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Evaluation of Enzyme (Maxigrain®) Supplementation of Graded Levels of Palm Kernel Meal (PKM) on the Performance of Broiler Chickens

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Abstract: This study was conducted to evaluate the effects of Palm Kernel Meal (PKM) in diets supplemented with or without enzyme (Maxigarin®) as replacement for Maize in broiler diets. Four hundred and five day old Arbor acres broiler chickens were randomly allotted to nine isonitrogeneous diet where PKM was included in the diet at 10, 20, 30, and 40% levels. Four of the diets contain PKM without Maxigrain® while the other four contained PKM with Maxigrain® supplementation. The Maxigrain® was added to the already formulated diet (supplementation) at 0.01% to four of the nine diets. At the starter phase the final body weight, weight gain and average daily weight gain were significantly ($P<0.001$) higher in 10% and 20% PKM diets Maxigrain® supplementation compared to other treatments. Feed intake was significantly ($P<0.001$) higher in the control, 10% and 20% PKM diets with Maxigrain®. The feed : gain ratio was significantly ($P<0.001$) lower in the 10% PKM diet with Maxigrain® compared to all other treatments. All levels of PKM diets with Maxigrain® were significantly ($P<0.001$) lower than the corresponding levels without Maxigrain®. The feed cost/kg weight gain were significantly ($P<0.001$) lower in all PKM diets with and without Maxigrain® compared to the control. At the finisher phase, the final weight, weight gain and average daily weight gain were significantly ($P<0.001$) higher in the 10% and 20% PKM diets with Maxigrain® compared to all other treatments. Feed intake was significantly ($P<0.001$) higher in all PKM diets with and without Maxigrain® compared with the control. Feed : gain ratio and feed cost/kg weight gain (N) were significantly ($P<0.001$) lower in the control and all PKM diets with Maxigrain® supplementation compared to all PKM diets without Maxigrain®. The results indicate that Maxigrain® supplementation of PKM diets improved the utilization of PKM. Diets with 10 and 20% inclusion of PKM and Maxigrain® were better than the control maize based diets. The dressed weight, neck, liver, lungs, kidney, abdominal fat, pancrease, spleen and length of intestines were significantly ($P<0.001$) different across treatments. Similarly, the percentage weight of the breast, thigh, heart and the intestines were significantly ($P<0.001$) different across treatments with no particular trend established. The drumstick, wings, head and gizzard were significantly ($P<0.05$) different across treatments. No significant difference in the dressing percentage and the back across the treatments.

Key words: PKM, Maxigrain®, supplementation, broiler performance

Introduction

The advent and use of commercial feed enzymes in livestock feeding has opened new horizon for the use of hitherto waste feedstuff. Results of experiments (Atteh, 2001) showed that with the use of a bacterial xylanase enzyme, it was possible to replace 50% of maize with wheat offal without detrimental effect on broiler performance. Atteh (2001) reported 56% and 26% increase in apparent metabolizable energy (AME) of wheat offal and BDG respectively when supplemented with xylanase enzyme. Palm Kernel Meal is one of the abundant agricultural by-products, is cheap and readily available. It is aflatoxin free, palatable and has considerable potential as a carbohydrate and protein source. However, due to it's low nutritive value, grittiness and potential for deterioration in unhygienic conditions, a large amount of PKM is often discarded and can create environmental problems in the future (Sundu and Dingle, 2005). With the availability of feed enzymes to digest fibre, there is need to evaluate these feeding value of enzyme treated PKM. From the composition of PKM, it appears that three main enzymes are needed to improve their nutritive value namely: mannanase, β-galactosidase and cellulase. (Balasubramaniam, 1976). PKM has been reported to contain mannan and galactomannan and these are likely to have anti-nutritive properties. Of the total NSPs in PKM, 78% is mannan, 3% is arabinoxylans, 3% is glucoronoxylans which were found to be water-insoluble and 12% is cellulose (Dusterhoft *et al*., 1992). These problems are mostly tackled by either a careful formulation of diet for protein and energy balance or the inclusion of enzymes, particularly mannanase, galactosidase and cellulase. 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. Enzymes have been approved for use in poultry feed because they are natural products of fermentation and therefore pose no threat to the animal or the consumer. (Vukic Vranjes and Wenk, 1993) Their use in poultry feeds has predominantly been related to the hydrolysis of fibre or non-starch polysaccharide (NSP) fraction of cereal grains. These NSPs cannot be digested by the endogenous enzymes of poultry and can have anti-nutritive effects. They cause an increase in viscosity of intestinal content and entrap large amounts of well digestible nutrients like starch and proteins. This leads to an impaired digestion and digestive problems. (Almirall *et al.*, 1995)

This study aims to determine the effects of Maxigrain® supplementation of Palm Kernel Meal on the performance of broiler chicks, evaluate the economics of raising broiler chicks on Maxigrain® supplemented Palm Kernel Meal, and determine the effects of Maxigrain® supplementation of Palm Kernel Meal on carcass characteristics of broilers.

Materials and Methods

The starter phase lasted from 0-4 Weeks. Four hundred and five day old chickens (mixed sexes) of Arbor acres strain were used for this study. The birds were weighed at day old and randomly assigned to nine isonitrogeneous diets, formulated at 23% crude protein as shown on Table 2. Here the compounded diet was supplemented with Maxigrain® at 100gm per metric ton inclusion irrespective of the PKM levels in the diet. Chemical analysis of diets were done by the method of A.O.A.C. (1990).

The birds were housed on deep litter system in a 4x2+1 factorial combination of dietary levels of PKM with or without Maxigrain® in a Completely Randomized Design (CRD). The treatments were replicated three times with fifteen chicks per replicate. The chicks were brooded conventionally in a deep litter system. Feed and water were supplied *ad-libitum* while vaccinations were administered appropriately. Mortality was recorded as it occurred. The birds were weighed weekly, live weight, weight gain, average daily gain, feed intake, water intake, feed : gain ratio and feed cost (N/kg gain) were determined at weekly intervals.

The finisher phase lasted from 5-8 weeks of age. At the end of the starter phase, the birds were fed on the finisher diet at the beginning of the fifth week. There were nine(9) diets, the composition of which is shown in Table 3. The diets were isonitrogeneous at 20% crude protein. Each treatment was replicated three times. Feed and water were supplied *ad-libitum* during the experimental period. Mortality was recorded as it occurred. Weekly records of live weight, weight gain, average daily gain, feed intake, water intake, feed : gain ratio and feed cost (N/kg gain) were determined. At the end of the eight week of feeding trial, two birds from each replicate were randomly selected, weighed for carcass evaluation.

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).

Results

Effects of Maxigrain® supplementation of PKM on broiler performance: The effect of Maxigrain® supplementation on the performance of broiler starter chicks (0-4 weeks) is presented in Table 4. The final weights and average daily gain of the 10 and 20% diets with Maxigrain® were significantly ($P<0.001$) superior to control while 20, 30 and 40% diets without Maxigrain® were inferior to control. The control diet was similar to 30 and 40% diets with Maxigrain® and 10% diet without Maxigrain® in their final weights. All the Maxigrain® supplemented diets show relatively higher weights than diets without Maxigrain® at comparative levels.

Feed intake was similar between control and 10% Maxigrain® supplemented diet but significantly ($P<0.001$) different compared with all other diets with or without Maxigrain® supplementation. The feed in take among Maxigrain® supplemented diets were relatively higher than diets without supplementation. The feed in take at 40% PKM inclusion with or without Maxigrain® was similar.

Feed : gain ratio was similar between control and all other diets with or without Maxigrain® except 10, and 20% diets with Maxigrain® which were superior to control. The best diet was 10% with Maxigrain® supplementation with a feed : gain ratio value of 1.34. The feed : gain ratio at 30%, were similar with or without Maxigrain®.

Feed cost/kg weight gain was significantly ($P<0.05$) different between control (with the highest value) and all other diets with or without Maxigrain® supplementation. The feed cost/kg weight at 10, 20 and 30% with Maxigrain® is similar to 10, 20, 30 and 40% diets without Maxigrain®. The best diet in feed cost/kg weight was at 40% with Maxigrain® at a value of N50.43.

Water intake shows that the control was similar to 10% diet with Maxigrain® but significantly ($P<0.001$) higher than all other diets.

The water intake at 10, 20, 30% PKM inclusion level in the Maxigrain® supplemented diets were significantly ($P<0.001$) higher than in diets without Maxigrain® supplementation. The water intake at 40% PKM inclusion was similar in diets with or without Maxigrain®.

Table 1: Endogeneous enzymes in poultry

Organ	Enzyme produced	Substrate acted upon	End product
Mouth (Saliva)	Alpha-Amylase	Starch	Glucose, Maltose Dextrins
Proventiculus	Pepsin	Protein	Peptides
Pancrease	Amylase	Starch	Glucose, Maltose Limit Dextrins. Fatty Acids, Monoglycerides.	Amino acids and small peptides.
	Lipase	Fat	Amino acids
	Trypsin	Proteins	
	Chymotrysin	Peptides	
	Elastase		
	Carboxy peptidase		
Intestinal Mucosa	Oligo-1,6 - glucosidase	Dextrin	Glucose
	Maltase		
	Sucrase	Maltose	Glucose
	Amino-petidase	Sucrose	Glucose & Fructose
	Dipeptidases	Peptides	Amino acids
		Dipeptides	Amino acids

Source: Card and Neshien (1972)

Table 2: 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.

The water : feed ratio was similar in all diets with or without Maxigrain®.

There was no significant ($P>0.05$) difference in mortality in all diets with or without Maxigrain® supplementation.

Table 5 : shows the dietary effects of the treatments on the performance of broiler finisher chickens (5-8weeks). The initial weight of the birds in this phase is the same as the final weight of the starter phase of this study.

Control was significantly ($P<0.001$) different compared with all other diets with or without Maxigrain® supplementation in the final weights but inferior to 10 and 20% diets with Maxigrain®. All the supplemented diets were significantly ($P<0.001$) higher in their final weights when compared with the unsupplemented diets at the same level of PKM inclusion. PKM inclusion at 10% was the best followed by 20% in the supplemented diets in their final weight gain while the control diet was significantly ($P<0.001$) superior to all the other diets with or without Maxigrain®. The supplemented diets were significantly ($P<0.001$) different at comparable levels of inclusion with the unsupplemented diets.

The feed intake by the control was the lowest and significantly ($P<0.001$) different from all other diets with or without Maxigrain® supplementation. Feed intake increased with increasing level of PKM inclusion with or without Maxigrain® supplementation. Maxigrain® supplemented diets at 30 and 40% were similar when compared with the same levels without supplementation.

The feed : gain ratio between control, 10 and 20% Maxigrain® supplemented diets were similar. The feed : gain ratio increased with increasing levels of PKM with

Table 3: 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	2.60	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 2000 I.U: Vit E 30mg; Vit K_3 3.75mg; Vit B_1, 2.5mg: Vit B_2 5.0mg; Vit B_6 3.75mg: Niacin 30mg; Pantothenate acid 12.5mg; Biotin 0.50mg; Vit B_{12} 25mg; Folic acid 0.750mg; Chloline chloride 375mg; Manganese 150mg: Iron 25mg; Zinc 37.5; copper 2.0mg; Iodine 1.0mg; cobalt 0.200mg; selenium 0.100mg; Growth promotant 20mg; Antioxidant 100mg. *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 ($)

or without Maxigrain® supplementation. The best diet was 10% with Maxigrain® at a value of 2.26 when compared with all other diets with or without supplementation.

Feed cost/kg gain was observed to have similar trend as in the feed : gain ratio at all levels. The best diet was 10% with supplementation at a value of N93.46 similar to control and 20% diet with supplementation.

There was significant ($P<0.001$) difference in water intake between control and all other treatments with or without supplementation. There was significant ($P<0.001$) difference at 10% PKM inclusion with Maxigrain® compared with the same level without Maxigrain®. Water intake was similar at 20, 30 and 40% diets with Maxigrain® supplementation were similar when compared with the same levels without Maxigrain®.

There was no significant ($P>0.05$) difference in mortality in all the treatments with or without Maxigrain® supplementation.

Water : feed ratio was calculated without any observable adverse effect of increasing levels of PKM with or without Maxigrain on water consumption ratio.

Table 6 show the results of the carcass analysis of the birds fed the Maxigrain® supplemented diets. The results shows that there was significant ($P<0.001$) difference in the dressed weight of the control diet compared to all other diets with or without Maxigrain® supplementation but was observed to be significantly ($P<0.001$) inferior to 10 and 20% diets with Maxigrain®. The dressed weight was progressively lower with increasing levels of PKM with or without supplementation except at 10 and 20% Maxigrain® supplementation where dressed weight was higher.

There was no significant difference ($P>0.05$) in the dressing percentage and the back of the birds with or without supplementation. There was significant difference ($P<0.05$) in the breast, neck, thigh, drumstick, wings, head, lungs, gizzard, pancrease, intestines, spleen and intestinal length but there was no specific trend established.

The %heart of the birds fed supplemented diets were significantly ($P<0.001$) different than and those fed the unsupplemented diets which were bigger than control and all supplemented diets. The weight of the heart in the control diet was similar to the weight of the heart of all Maxigrain® supplemented diets at all levels of inclusion.

The %liver in the control was similar to 10 and 20% diets with Maxigrain® and 10% without Maxigrain® At all levels of inclusion, the liver in Maxigrain® supplemented diet were significantly ($P<0.001$) lower than those in the unsupplemented diets where the size of the liver was observed to increase with increasing levels of PKM inclusion with or without Maxigrain®.

The %kidney was similar between control, 10 20 and 40% diets with Maxigrain® and 10% without Maxigrain® but significantly ($P<0.001$) lower than the other treatments. The size of the kidney was observed to increase with increasing levels of PKM in the unsupplemented diets compared with the Maxigrain® supplemented diets. The abdominal fat was significantly

Table 4: Performance of broiler starter (0 - 4 weeks) chicks on PKM diets with or without Maxigrain® supplementation

Parameters	control	PKM 10+	With 20+	Maxi grain® 30+	Diets 40+	PKM 10-	without 20-	Maxi-grain® 30-	diets 40-	SEM	Levels of Signi-ficance
Initial weight(g)	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	-	NS
Final weight(g)	916.33^{c}	1034.67^{a}	978.00^{b}	895.67^{c}	878.33^{c}	894.00^{c}	826.00^{d}	748.33^{e}	745.67^{e}	8.30	***
Weight gain(g)	876.33^{c}	994.67^{a}	938.00^{b}	855.67^{c}	838.33^{c}	854.00^{c}	786.00^{d}	708.33^{e}	705.67^{e}	8.30	***
Ave Daily gain(g)	31.30^{c}	35.52^{a}	33.50^{b}	30.56^{c}	29.94^{c}	30.50^{c}	28.07^{d}	25.30^{e}	25.20^{e}	0.29	***
Feed in take (g)	1363.67^{a}	1332.67^{ab}	1311.33^{b}	1243.00^{c}	1181.00^{d}	1248.00^{c}	1198.00^{d}	1171.00^{d}	1168.00^{d}	8.47	***
Feed:Gain Ratio	1.56^{de}	1.34^{a}	1.40^{bc}	1.45^{bcde}	1.41^{bcd}	1.46^{cde}	1.53^{de}	1.66^{e}	1.6^{e}	0.02	***
FeedCost/kgwt(N)	66.92^{c}	57.35^{b}	57.06^{b}	54.92^{b}	50.43^{a}	58.46^{b}	58.02^{b}	57.94^{b}	54.77^{b}	0.75	*
Water intake (lts)	3206.33^{a}	3209.33^{a}	3086.33^{b}	2952.00^{c}	2787.33^{de}	2834.33^{d}	2828.33^{d}	2756.00^{e}	2756.67^{e}	10.57	***
Water:Feed Ratio	2.36	2.41	2.36	2.38	2.36	2.28	2.36	2.36	2.36		
Mortality	0.33	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.33	0.12	NS

•abcdef Means with different superscript within the same row are significantly (P<0.001)different

*** = (P<0.001), NS: No significant difference (P>0.05). One Naira (N) is equivalent to 128 US Dollars ($)

(P<0.001) higher in the control group compared to all other treatments. Similarly, the abdominal fat in the Maxigrain® supplemented diets were significantly (P<0.001) lower than the unsupplemented diets at all levels of PKM inclusion.

Discussion

The performance of broiler starter (0-4weeks) chicks with or without Maxigrain® supplementation showed increase in final weight gain, improved feed : gain ratio in the control and Maxigrain®treated diets relative to diets without Maxigrain®. This is expected as Choct (2006) reported the degradation of β - mannan and 70% NSPs into soluble metabolizable products for monogastrics when enzymes are added to high fibre monogastric diets. Feed and water intake was slightly higher up to an optimum of 30% in the Maxigrain® supplemented diets compared to diets without Maxigrain®. Onwudike, (1986), Ezieshi and Olomu (2004) reported higher fed intake of birds fed a PKM based diet compared with a maize – based diet due probably to its faster passage rate in the digestive tract. Feed : gain ratio was better among Maxigrain® supplemented diets compared with the control and all other diets without Maxigrain®. This is similar to the report of Atteh (2000) who observed an improvement in weight gain and feed conversion efficiency in birds fed enzyme supplemented diets. Ariff Omer *et al.* (1998) and McDonald *et al.* (1995) observed lower weights of birds fed increasing levels of PKM without supplementation.

The performance of broiler finisher (5-8weeks) chicks with or without Maxigrain® indicated that the birds on control and Maxigrain® treated diets had a higher final weight gain, improved feed : gain ratio compared to diets without Maxigrain®. Feed and water intake increased with increasing inclusion of PKM probably due to the critical need for energy in finisher chickens but this did not translate into higher live weight or weight gain especially among diets without supplementation. Feed : gain ratio and feed cost/kg weight gain was best at 10% diet with supplementation similar to the control. This is supported by the report of Classen *et al.* (1995) and Scott *et al.* (1998) who reported that the responses to the use of enzymes is highest on poor quality raw materials. Panigrahi and Powell (1991) found that the inclusion of PKM up to 50% was tolerated provided that the birds were kept to 7 weeks of age. The water intake of birds fed PKM based diets is also increased (Panigrahi and Powell, 1991) and there is increased moisture content of excreta (Onifade and Babatunde, 1998).

The economic analysis reveal a comparative feed cost/kg weight (N/kg) similar to the control diet in the Maxigrain® supplemented diets up to 20% inclusion of PKM with the best result of N93.46 recorded at 10% PKM inclusion with supplementation. This is expected as the cost per metric ton of maize is widely higher than PKM at about N40.000 to N8,000 for maize and PKM, respectively. Akpodiete *et al.* (2006) reported that the cost of a kilogram feed reduction in cost with increasing PKM inclusion with the lowest cost at the highest PKM replacement level.

The carcass evaluation of broiler chicks fed diets with or without Maxigrain® supplementation showed similar trend as that of the growth performance. The birds fed on Maxigrain® supplemented diets had higher pre-slaughter weight, and carcass weight, compared to those on similar diets without Maxigrain® supplementation. There was no significant variation in the dressing percentage of the birds with or without Maxigrain®.

There was significant variation in the breast, neck, thigh, drum stick, wings, head, gizzard, and intestinal length but no trend was established. The lungs, liver, kidneys, pancrease and intestines were within the normal range reported for chickens suggesting the absence of toxic effects by the treatments.

However, a trend was observed in the heart, liver, kidney and abdominal fat. The heart appears to increase in diets without Maxigrain® supplementation probably due to increased function. This agrees with Brenes *et al.*, (1993), who reported that enzyme supplementation affects the relative size of some organs with relative reductions in the weights of such organs. Similar trend

Table 5: Performance of broiler finisher (5-8weeks) chicks on PKM diets with or without Maxigrain® supplementation

Parameters	Control	PKM 10+	with 20+	Maxi grain® 30+	diets 40+	PKM 10-	without 20-	Maxi grain® 30-	diets 40-	SEM	Levels of Signi-ficance
Initial weight(g)	916.33^{c}	1034.67^{a}	978.00^{b}	895.67^{c}	878.33^{c}	894.00^{c}	826.00^{d}	748.33^{e}	745.67^{e}	8.30	***
Final weight(g)	2107.00^{c}	2376.33^{a}	2279.00^{b}	1870.00^{e}	1722.00^{f}	1942.33^{d}	1654.67^{g}	1377.00^{h}	1304.67^{i}	12.43	***
Weight gain(g)	1190.67^{b}	1341.67^{a}	1301.00^{a}	974.33^{d}	843.67^{e}	1048.33^{c}	828.67^{e}	628.67^{f}	559.00^{g}	9.67	***
AveDaily gain(g)	42.52^{b}	47.92^{a}	46.46^{a}	34.80^{d}	30.13^{e}	37.44^{c}	29.60^{e}	22.45^{f}	19.96^{g}	0.34	***
Feed intake (g)	2781.33^{a}	3036.33^{c}	3259.67^{e}	3269.00^{e}	3397.97^{f}	2923.67^{b}	3130.67^{d}	3263.00^{e}	3388.00^{f}	12.16	***
Feed: Gain Ratio	2.34^{a}	2.26^{a}	2.60^{ab}	3.36^{c}	4.03^{d}	2.79^{b}	3.78^{d}	5.19^{e}	6.10^{f}	0.07	***
FeedCost/kgwt(N)	93.53^{a}	93.46^{a}	94.71^{a}	121.00^{c}	136.13^{d}	107.34^{b}	132.24^{cd}	171.41^{e}	189.18^{f}	2.32	***
Water intake (lts)	6655.67^{a}	7056.33^{b}	7303.67^{d}	7385.67^{e}	7459.33^{f}	7163.33^{c}	7256.00^{d}	7389.33^{e}	7507.00^{f}	10.57	***
Water:Feed Ratio	2.4	2.33	2.24	2.26	2.20	2.45	2.32	2.27	2.22		
Mortality (%)	0.66	1.00	0.33	0.66	0.66	0.33	0.33	0.66	1.00	0.30	NS

•abcdef Means with different superscript within the same row are significantly (P<0.001) different
•*** = (P<0.001) NS: No significant difference (P>0.05).

Table 6: Carcass characteristics of broiler chicks fed on PKM diets with and without Maxigrain® supplementation (expressed as percentage of live weight)

Parameters	Control	PKM 10+	with 20+	Maxi grain® 30+	diets 40+	PKM 10-	Without 20-	Maxi grain® 30-	diets 40-	SEM	Levels of signi-ficance
Live Wt(g)	2073^{b}	2360^{a}	2274^{a}	1875^{c}	1722^{d}	1966^{c}	1641^{d}	1370^{e}	1326^{e}	27.09	***
Dressed Wt(g)	1670^{b}	1871^{a}	1806^{a}	1389^{d}	1353^{ed}	1575^{c}	1273^{e}	1080^{f}	1046^{f}	25.17	***
Dressing %	80.54	79.48	79.42	77.08	78.57	80.06	77.55	78.80	78.80	0.93	NS
Breast%	26^{abc}	29^{a}	25^{bc}	24^{bc}	25^{abc}	23c	28^{ab}	25^{bc}	26^{abc}	0.82	**
Neck%	5.0^{d}	7.7^{ab}	8.0^{a}	7.0^{abc}	5.0^{d}	7.6^{bcd}	5.0^{d}	6.0^{cd}	6.0^{cd}	0.36	***
Thigh%	27.5^{bc}	30.5^{ab}	25.8^{c}	30.7^{a}	25.6^{c}	28.5^{abc}	27^{c}	25.7^{c}	26.6^{c}	0.82	**
Drum stick%	14.9^{a}	13.5^{a}	14^{a}	12.9^{ab}	13a	11^{b}	13.5^{a}	13^{a}	13.5^{a}	0.50	*
Wings%	9.4^{bcd}	9.0^{cd}	8.8^{d}	11^{a}	10^{abcd}	10.5^{abcd}	11^{a}	10.9^{abc}	11^{ab}	0.46	*
Back%	14.0	15.0	13.9	15.3	15.4	14.4	14.4	13.7	14.0	0.59	NS
Head%	2.5b	3.0^{ab}	3.0^{ab}	3.5^{a}	3.0^{a}	2.9^{ab}	2.9^{ab}	3.5^{a}	3.0^{a}	0.16	*
Heart%	0.47^{cd}	0.47^{d}	0.48^{bcd}	0.45^{d}	0.45^{d}	0.5^{abcd}	0.56^{ab}	0.55^{abc}	0.5^{a}	0.03	**
Liver%	1.46^{ef}	1.3^{f}	1.29^{f}	1.86^{cd}	1.99^{c}	1.6^{de}	2.09^{c}	2.4^{b}	2.98^{a}	0.08	***
Lungs%	0.57^{c}	0.58^{c}	0.57^{c}	0.74^{ab}	0.6^{c}	0.55^{c}	0.6^{c}	0.7^{b}	0.8^{a}	0.02	***
Kidney%	0.4^{d}	0.4^{d}	0.44^{cd}	0.5^{bc}	0.45^{cd}	0.4^{d}	0.5^{bc}	0.57^{ab}	0.6^{a}	0.06	***
Gizzard%	2.49^{c}	2.75^{bc}	2.99^{abc}	4.0^{a}	3.8^{abc}	3.0^{abc}	2.66^{bc}	3.6^{abc}	4.0^{ab}	0.37	*
AbdominalFat%	1.5^{a}	0.85^{c}	0.7^{cde}	0.6^{de}	0.5^{e}	1.1^{b}	1.3^{b}	0.8^{cd}	0.6^{de}	0.05	***
Pancrease %	0.32^{c}	0.34^{c}	0.36^{bc}	0.44^{a}	0.49^{a}	0.34^{c}	0.40^{ab}	0.50^{a}	0.40^{ab}	0.02	***
Intestines%	3.0^{c}	4.7^{ab}	4.4^{ab}	4.56^{ab}	4.34^{ab}	3.99^{bc}	4.44^{ab}	5.04^{ab}	5.0^{a}	0.26	**
Spleen%	0.17^{bcd}	0.15^{cd}	0.19^{bc}	0.19^{bc}	0.17^{bcd}	0.12^{d}	0.15^{cd}	0.21^{ab}	0.25^{a}	0.01	***
Intestinal Length (cm)	224b^{cd}	250^{a}	237^{ab}	235^{ab}	231^{bc}	234^{b}	214^{d}	213^{d}	217^{cd}	4.15	***

•abcdef Means with different superscript within the same row are significantly (P<0.001) different
NS: No significant difference (P>0.05). * = (P<0.05) ** = (P<0.01) *** = (P<0.001)

was observed with the liver as reported by Fasina *et al.* (2004) and Odunsi *et al.* (2006). Atteh (2004) also reported reduced liver weight with enzyme supplementation. The increased fat deposit observed in the control diet and other diets could be attributed to the higher bioavailable ME levels which could be converted to fats in the control and Maxigrain® supplemented PKM diets relative to the diets without Maxigrain® as reported also by Akpodiete *et al.* (2006).

Conclusion: When Maxigrain® was applied by supplementation, the maximum impact on broiler performance was observed to be between 10 and 20% diets which were better than the control diet in both starter and finisher phases. However, PKM at all levels (10, 20, 30, 40%) with or without Maxigrain® treatment did not result in any deleterious effect on overall broiler performance. The carcass analysis did not show any increase in the economic parts of the breast, thigh and drumstick with or without Maxigrain® irrespective of the method of application. The economic analysis reveal a downward reduction in cost of feed (N/kg) with increasing level of PKM inclusion. The health of the birds was not affected and mortality was not significant throughout the study.

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