Mal. J. Anim. Sci. 21(1): 41-51 June 2018 Malaysian Society of Animal Production

Performance and carcass characteristics of broiler chicken fed diets containing palm oil mill effluent with or without enzyme supplementation

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Received: 1 March 2018. Accepted: 29 May 2018.

Abstract

An 8-wk feeding trial was conducted using 320 broiler chicks of Arbor Acre strain to evaluate the effect of replacing maize with Palm Oil Mill Effluent (POME) with or without enzyme on the performance and carcass characteristics of broilers. Four diets were formulated in which POME replaced either 25% (diet 2), 50% (diet 3) or 75% (diet 4) maize in the control diet (diet 1). Each diet was fed to any of the eight groups of forty broiler chicks with or without Maxi grain enzyme in a 4 x 2 factorial experiment. Each experiment was replicated four times with each replicate consisting of 10 birds. Data were collected on feed intake, weight gain, feed conversion ratio, mortality, and nutrient utilization and carcass characteristics. Data were analyzed by two- way analysis of variance using General Linear Model procedure of SAS. Results revealed that live weight gain and feed conversion ratio were similar in birds that were fed 25% POME and control diet but these parameters were adversely affected in birds that received diets that contained 50% and 75% POME. Addition of Maxi grain enzyme improved the growth performance of the birds that received diet that contained 50% POME. Feed intake and livability were not adversely affected by the diets. Inclusion of POME in the diets decreased the utilization of dry matter and crude protein while fibre utilization was increased and ether extract unaffected. Addition of Maxi grain improved the utilization of all the nutrients considered except ether extract. Abdominal fat pad decreased with increased level of POME in the diets and was not affected by enzyme inclusion. Carcass yield and primal cuts were neither affected by POME inclusion nor enzyme supplementation. It was concluded from this study that POME can replace 25% maize in broiler diet but with Maxi grain enzyme supplementation it can be increased to 50%.

Keywords: Palm oil mill effluent, broiler chickens**,** Performance. Nutrient utilization, Feed cost

Introduction

Energy and protein feed resource constitute the major proportion of poultry diet. The price of maize which supplies the bulk of energy in poultry diet has continued to follow upward trend in the recent years. The search for alternative energy feed resources that are cheap, readily available and can replace all or part of maize has been identified to be the most feasible solution to the problem of high cost of poultry feed in Nigeria like in most African countries. A lot of agro-industrial by-products that contain substantial amount of energy and are cheap abound in Nigeria. These include cassava peels, yam peels, rejected plantain, sweet potato peel and palm oil mill effluent.

Palm oil mill effluent is a by-product of palm oil mill processing industry that is generated after the extraction of the oil from the fresh fruit bunch. It is the final liquid discharge after extraction of the oil from the fresh fruit bunch which contains 5% of dry matter. Nigeria ranks third in the world production of palm oil and generate large quantity of POME as waste. Palm oil mill has been identified to be a potential feed resource for poultry and pig. This by-product contains about 15% crude protein (Devendra, 1977) and energy level of about 17.76MJ/kg (Nimbi *et al.*, 2011) which makes it relatively comparable to maize with about 90g/kg crude protein and 14.37 MJ/kg metabolizable energy.

The use of palm oil mill effluent for pig is limited to 15% (Alimon and WanZahari, 2012) and 10% for growing rabbits (Abu and Ekpenyong, 1993) due to its high fibre content which may also include non starch polysaccharide. The use of exogenous enzyme as a supplement has been identified as an effective means of achieving a near complete breakdown of fibre and has been found useful in improving the utilization of fibrous feed resources. The use of palm oil mill effluent as feed for poultry could be a way of reducing the cost of producing poultry meat as well as solving the problem of environmental pollution if the limitation imposed by fibre can be eliminated. This study was therefore designed to evaluate the effect of replacing maize with palm oil mill effluent with or without enzyme on the growth performance, nutrient utilization and carcass characteristics of broiler chicken.

Materials and Methods

Location of The Study

The study was carried out at the Poultry Unit of Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria. Ogbomoso is situated in the derived Savannah zone of Nigeria and lies on longitude $4^{0}15^{1}$ east of Greenwich meridians and latitude $8^{0}15^{1}$ north of the equator. The altitude is between 300 and 600m above sea level while the mean temperature and annual mean rainfall are 27^{0}C and 1247mm, respectively.

Source, Collection and Processing of Palm Oil Mill Effluent

Palm oil mill effluent used for this study was collected from a small scale palm oil mill at Oko, Oyo State, Nigeria. The material was stuffed in a jute bag after which water was pressed out using hydraulic press. The dehydrated sample was then sun-dried on a clean concrete slab for 6 d when the material attained about 13% moisture content. The dried sample was then milled using hammer mill to obtain what was called Palm Oil Mill Effluent (POME).

Source and Properties of the Enzyme Used

Maxigrain is a concentrated powder which contains cocktail enzymes. Each gram of Maxigrain contained 10,000 IU cellulase, 200 IU betaglucanase, 10,000 IU xylanase and 2500 FTU phytase. The enzyme was manufactured by Polchem Hygiene Laboratory, India and purchased from an accredited agent in Nigeria. It was used at the rate of 100mg/kg of diet as recommended by the manufacturer.

Diet Preparation

Four diets were prepared. Control diet (diet 1) were formulated to contain 22% crude protein and 2850kcal/kg metabolizable energy at starter phase and 19.46% crude protein and 2720kcal/g metabolizable energy at finisher phase. The maize in the control diet was replaced with either 25% (diet 2) or 50% (diet 3) or 75% (diet 4) POME. The gross composition of the diet is shown in Table 1.

Table 1. Gross composition of experimental diets (%)

	Starter Phase Replacement level (%)				Finisher phase Replacement level (%)			
Ingredient	0(1)	25(2)	50(3)	75(4)	0(1)	25(2)	50(3)	75(4)
Maize	49.0	36.75	24.50	12.25	45.0	33.75	22.50	11.25
POME	0.0	12.25	24.50	36.75	0.0	11.25	22.50	33.75
Soy bean meal	19.0	19.0	19.0	19.0	20.0	20.0	20.0	20.0
Groundnut cake	14.0	14.0	14.0	14.0	4.5	4.5	4.5	4.5
Fish meal	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5
Corn bran	5.0	5.0	5.0	5.0	6.0	6.0	6.0	6.0
Wheat offal	6.0	6.0	6.0	6.0	17.0	17.0	17.0	17.0
Bone meal	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0
Oyster shell	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Na Cl	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
Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Premix	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated Analysis								
Crude protein (%)	22.0	22.18	22.30	22.42	19.46	19.58	19.69	19.8
Crude fibre (%)	4.02	5.64	7.88	8.57	4.57	6.15	7.61	8.84
Ether extract (%)	2.5	2.7	3.0	3.5	2.5	2.6	2.9	3.3
ME (Kcal/kg)	2850	2850	2870	2890	2720	2750	2760	2780

Premix used contained per5 kilogram: Vitamin A, 20000000IU, Vit. D3 4000000IU; Vitamin E 460mg; Vitamin K3 40mg; Vitamin ; Vitamin B1 60mg; Vitamin B2 120mg; Niacin 1000mg; Calcium pantothenate 200mg; Vitamin B6 100mg; Vitamin B125mg; Folic acid 20mg; Biotin 1mg; Chlorine chloride 8000mg; Manganese 2400mg; Iron 2000mg; Zinc 1600mgCopper 170mg; Iodine 30mg; Cobalt 6mg; Selenium 24mg; Anti-oxidant 2400mg.
POME = Palm oil mill effluent; ME = Metabolizable energy

Experimental Birds and Management

Three hundred and twenty day-old broiler chicks of Arbor Acre strain average body weight of 51±1g were used for the study. The chicks were randomly divided into eight groups of 40 birds each. The four diets were randomly assigned to the eight groups such that each diet was fed with or without Maxigrain enzyme in a 4 x 2 factorial experiment. Each treatment was replicated four times to give ten chicks per replicate. Birds were housed in a deep litter pen measuring 2×1.5m and the floor littered with wood shavings. Brooding temperature were 35^0C , 32^0C, 29^0C and 29^0C for the first four weeks respectively. Feed and water were supplied *ad libitum*. Vaccination and medication were carried out as recommended for the derived savannah zone of Nigeria. Starter diets were fed for the first four weeks and finisher diets for the remaining four weeks.

Data were collected on feed intake, weight gain, feed conversion ratio, mortality, feed cost, feed cost/kg live weight gain, nutrient utilization and carcass characteristics.

Feed intake: This was estimated by subtracting the feed left-over from the feed supplied over a period of 24 h.

Feed Intake = Feed supplied - Feed rejected

Weight gain: Birds were weighed at the beginning of the experiment using an electric weighing scale and thereafter weekly to monitor the growth. Weight gain was then estimated as the difference in weight of the birds in two successive weeks.

Weight gain
= Final weight – Initial weight

Feed conversion ratio: This was calculated from the record of feed intake and weight gain using the following formula:

Feed conversion ratio
= Feed intake/Weight gain

Mortality: Records of mortality were collected and then expressed as the percentage of the birds housed at the beginning of the experiment.

Feed cost: This was estimated from the cost of the ingredients used in feed preparation. Cost of POME was calculated from the cost of transportation, labour and drying.

Cost/ kilogram live weight gain: This was calculated from the feed cost and feed conversion ratio.

Nutrient Utilization

Metabolic trial was conducted using 12 birds per treatment. The birds were housed in metabolic cages equipped with feeders and drinkers and facility for faecal collection. Birds were allowed 3 d adjustment period to acclimatize. Known quantities of feeds were supplied daily at 8am and the remnant feed weighed the following day at the same time. Faeces were collected, weighed and oven-dried at 65^{0}C for 48 h. At the end of the trial which lasted for 3 d, faeces from the same treatment were bulked, milled and the representative samples saved for laboratory analysis.

Nutrient utilization was calculated using the results of the proximate analyses of the feeds, faeces and the data collected during metabolic trial as shown below:

Nutrient Utilization (%)
= (Nutrient in the feed – Nutrient in the faeces)/Nutrient in the feed x 100

Carcass Evaluation

Eight birds that had their weights close to the mean for their groups were selected for carcass evaluation. The birds were fasted for 24 h and then weighed to determine their pre-slaughtered weight. The birds were properly tagged, bled and the bled weight recorded. They were then scalded by immersing in the hot water (80^{0}C) and then properly defeathered. Birds were opened, abdominal fat pad recovered, weighed and expressed as a percentage of the pre-slaughtered weight. Carcasses were also dressed, weighed and the carcass yield determined as the percentage of the pre-slaughtered weight. Carcasses were also cut into primal cuts and expressed as the percentage of the pre-slaughtered weight of the birds.

Laboratory analyses

Feeds, faeces, and POME were analyzed for dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract using the methods of AOAC (1995), while

ADF and NDF were analyzed by the methods of Van Soest *et al.,* (1991).

Statistical Analysis

Data were analyzed by General Linear Model Procedure of SAS (1999) . Significance was determined at P = 5% and where means were significant, Duncan's option of the same software package was used to separate the means.

Results and Discussion

The results of the chemical analyses of the palm oil mill effluent used for this study are shown in Table 2. The dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract were 93.58%, 11.0%, 15%, 13%, 7% and 54%, respectively while the neutral detergent fibre and acid detergent fibre were 47.43% and 42.45%, respectively. The crude protein , crude fibre, neutral detergent fibre and acid detergent fibre of the POME used in this study were lower than the values reported by Alimon and WanZahari (2012) but its content of ether extract was higher than the value reported by the same author. The difference could be due to variation in processing method and the cultivar of oil palm. The POME used however compared favourably with maize in terms of protein content.

Table 2. Chemical composition of Palm oil mill effluent on dry matter basis

Component	%
Dry matter	93.58
Crude protein	11.00
Crude fibre	15.00
Ether Extract	13.0
Ash	7.00
Nitrogen free extract	54.0
Neutral detergent fibre	47.43
Acid detergent fibre	42.45

The chemical analyses of the experimental diets (Table 1) revealed that its contents of crude protein, crude fibre, ether extract, and metabolizable energy ranged from 22.0- 22.42%, 4.02-8.57%, 2.5- 3.5% and 2850- 2890Kcal/kg metabolizable energy respectively for broiler starter and 19.46-19.80%, 4.57- 8.84%, 2.5 – 3.3%, and 2720-2780 Kcal/kg metabolizable energy respectively for broiler finisher. These values are within the range recommended for broiler chicken at these phases of production by NRC (1994).

The results of the growth performance of the broiler chicken fed POME with or without Maxigrain is shown in Table 3 while interaction between POME and Maxigrain enzyme on production performance is shown in Table 4. Feed consumed by the birds was not affected by inclusion of POME in the diets (Table 3). This implied that the palatability of the diets was not affected by inclusion of the POME. Abu and Ekpenyong (1993) also observed that feed intake by the rabbits was not affected by including POME in their diets. This finding however contradicts the report of Hertrampf (1998) and Ezekwe *et al.,* (2011) who observed an increase in the feed intake of pigs as a result of inclusion of POME in their diets. Also Maxigrain enzyme supplementation of the diet had no significant (P>0.05) effect on the feed intake of the birds. No interaction was observed between POME and Maxigrain enzyme on feed intake.

Table 3. Performance characteristics of broilers fed palm oil meal effluent with or without enzyme supplementation

Dietary treatment	Feed intake (g/bird/day)	Weight gain (g/bird/day)	Feed conversion Ratio	Mortality (%)	Feed cost (N/Kg)	Feed cost/kg Wt gain (N)
Level of POME (%)						
0	72.6	37.85[a]	1.92[c]	3.2	105.12[a]	201.8[d]
25	72.7	37.77[a]	1.93[c]	3.19	104.64[b]	201.4[d]
50	77.93	35.75[b]	2.19[b]	3.18	103.87[c]	227.2[b]
75	78.93	33.05[c]	2.45[a]	3.19	102.84[d]	251.9[a]
Maxigrain enzyme						
-	75.34	33.48[c]	2.19[b]	3.17	105.11[a]	227.3[b]
+	73.12	37.43[a]	1.90[c]	3.16	105.36[a]	222.7[c]
Interaction (POME×Maxigrain)	NS	*	*	NS	NS	*
SEM	8.0	2.0	0.3	0.3	0.4	5.0

[abc]Means bearing different superscripts in the same column are significantly different (P≤0.05)
POME = Palm oil mill effluent; N= Nigerian Naira; Wt weight; NS =Not significant

Weight gained by the birds that received diet in which 25% maize was replaced with POME was similar to that of those fed control diet. This is in agreement with the findings of Alimon and Wan Zahari (2012) who also reported optimum level of POME inclusion in broiler diet to be 15% of the total diet. Live weight gain was however lower (P<0.05) in the birds that received diets in which 50% (diet 3) and 75% (diet 4) maize was replaced with POME without enzyme supplementation. This could be due to higher fibre content of these diets which might also contain non starch polysaccharides as palm kernel cake, another by-product of oil palm which has been documented to contain this compound (WanZahari *et al.*, 2012). Interaction between POME and Maxigrain was significant on weight gain (Table 4). Weight gain was significantly (P<0.05) improved by Maxigrain enzyme to the extent that birds that were fed 50% POME (diet 3) with Maxigrain enzyme supplementation had similar weight with those that were fed control diet without enzyme supplementation. This can be attributed to the effect of Maxigrain enzyme supplementation. The use of exogenous enzyme has long been recognized as a way of improving the digestibility of diets and productivity of poultry birds (Alam *et al.,* 2003); Bedford and Partridges, 2010). Their effectiveness in achieving this has been attributed to their ability to disrupt the fibres and releasing the lock up nutrients and make them available to the animals (Bedford, 2000 ; McDonald *et al.*, 2010).

Table 4. Interaction between POME levels of inclusion and Maxigrain enzyme on production performance

Weight gain (g/bird/day)			Feed:gain ratio			Feed cost/kg wt gain(N)		
	Maxigrain			Maxigrain			Maxigrain	
Level of POME	-	+	Level of POME	-	+	Level of POME	-	+
0	37.9^{a}	38.0^{a}	0	1.9^{b}	1.9^{b}	0	202^{c}	201^{c}
25	37.6^{a}	38.0^{a}	25	2.0^{b}	1.9^{b}	25	201^{c}	199^{d}
50	34.0^{b}	37.9^{a}	50	2.4^{a}	2.0^{b}	50	249^{b}	202^{c}
75	32.0^{c}	34.1^{b}	75	2.5^{a}	2.4^{b}	75	255^{a}	249^{a}
SEM	1.5	2.0		0.2	0.2		1.0	1.0

^{abc}Means bearing different superscripts in the same column are significantly different ($P \leq 0.05$)
POME – Palm oil mill effluent; N= Nigerian Naira; Wt weight

Feed conversion was poor in the birds that were fed diets 3 and 4 without Maxigrain enzyme as evident by higher ($P<0.05$) feed: gain ratio observed in these birds. This could be due to high dietary fibres in these diets as explained earlier. The values observed in those that were fed 25% POME (diet 2) and 50% POME (diet diet 3) without enzyme supplementation were however similar to that of the control group without Maxigrain. This agrees with the report of Abu and Ekpenyong (1993) who also observed no difference in feed conversion efficiency of rabbits fed up to 10% of total diet. Significant interaction was also observed between POME and Maxigrain with respect to feed conversion. Maxigrain enzyme significantly ($P<0.05$) improved feed conversion in this study and this can be attributed to its enhancing effect on digestibility.

Feed cost decreased progressively with increased level of POME in the diets. This was a direct consequence of the lower cost of POME compared to maize since it was collected free from the processing unit. The POME is considered a nuisance and is usually discarded or further processed to reduce its pollution value (Webb *et al.*, 1977). **S**upplementation of the diets with Maxigrain enzyme had no significant effect on the feed cost. Interaction of POME and Maxigrain on feed cost was not significant. Feed cost/kg live weight gain was similar for the birds that were fed 0% (diet 1) and 25% (diet 2) POME in replacement for maize but the values obtained for those that were fed 50% and 70% were significantly higher ($P<0.05$). Significant interaction effect of POME and Maxigrain was also observed on feed cost/kg live weight gain. Addition of Maxigrain to the diets had reducing effect on the production cost. This can be attributed to enhancing effects of this enzyme on feed conversion and nutrient utilization.

The effect of replacing maize with POME with or without Maxigrain enzyme in the diets of broilers on nutrient utilization is shown in Table 5 while the interaction effect of POME and Maxigrain on nutrient utilization is shown in Table 6. Dry matter and crude protein utilization decreased ($P<0.05$) with increased level of POME in the diets. This can be attributed to the higher crude fibre in these diets which probably prevented enzymes from having access to these nutrients. Interaction between POME levels and Maxigrain on dry matter and crude protein utilization was significant. Supplementation of diet with Maxigrain improved dry matter and crude protein utilization. This is a direct consequence of Maxigrain enzyme which helped in disrupting the fibre and exposed these nutrients to enzymatic digestion. Fibre utilization increased with increasing level of POME in the diet. This could be a direct consequence of higher concentration of fibre in the gastro-intestinal tract as the level of fibre increased in the diets. Significant interaction between POME and Maxigrain was also observed in crude fibre utilization with birds which were fed diets that were supplemented with the enzyme had higher ($P<0.05$) values than those not fed with the enzyme.

Table 5. Nutrient utilization by broiler chicken fed diets containing POME with or without enzyme

Dietary treatment	Dry matter	Crude protein	Crude fibre	Ether extract	NFE
Level of POME (%)					
0	88.16^{a}	85.74^{a}	63.81^{d}	83.80^{b}	86.4
25	88.02^{a}	85.66^{a}	64.48^{c}	83.75^{b}	86.14
50	86.86^{c}	84.65^{c}	65.23^{b}	83.50^{b}	86.0
75	85.69^{d}	83.79^{d}	65.83^{a}	83.27^{b}	86.15
Maxigrain enzyme					
-	86.30^{c}	84.39^{c}	63.82^{d}	83.82^{b}	86.0
+	87.72^{b}	85.0^{b}	65.84^{a}	84.63^{a}	86.34
Interaction (POME×Maxigrain)	*	*	*	*	NS
SEM	0.4	0.4	0.5	0.6	0.5

[abc]Means bearing different superscripts in the same column are significantly different ($P\leq0.05$)
POME =Palm oil mill effluent; NFE = Nitrogen free extract; NS =Not significant

Table 6. Interaction between POME and Maxigrain on nutrient utilization

	DM			CP			CF			EE	
POME levels (PL)	Maxigrain			Maxigrain			Maxigrain			Maxigrain	
	-	+	PL	-	+	PL	-	+	PL	-	+
0	87.6^{a}	88.4^{a}	0	85.3^{a}	86.2^{a}		64.5^{b}	65.3^{b}	0	83.2	84.2
25	87.3^{a}	88.3^{a}	25	85.1^{a}	85.2^{a}		64.7^{b}	65.6^{b}	25	83.3	84.4
50	85.9^{b}	88.0^{a}	50	83.7^{b}	85.0^{a}		64.9^{b}	65.9^{b}	50	83.5	84.4
75	85.5^{b}	86.0^{b}	75	83.4^{b}	84.2^{b}		65.8^{a}	66.8^{a}	75	83.4	84.6
SEM	0.6	0.8		0.6	0.5		0.5	1.0		0.3	0.5

[ab]Means bearing different superscripts in the same column are significantly different ($P\leq0.05$)
POME – Palm oil mill effluent; DM = Dry matter; CP = Crude protein; CF = Crude fibre; EE = Ether extract

Ether extract utilization was not affected by inclusion of POME in the diet. Significant interaction between POME and Maxigrain was however observed on ether extract utilization. Addition of Maxigrain enzyme to the diet increased the utilization of ether extract. Dietary treatment had no significant effect on the utilization of nitrogen free extract. The improvement that was observed in the utilization of all the nutrients when Maxigrain was added to the diets could be attributed to this enzyme. Enzymes have long been demonstrated to increase the digestibility of poorly digested diets and are commonly used when the dietary ingredients contain relatively higher amounts of fiber (Bedford and Partridge, 2010; Scott *et al.*, 1998).

The results of replacing maize with POME with or without Maxigrain enzyme on carcass characteristics are shown in Table 7. The pre-slaughter weight was significantly (P<0.05) lower in the birds that were fed diets in which 75% maize was replaced with POME compared to those fed other diets. This was a direct consequence of poor growth observed in this group. Values obtained in the birds fed other diets were however similar. No significant effect of diets was observed on carcass yield, breast, thigh, drumstick and back weights. This implied that replacement of maize with POME in broiler diet did not have any adverse effects on carcass yield. Abdominal fat however increased with increase level of POME in the diet. This corroborates the report of Onibi *et al*. (2011) who also reported increase in the lipid content of meat of broiler chicken fed diets in which 40% dietary energy was supplied by POME. No interaction effect of POME and Maxigrain was observed in all carcass parameters measured. The higher abdominal fat pad that was observed in the birds as POME increased in the diet could be of health concern as fat has been implicated in heart diseases.

Table 7. Carcass characteristics of broilers fed palm oil meal effluent with or without enzyme

Dietary treatment	Pre-slaughter weight (kg)	Carcass yield (%)	Breast (%)	Thigh (%)	Drumstick (%)	Back (%)	Abdominal Fat (%)
Level of POME (%)							
0	2.23[a]	67.3	17.6	11.8	9.8	19.6	0.2[b]
25	2.20[a]	67.5	17.7	11.4	9.6	19.5	0.2[b]
50	2.04[a]	67.4	17.6	11.7	9.4	19.3	0.3[b]
75	1.83[b]	67.2	17.5	11.3	9.7	19.5	0.8[a]
Maxigrain enzyme							
-	2.02[a]	67.3	17.4	11.6	9.6	19.7	0.4[b]
+	2.13[a]	67.4	17.5	11.5	9.5	19.8	0.6[ab]
Interaction (POME×Maxigrain)	NS	NS	NS	NS	NS	NS	NS
SEM	0.5	0.5	0.4	0.6	0.5	0.8	0.5

[ab]Means bearing different superscripts along the same column are significantly different (P≤0.05)
POME – Palm oil mill effluent; Not significant

Conclusion

The results of this study suggest that broiler chicken can tolerate up to 25% palm oil meal effluent when substituted for maize in their diets. This can however be increased to 50% when supplemented with Maxigrain enzyme. At these levels growth performance, carcass characteristics and production cost were not adversely affected but exceeding these levels resulted in growth depression and high production cost.

Acknowledgement

The author appreciate the support of Mr Oyebode S , Mr Onyia S. and other farm staff for their support during the field study.

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