing the energy availability and NFE. The NFE represents the soluble carbohydrates in the diet. The addition of enzymes to BDG and PKM based diets is expected to ameliorate the anti-nutritive effect of β-mannan and also to degrade large percentage of NSPs and oligo-saccharide components of the diet (Akpodiete *et al*., 2006). The lower values of NFE digestibility across the treatment groups could be attributed to low activity of Maxigrain® on the BDG and PKM based diets with subsequent release of soluble carbohydrates. As reported by Akpodiete *et al.* (2006) a higher level of the enzyme could give better results. Choct (1998) reported that the current enzymes in the market are not capable of depolymerizing NSPs to their simple constituents during the digesta transit time in poultry. PKM contains 78% linear mannan with very low galactose substitution, 12% cellulose, 3% glucoronoxylans and 3% arabinoxylans which Maxigrain® does not contain mannanase for specific enzymatic cleavage (Dusterhoff and Voragen, 1992).

5.4 Effect of feeding graded levels of BDG and PKM based diets on the egg production and egg quality parameters of quail layers (6-20weeks).

There were significant differences in egg production parameters measured. Quails fed diets containing 15%, 30% BDG, 15% and 30%PKM were similar to the control in terms of hen house egg production while the age at peak production increased as the inclusion levels of BDG and PKM increased in the diets. Also, 30%BDG and 30%PKM gave the best result in terms of cost per dozen eggs. The result showed that enzymes added to quail layer feed had little effect on egg weight but improved efficiency (VukicVranjes and Wenk, 1993; Benabdeljelil and Arbaoui, 1994), energy utilization (Wyatt and Goodman, 1993; VukicVranjes and Wenk, 1993), and laying rate (Poultry international, 1996).

The study also showed that all the parameters measured to determine the egg quality were all statistically the same. There was no significant difference among the treatments. This indicates that BDG and PKM supplemented with Maxigrain® enzyme had no adverse effect on egg quality. White *et al.* (1989) fed 0, 25 and 40% BDG to laying birds and reported non-significant differences in egg quality parameters up to 25% level. They however observed that at the 40% level, egg weights and production rates fell drastically.

CHAPTER SIX

6.0 Summary and Conclusions

6.1 Summary of major findings

- Daily feed intake of quails on BDG and PKM based diets increased with increased levels of BDG and PKM in the diet during the grower phase.
- The average daily weight gain of quails fed diets containing 15% BDG and 15% PKM were similar to those on the control diet during the grower phase.
- The feed to gain ratio of quails fed the control diet was similar to those quails fed 15%PKM and 15%BDG diets during the grower phase.
- The improvement in dry matter, crude protein, fat and NFE digestibility were observed to be more than crude fibre digestibility.
- The carcass analyses did not show any significant difference in dressing percentage, thigh, liver, intestinal weight and wings.
- BDG and PKM based diets did not result in any deleterious effect on overall quail performance. No mortality was recorded and the quails attained an acceptable average weight of 140g at six weeks of age.
- BDG and PKM based diets did not show any negative effect on egg quality parameters measured.
- Generally, quails on diets containing 30%BDG+30%PKM had the lowest values in terms of hen house egg production, egg production at peak and age at peak production.
- Cost per dozen egg decreased as the inclusion levels of BDG and PKM increased in the diets.

6.2 Conclusions

BDG and PKM were beneficial for inclusion in the diets of quails but separate use of either 15% BDG or 15% PKM gave the best results during the grower phase. Feed digestibility and feed efficiency were improved with the use of enzyme resulting in higher weight gain. Also, utilization of BDG and PKM at 30% inclusion levels during egg laying phase gave the best performance and did not affect egg production and egg quality. There is an economic advantage of using BDG or PKM in quail diets with lower feed cost per kg weight gain and therefore, their usage should be encouraged.

6.3 Recommendations

From the findings of these studies, the following recommendations are made:

1. BDG and PKM should be included into the diets of grower quails at 15% inclusion level.
2. BDG and PKM should be included into the diets of quail layers at 30% inclusion level.
3. Higher inclusion levels of BDG and PKM is recommended in quails diets due to cost effectiveness and profitability.
4. Further studies into the utilization of BDG and PKM at different levels of inclusion with mannase enzyme supplementation should be conducted.

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