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Evaluation of Enzyme (Maxigrain®) Treatment of Graded Levels of Palm Kernel Meal (PKM) on Nutrient Retention

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Abstract: A nutrient retention trial was conducted over a twenty four day period. Eighty one day old chicks of Arbor acres strain were randomly allotted to nine isonitrogeneous dietary treatments where PKM was included in the diet at 0,10,20,30 and 40% levels and PKM treated with Maxigrain® at 10, 20, 30, and 40% levels with three replicates and three birds each in metallic cages. Results show that there was significant (P<0.001) difference in protein, fat, NFE and metabolizable energy retention which were higher in the control and Maxigrain® treated diets compared with the corresponding diets without Maxigrain®. The crude fibre retention was significant (P<0.05) lower in the control compared treatments. The crude fibre retention values at 20 and 30% PKM diets with Maxigrain® were significantly (P<0.05) lower than values for 20 and 30% PKM diets without Maxigrain®. The results indicates that enzyme treatment of PKM increased the retention of vital nutrients and metabolizable energy.

Key words: Palm kernel meal, Maxigrain®, broiler, nutrient retention, metabolizable energy

Introduction

The role of enzymes as feed additive in poultry diets is well established. Hastings (1946) and Allen *et al.* (1997) all observed that enzyme addition to monogastric animal feed reduced viscosity of ingesta in the intestine and showed a marked improvement on the various morphological effects of feeding fibrous materials to non-ruminant animals. The use of PKM in poultry diets has been practiced for several decades. Its low level of key essential amino acids (Lysine and Methionione in particular), high dietary fibre (particularly in the form of β-mannan) and grittiness have precluded its inclusion in broiler diets. Nutritionally, Palm Kernel Meal contains moderate amounts of protein and carbohydrate. Crude protein of Palm Kernel Meal ranges from 14 to 21%. This level is too low for use in starter diets for young chicks but it is adequate for older birds. Table 1 Show the physical characteristics and nutrient composition of PKM, while Table 2 shows the amino acid availability, exceeding 85%, except for valine and glycine.

Examination of the physical characteristics of Palm Kernel Meal reveals that its bulk density is quite high compared to copra meal (coconut) their respective values are 0.67 and 0.56g/cc. Although Palm Kernel Meal and copra meal have some common properties in carbohydrate composition, their water holding capacity differs greatly. Palm Kernel Meal 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).

A detailed description of the carbohydrate fraction of PKM has been reported by Knudsen (1997). This author reported that total carbohydrate of Palm Kernel Meal, 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) (Knudsen, 1997). This means that 81% of Palm Kernel Meal Carbohydrate is in the form of NSPs. Of the total NSPs present in Palm Kernel Meal 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 feel gritty and fibrous. Fractionation of Palm Kernel Meal based on its proximate analysis reveals that 49% of the dry matter of Palm Kernel Meal is in the form of nitrogen free extract (Sue, 2001; Sundu *et al.*, 2004). Of the NSPs present, it has been found that 78% is linear Mannan with very low galactose substitution, 12% cellulose, 3% glucoronoxylans and 3% arabinoxylans (Dusterhoft *et al.*, 1992). It also contains small amount of galactomannan (Daud and Jarvis, 1992; Dusterhoft *et al.*, 1992; Knudsen, 1997). This type of Mannan is characterized as hard and water insoluable (Warren, 1996). Most Palm Kernel Meal mannan is extremely hard, highly crystalline and water insoluble (Aspinal, 1970). However, Dusterhoft *et al.* (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 widely, from at least 2591 cal/kg (Chin, 2002) to 3959 cal/Kg (Sundu *et al*, 2005). This may be due to the fact that the oil content of palm kernel meal varies due to differences in oil extraction process. The higher metabolizable energy values may be due to higher oil content remaining in the Palm Kernel Meal after the product is processed by expeller machinery (O'Mara *et al.*, 1999). MAXIGRAIN® - contains cellulose-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.

Numerous researchers have demonstrated that the soluble-NSP fraction, not the total NSP fraction, is responsible for anti-nutritive responses. These NSPs can bind large amounts of water, and as a result, the viscosity of fluids in the digestive tract is increased. The increased viscosity causes problems in the small intestine because it reduces nutrient availability (Particularly fat) and results in increased amounts of sticky droppings. (Choct, 1998).

To counteract these anti-nutritional effects, enzymes are often added to the feed. This study was therefore designed to evaluate the nutrient retention profile of broilers fed graded levels of PKM treated with and without Maxigrain®.

Materials and Methods

Eighty one day old broiler chicks (mixed sexes) of Arbor acres strain was used for this experiment. The birds were weighed at day old and brooded and fed a controlled diet shown in Table 3, during a two weeks adaptation period.

At two weeks of age, they were randomly assigned to nine groups housed in metallic cages and fed nine isonitrogeneous experimental diets formulated at 23%CP. The treatments were replicated three times with three chicks per cage. The experimental diet was fed during a 7-day pre- faecal collection period. This was followed by a 3 day excreta collection period using the total collection procedure. The excreta collected was oven dried at a temperature of 70°C for 48 hours. Weighed and ground prior to chemical analysis.

Feed and water was supplied *ad-libitum* during the trial period which lasted 24 days.

The treatment diets for the experiment were:

Treatment 1 – control diet without PKM or Enzyme
Treatment 2 – contain 10% PKM with Enzyme treatment
Treatment 3 – contain 10% PKM without Enzyme
Treatment 4 – contain 20% PKM with Enzyme treatment
Treatment 5 – contain 20% PKM without Enzyme
Treatment 6 – contain 30% PKM with Enzyme treatment
Treatment 7 – contain 30% PKM without Enzyme
Treatment 8 – contain 40% PKM with Enzyme treatment
Treatment 9 – contain 40% PKM without Enzyme

The PKM was treated with 100gm per metric ton of Maxigrain® and added at 10%, 20%, 30%, 40% inclusion of PKM to the diets. The compositions of the diets are as shown on Table 3. Samples of basal diet, test diets and excreta were analyzed for moisture, ether extract and crude fibre, using the method of AOAC (1990).

Table 1: Physical characteristics and nutrient content of palm kernel meal

Fractions	Composition	References
Dry matter (%)	94	(1)
Crude protein (%)	14-21	(1) (2) (3)
Gross Energy (K.Cal/kg)	4998*	(1)
Crude fibre (%)	21-23	(1) (4)
Lipid (%) 17-Aug	(1) (4)	
Ash (%) 6-Mar	(1) (4)	
Bulk density (unmodified) (g/cm^3)	0.67	(1)
Bulk density (0.5mm) (g/cm^3)	0.57	(1)
WHC (1mm) (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.

All data obtained were subjected to the analysis of variance using the General Linear Model procedure of Statistical Analysis System (SAS) computer software package (1985). Significance of difference between means was determined by applying the Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

The Apparent Metabolizable Energy (AME), True Metabolizable Energy (TME) and Nitrogen Corrected Metabolizable Energy (MEn) of each diet were calculated using the following equations.

AME = Ge_f x Quantity of feed consumed – GE_{fa} x Quantity of faecal output.

TME = Ge_f x Quantity of feed consumed – GE_{fa} x Quantity of excreta of fed bird – GE_{fa} x Quantity of excreta of fasted birds

MEn = Ge_f x Quantity of feed consumed – GE_{fa} x Quantity of faecal output. ± (8.22 X Nitrogen retained).

Where Ge_f = Gross Energy of feed in Kcal/kg
Ge_{fa} = Gross Energy of faeces in Kcal/kg

Nutrient retention (NR) was determined for crude protein, fat, crude fibre, ash, and NFE, using the equation.

$$N.R = \frac{\text{Nutrient Intake} - \text{Nutrient output}}{\text{Nutrient Intake}} \times 100$$

Where: Nutrient Intake (g) = Dry feed intake x Nutrient in diet

Nutrient Output (g) = Dry faecal output x Nutrient in faeces.

Results

The effects of PKM with and without Maxigrain® treatment on nutrient retention is presented on Table 5. The protein retention in the control, 20, 30 and 40% Maxigrain® treated diets and 10 and 20% diets without Maxigrain® were similar but significantly (P<0.001) higher than values for 30, 40% diets without Maxigrain®

Table 2: Amino acid composition and availability of Palm Kernel Meal (percentages)

Amino Acids	Composition (%)			Availability	0-3 weeks 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
Phenylanine*	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

and 40% with Maxigrain®. Protein retention of the 10% Maxigrain® treated diet show best results compared with control and other treatments with or without Maxigrain® treatment. PKM supplies both protein (CP 18%) and gross energy (4998kcal/kg) which is classified as protein source of medium grade. The superiority of protein retention at all levels of PKM treated with Maxigrain® compared to the PKM without enzymes indicated that Maxigrain® improves the protein content of PKM.

Fat retention profile were significantly (P<0.001) different across the treatments. The values for the control, 10 and 20% PKM with Maxigrain® were significantly (P<0.001) higher than all other treatments. Fat retention in the Maxigrain® treated diets were similar in 10, 20 and 30% PKM levels followed by a decline in 40% PKM level. The fat retention values were similar in 40% PKM with Maxigrain® and 10, 20, 30 and 40% PKM without Maxigrain®.

The crude fibre retention in the control diet was significantly (P<0.05) lower than all other diets with or without Maxigrain®. The crude fibre retention increased with increasing levels of PKM with or without enzyme.

The ash retention was significantly (P<0.001) higher in 10% PKM with Maxigrain® than all other treatments. The values in the control, 20 and 30% PKM with Maxigrain® and 10 and 20% PKM without Maxigrain® are similar but significantly (P<0.001) higher than values for 40% PKM with Maxigrain® and 30 and 40% PKM without Maxigrain®.

The NFE retention in the control, 10, 20 and 30% PKM with Maxigrain® and 10% PKM without Maxigrain® were significantly (P<0.001) higher than all other treatments. Similarly, the NFE retention values for all levels of PKM with Maxigrain® were significantly (P<0.001) higher than the values for the corresponding levels of PKM without Maxigrain® except at 40% with and without Maxigrain® where the values similar.

The effects of PKM with and without Maxigrain® treatment on metabolizable energy is presented on Table 6. The values for the apparent metabolizable energy and nitrogen corrected metabolizable energy in the control and 10% PKM with Maxigrain® were significantly (P<0.001) higher than all other treatments. Similarly, the apparent metabolizable energy values for all levels of PKM with Maxigrain® were significantly (P<0.001) higher than the values for corresponding levels of PKM without Maxigrain® except at 40% with or without Maxigrain® where the values were similar. The true metabolizable energy (True ME) values in the control and all levels of PKM with Maxigrain® are significantly (P<0.001) higher than all levels of PKM without Maxigrain® except at 40% with and without Maxigrain® where the values were similar.

Discussion

The effects of Maxigrain® treatment of PKM on nutrient retention showed that protein retention between diets with Maxigrain® treatment were higher compared to diets without Maxigrain® which could have contributed to the higher body weight gains observed among birds fed Maxigrain® treated diets maximized with optimum at 20% PKM inclusion compared with control and other diets with or without Maxigrain®. This agrees with the findings of Ariff Omer *et al.* (1998) who reported optimum PKM inclusion rate in poultry ration at 20%.

There was significant variation in fat retention among all treatment, which is higher in the control and Maxigrain® treated diets compared with diets without Maxigrain®. This is in agreement with Marquardt *et al.* (1996) who reported improvement in the body weight and feed conversion efficiency due to an increase in fat and protein digestibility. Increase fat retention also increases the bioavailability of fat soluble vitamins. This was easily observable in the increase in ash retention in Maxigrain® treated diets compared with diets without Maxigrain®. The observation of Swain and Johri (1999) that the addition of enzyme to feed caused increase in

Table 3: Percentage composition of starter diets

Ingredient	Control	10%	20%	30%	40%
Maize	55.00	47.50	40.00	33.00	25.00
Soyabean Meal	40.00	37.50	35.00	32.00	30.00
*PKM	0.00	10.00	20.00	30.00	40.00
Bone meal	2.60	2.60	2.60	2.50	2.60
Limestone	1.60	1.60	1.60	1.60	1.60
Salt	0.35	0.35	0.35	0.35	0.35
**Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00	100.00
Cost/kg diet(N)	43.00	40.00	38.00	35.00	33.00
Calculated analysis of starter diets					
ME Kcal/kg	2800.00	2757.00	2657.00	2561.00	2456.00
Crude Protein(%)	23.00	23.00	23.00	23.00	23.00
Crude Fibre(%)	4.00	5.00	5.40	6.00	7.00
Ether Extract(%)	3.50	3.80	4.00	4.20	4.50
Lysine (%)	1.35	1.33	1.30	1.30	1.30
Methionine(%)	0.44	0.45	0.46	0.48	0.50
Calcium (%)	1.50	1.50	1.50	1.50	1.50
Available Phosphorus(%)	0.70	0.70	0.70	0.70	0.70

**Bio-mix premix supplied per kg of diet: Vitamin A 12500 I.U Vit D_3 2500 I.U Vit E 50mgL Vit K_3 2.5mg; Vit B_1, 3.0mg: Vit B_2 6.0mg; Vit B_6 6.0mg: Niacin 40.0mg; calcium pantothenate 10.0mg; Biotin 0.80mg; Vit B_{12} 0.25mg; Folic acid 1.0mg; Chloline chloride 300mg; manganese 100mg: Iron 50mg; Zinc 45; copper 2.0mg; cobalt 0.25mg; iodine 1.55, selenium 0.1mg.

Table 4: Percentage composition of finisher diets

Ingredient	Control	10%	20%	30%	40%
Maize	65.00	55.00	50.00	40.00	32.00
Soyabean Meal	30.00	30.00	25.00	25.00	23.00
*PKM	-	10.00	20.00	30.00	40.00
Bone meal	2.60	2.60	2.6.00	2.60	2.60
Limestone	1.60	1.60	1.60	1.60	1.60
Salt	0.35	0.35	0.35	0.35	0.35
**Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00	100.00
Cost/kg diet(N)	40.00	38.50	35.00	33.00	31.00
Calculated analysis					
ME Kcal/kg	3000.00	2850.00	2758.00	2635.00	2528.00
Crude Protein (%)	20.00	20.00	20.00	20.00	20.00
Crude Fibre (%)	3.00	4.00	5.00	6.00	7.00
Ether Extract (%)	3.70	3.90	4.10	4.30	4.50
Lysine (%)	1.10	1.14	1.00	1.00	1.00
Methionine (%)	0.39	0.42	0.42	0.40	0.45
Calcium (%)	1.50	1.50	1.50	1.50	1.50
available Phosphorus (%)	0.60	0.60	0.60	0.60	0.60

**Bio-mix premix supplied per kg of diet: Vitamin A 12500 I.U Vit D_3 2500 I.U Vit E 50mgL Vit K_3 2.5mg; Vit B_1, 3.0mg: Vit B_2 6.0mg; Vit B_6 6.0mg: Niacin 40.0mg; calcium pantothenate 10.0mg; Biotin 0.80mg; Vit B_{12} 0.25mg; Folic acid 1.0mg; Chloline chloride 300mg; manganese 100mg: Iron 50mg; Zinc 45; copper 2.0mg; cobalt 0.25mg; iodine 1.55, selenium 0.1mg.
*The PKM based diets consists of 10%, 20%, 30% and 40% with Maxigrain® and 10%, 20%, 30% and 40% without Maxigrain®.
One Naira (N) is equivalent to 128 US Dollars ($)

energy but a reduction in fat retention is not in agreement with this study since retention of fat relates to vitamin storage in the body, a reduction may be detrimental to broilers. The results of experiments conducted by Langhout and Schutte (1995) showed that the effects of chick performance and nutrient digestibility of dietary endo-xylanase in wheat and rye based diets are influenced by the type of fat in the diet. The crude fibre retention was poorest in the control as there was no enzyme or PKM in the diet. Retention of crude fibre was lower in 20 and 30% Maxigrain® treated diets compared to the correspondingly diets without Maxigrain®. Even at 10 and 40% PKM levels with and without Maxigrain® where crude fibre retention values were not significantly different, the values for the Maxigrain® treated diets were numerically lower. This

Table 5: Effects of treated PKM with and without Maxigrain® on nutrient retention of broiler chicks

		--------- PKM with Maxigrain® Diets ---------				-------- PKM without Maxigrain® Diets --------					Signifi-
Parameters	Control	10+	20+	30+	40+	10-	20-	30-	40-	SEM	cance
Protein	54.333^{bc}	64.667^{a}	58.393^{ab}	51.653^{bcd}	47.28^{cde}	50.94^{bcd}	47.00^{cde}	44.643^{de}	42.653^{e}	1.41	***
Fat	79.937^{a}	78.333^{ab}	71.91^{bc}	70.797^{cd}	62.387^{ef}	59.637^{f}	63.927^{def}	66.33^{cdef}	68.667^{cde}	1.34	***
Crude Fibre	17.163^{a}	25.997^{b}	28.333^{b}	48.00^{c}	54.417^{d}	28.00^{b}	48.667^{c}	54.323^{d}	56.333^{d}	0.90	*
Ash	33.00^{b}	42.00^{a}	35.333^{b}	31.67^{b}	26.00^{c}	34.33^{b}	33.00^{b}	26.00^{c}	21.67^{d}	0.78	***
NFE	71.00^{ab}	75.667^{a}	74.667^{a}	66.00^{bc}	52.00^{ef}	68.667^{b}	61.00^{cd}	55.333^{de}	49.00^{f}	1.10	***

· Abcdef Means with different superscript within the same row are significantly (P<0.001) different. · *= (P<0.05) *** = (P<0.001)

Table 6: Effects of treated PKM with and without Maxigrain® on metabolizable energy of broiler chicks

		--------- PKM with Maxigrain® Diets ---------				-------- PKM without Maxigrain® Diets --------					Signifi-
Parameters	Control	10+	20+	30+	40+	10-	20-	30-	40-	SEM	cance
Apparent ME	3496.7^{a}	3407.00^{a}	3017.00^{b}	2724.70^{bc}	1742.00^{de}	2839.00^{b}	2439.33^{c}	2035.0^{d}	1641.70^{e}	71.63	***
Men	3498.7^{a}	3409.0^{a}	3019.0^{b}	2725.7^{bc}	1744.0^{de}	2841.0^{b}	2441.3^{c}	2037.0^{d}	1643.7^{e}	71.63	***
True ME	3402.7^{a}	3315.3^{ab}	2922.0^{bc}	2625.3^{cd}	1640.3^{f}	2593.7^{cd}	2276.0^{de}	1867.3^{ef}	1525.0^{f}	79.83	***

•abcdef Means with different superscript within the same row are significantly (P<0.001) different. • *** = (P<0.001), Apparent ME = Apparent Metabolizable Energy. • Men = Nitrogen Corrected Metabolizable Energy. • True ME = True Metabolizable Energy

indicates that Maxigrain® a cocktail of enzymes must have broken down some of the NSPs in the PKM. Of the NSPs in PKM, 78% is linear mannan, 12% cellulose, 3% glucoronoxylans and 3% arabinoxylans (Dusterhoft *et al.*, 1992). Since Maxigrain® contains cellulose, β-glucanase, xylanase and phytase, these enzymes must have acted on cellulose, glucoronoxylans and arabinoxylans thereby reducing the crude fibre content and subsequently increasing the energy content retention and NFE. The NFE represent the soluble carbohydrates in the diet. The addition of enzymes to PKM is expected to ameliorate the antinutritive effect of β-mannan and also to degrade large percentage of NSPs and oligo-saccharide components of the diet. (Akpodiete *et al.*, 2006) The higher values of NFE retention in PKM diets with Maxigrain® as compared with PKM diets without Maxigrain® can be attributed to the degradative effect of Maxigrain® on the NSPs of PKM with subsequent release of soluble carbohydrates.

The effect of Maxigrain® treatment on ME of broiler chicks show increase in bioavailable energy (AME, TME and MEn) in the PKM diets treated with Maxigrain® to a maximum inclusion of 30% PKM. Atteh (2000) had earlier observed improvement in crude fibre digestion and ME of diets where enzyme supplementation of 50% wheat bran replaced 50% of maize in a control diet relative to an unsupplemented wheat bran diet. The AME and MEn of the different diets and the control with or without Maxigrain® show little variation. This support the work of Sibbald and Slinger (1962) who observed a close correlation between corrected and classical ME values and therefore stated that since the amount of tissue protein which is catabolized is small relative to the amount stored by growing birds, or deposited in eggs of laying hens, the imposition of penalty of nitrogen retention is a questionable procedure. Swift and French (1954) argued that since storage of protein characterize growth, it is difficult to justify the imposition of penalty for nitrogen retention. Muztar *et al.* (1977) concluded that application of nitrogen correction does not seem to be of major consequence when one considers the amount of time and labor in determining the nitrogen content of feed and excreta samples. Therefore the little variations observed between the AME and MEn of the different diets in this study support the earlier works that believe that the exertion of penalty of nitrogen correction of energy was not necessary.

Conclusion: The improvement in protein, fat and NFE retention was observed to be more significant than crude fibre retention. The Apparent metabolizable energy (AME), True Metabolizable energy (TME), and Nitrogen corrected metabolizable energy (MEn) of the PKM treated diets show improvement higher than diets without PKM treatment. Maxigrain (a cocktail of exogenous enzymes) treatment improves nutrient retention on a relative bases but to maximize the benefit of enzyme supplementation of PKM, a more specific cocktail of enzymes containing mannanase must be included.

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