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Part II: Economic Analyses and the Growth Performance of Broiler Finisher (29-58day) Birds on High Fibre-low Protein Industrial Plant By-products

A. O. Fasuyi[1*], O. A. Aturamu[2] and A. S. Lawal[1]

[1]Department of Animal Production and Health Sciences, Faculty of Agricultural Sciences, Ekiti State University, Ado-Ekiti, Nigeria.
[2]School of Agricultural Sciences, College of Education, Ikere-Ekiti, Ekiti State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author AOF designed the study with significant input from author OAA on the aspect of economic evaluation of this study. Author AOF supervised the work while editing was done by authors AOF and OAA. Author ASL was part of the research team, as an undergraduate project student, that carried out the study on the teaching & research farm of Ekiti state university. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To explore the possibility of utilizing bio-fermented industrial plant by-products as supplementary crude protein sources in broiler finisher phase of production.
Study Design: Two hundred and eighty-eight (288) birds were picked and randomized into six treatments in a completely randomize designed experiment. The data collected were subjected to One Way Analysis of Variance (ANOVA) using Minitab computer model (Version 16).
Place and Duration of Study: Research study was carried out at the Teaching & Research Farm of Ekiti State University, Ado-Ekiti, a town in the Southwest Nigeria between June and September 2016.
Methodology: The composite of the palm kernel meal (PKM), brewer dried grains (BDG) and molasses were prepared using a ratio of 50litres of water to 25 kg of PKM, 25 kg of BDG and 2.5

**Corresponding author: Email: ayodeji.fasuyi@eksu.edu.ng;*

litres of molasses. The composite was fermented and dried before incorporation into experimental diets as protein supplement at 15, 20, 25, 30 and 35% inclusion levels in a completely randomized designed experiment.

Results: The average daily feed intake (ADFI) among treatments did not vary significantly ($p>0.05$). Birds fed the 30% PBMC (diet 5) had the highest ($P<0.05$) weight gain value of 44.5±6.2 g/bird/day. The feed conversion ratio (FCR) of birds on 30% PBMC (diet 5) had the lowest significant ($P<0.05$) value of 2.15±0.21. The protein efficiency ratio (PER) of birds on 30% PBMC had the highest significant ($P<0.05$) value of 2.39±0.50. Birds fed with diet 5 (30% inclusion level of PBMC) had the highest total net returns of N1511.86 followed by birds on diets containing zero level of PBMC, 35, 20, 15 and 25% PBMC inclusion levels in that order.

Conclusion: In conclusion, for practical poultry feed formulation, fermented PBMC can be incorporated at levels up to 30% inclusion rates in broiler diets at the finisher phase of production where PBMC can be significantly utilized and converted to broiler meat.

Keywords: Ensiling additives; fermentation biotechnology; revenue from broiler.

1. INTRODUCTION

The exploration of biotechnological methods of processing of high fiber-low protein plant by-products for incorporation into monogastric feed manufacturing becomes imperative from the background of dwindling economic fortunes from the livestock industry arising from the dearth of expensive feed ingredients especially of protein origins as a result of severe competition between man and animal [1]. The era of sourcing for alternative feed ingredients especially for monogastric livestock animals has come and will remain with us for a while particularly in developing countries of the world where the competition between man and domesticated livestock animals is rife. The protein ingredients such as fish meal, soybean meal and groundnut cake have become very expensive and a huge determinant in the overall cost of production of monogastric livestock animals. Poultry producers have started the re-examination of feeding programs for broilers. Methods of feeding broilers are sought which will substantially lower feed cost and yet provide nutrient intake for maintaining egg production in breeders, egg size and quality and feed efficiency [2]. The high cost of the major conventional feed ingredients, due to competition of these ingredients by human and livestock has made it difficult for farmers to formulate balanced and economical feed for livestock [2,3,4,5]. This development has led to drastic drop in their profit margin. The cost of fish meal, which is an important source of protein in animal ration, has increased by more than 60 percent. The price of soya bean meal which is also a major ingredient in poultry ration has increased sharply in recent times in Nigeria without a corresponding increase in the price of egg or life bird in the market [6]. Therefore, it is imperative to look for alternatives to this crude protein sources which will not have detrimental effects on the growth and production of birds and at the same time perfectly substitutes or replace the existing conventional crude protein sources.

Palm kernel cake or meal and brewer's dried grains are "waste" or by-products of the agro-processing industry which are of little or no nutritional importance to man. The nutrient composition of brewer dried grains subjected to solid state fermentation is improved with a reduction in pH, fiber content [7] therefore making the nutrients more available in poultry feed [8]. The aim of this study was to investigate through the growth performance and economic indices the viability of broiler production at the finisher phase (29-56 days) when the fermented composite of palm kernel meal (PKM), brewer dried grains (BDG) and molasses are used as a protein supplement.

2. MATERIALS AND METHODS

2.1 Experimental Site

The research study was carried out at the Teaching & Research Farm of Ekiti State University, Ado-Ekiti, a town in the Southwest Nigeria in the rain forest zone on latitude 7°40' North of the equator and longitude 5°15' East of the Greenwich Meridian with ambient temperature of 25-37°C; relative humidity, 70%; wind, SSW at 11mph (18km/h); barometric pressure, 29.68' Hg(F) during the summer of year 2016.

2.2 Bio-fermentation Technology and Procedure for Ensiling

Palm kernel meals (PKM) were obtained from local communities (especially Ogotun-Ekiti) around Ado-Ekiti where palm oil is produced majorly by solvent extraction method. Brewers dried grains (BDG) were obtained from Nigerian Bottling Company, Ibadan through a reputable feed mill in Ado-Ekiti, Ekiti State. Mixtures of the PKM, BDG, and molasses were prepared using a ratio of 50litres of water to 25 kg of PKM, 25 kg of BDG and 2.5 litres of molasses. The mixture of PKM, BDG, molasses, and water subsequently referred to as palm kernel, brewers spent grains, and molasses composite (PBMC) was gently compressed into 120 L plastic containers according to described method [9,10]. The compressing of the materials into containers was done manually at about 1-foot height interval until the containers were about ¾ filled. The containers were carefully covered with thick nylon covering with sand used to fill the spaces left. There were further compressions, and another thick nylon was spread across the rims of the containers before the containers were finally covered with their lids to ensure air–tightness. Containers containing the ensiled PBMC were opened on day 21 according to the literature [9]. Samples were taken for laboratory analyses. The ensiled PBMC was later sun-dried to achieve a moisture content of 12%. Dried samples of the ensiled PBMC were then analyzed for proximate acid composition before incorporation into feed formulation.

2.3 Experimental Ration Formulation

Samples of the BDG, PKM and PBMC were taken for proximate analyses after which they were incorporated into the diets. The experimental diets for the starter phase (0-28 days) were formulated as follows:

Diet 1 was the control diet without BDG and PKM mixture;
Diet 2 had PBMC at 10% inclusion level;
Diet 3 had PBMC at 15% inclusion level;
Diet 4 had PBMC at 20% inclusion level;
Diet 5 had PBMC at 25% inclusion level;
Diet 6 had PBMC at 30% inclusion level.

While the experimental diets for the finisher phase (29-56 days) were formulated as follows:

A sample of the BDG, PKM, and PBMC were taken for proximate analyses after which they were incorporated into the diets. The experimental diets were formulated as follows:

Diet 1 was the control diet without BDG and PKM mixture;
Diet 2 contained 15% ensiled PKM, BDG and molasses composite (PBMC);
Diet 3 contained 20% ensiled PBMC;
Diet 4 contained 25% ensiled PBMC;
Diet 5 contained 30% ensiled PBMC;
Diet 6 contained 35% ensiled PBMC.

2.4 Management of Experimental Birds

A total of 288 birds were randomly picked after sex on the 3rd day of the arrival of chicks for the experiment [11]. The 288 birds were randomly distributed into six treatments. Each treatment was replicated three times, and each replicate has 16 birds. The chicks were brooded in a brooder house using electricity supplied constantly by 1 KVA stand-by power generating plant at the Ekiti State University Teaching and Research Farms. A 5-day acclimatization period was observed before the commencement of the first phase (5-28 days) of the experiment during which the broiler chicks were fed ad libitum on commercial chicks mash containing 23% crude protein (CP) before data collection. The chicks were managed on the floor for the two phases of the experiment. Appropriate veterinary routines were observed from day old. The experimental birds were randomly allocated to the six experimental treatments as designed. The body weight (BW) of animals was measured every t3 days, and the body weight gain (BWG) was determined by the difference between two consecutive 3-day weighings using a scale. The food intake (FI) was calculated by subtracting the served on the refusal portion of food in the 3-day weighing. The food conversion ratio was determined by making the ratio of the amount of food consumed to the weight gain during the 3 days. Protein efficiency ratio was calculated by making the ratio of the weight gain to the protein intake. All these were calculated according to the following formula:

Body weight gain, g = body weight in 3 days (n+1) – body weight of the initial 3 days (n)
Feed intake, g = Served portion of feed – Refused portion of feed
Feed conversion ratio = Feed consumed, g /Weight gain, g
Protein efficiency ratio = gain in body weight, g/Protein intake, g

2.5 Statistical Analysis

The data collected for different parameters for growth performance and for fermented/ unfermented PBMC were subjected to analysis of variance (ANOVA) using statistical One Way Analysis of Variance and T-Test of the Minitab computer model (Version 16) [12].

2.6 Cost Implications/ Economics Analysis

A major objective of this study is to assess the economics of the bio-fermented palm kernel meal, brewer dried grains and molasses composite (PBMC) as a protein supplement in broiler starter diets. This will be assessed as described below:

For profitability analysis, it shall be determined as follows:

∏ = TR – TC ……………………………………1
TR = P*Q …………………………………….....2
TC – TVC + TFC …………………………………3

Where:

∏ = Net profit; TR = Total Revenue from broiler; TC = Total Cost involved; P = Price for the finisher phase of broiler production; Q = Total output for the finisher phase of broiler production; TVC = Total Variable Cost involved in the broiler production; TFC = Total Fixed Cost involved in the broiler production.

The equations above will be used to determine the profitability of the broiler production. The profitability level of the broiler production using feed-grade amino acids will be compared with that of feed with conventional diets without PBMC in the control experiments.

3. RESULTS AND DISCUSSION

3.1 Effects of Bio-fermentation Technology and Performance Characteristics

The increased percentage of crude protein (CP) and a decrease in percentage crude fiber (CF) in the fermented PBMC (Table 1) further emphasized the biotechnological advantages of ensiling PBMC. It has been reported that there was an increase in the concentration of NH3-N particularly within the first seven days of ensiling which was an indication of proteolytic organisms mainly *Clostridia* activities while the pH is still relatively high. The result is the breakdown of protein to amino acids, amines and NH3 [9]. The significant increase in water-extractable DM particularly with the increased addition of molasses conforms with the report from a similar study with Taro leaves (*Colocasia esculenta* L. Shott) revealing about 100% increase in water-extractable DM at 4% and 6% molasses addition [10]. The present study is in agreement with the previous findings [14,15] that reported an increase in the percentage CP of palm kernel cake/meal after fermentation. Similarly, an increase in the percentage CP value of cassava peels after 20 days fermentation has been reported [16].

The performance characteristics data of the birds fed with fermented palm kernel meal, brewer grain and molasses composite (PBMC) at varying inclusion levels of 0, 15, 20, 25, 30 and 35% are presented in Table 3.The average daily feed intake (ADFI) among treatments did not vary significantly ($p>0.05$). However, birds fed with diet 3 (20% PBMC based diet) had the highest figure for feed intake of 97.0±0.06 g/bird/day followed by birds fed with the control diet (0% PBMC) with an average of 96.9±0.19 g/bird/day. Birds fed with diet 6 (35%PBMC) had the lowest value for average daily feed intake which was 94.6±0.08 g/bird/day.

The similarity in the average daily feed intake (ADFI) among treatments was conceivable because of the significant reduction of the fiber level through the process of fermentation. Although palm kernel meal (PKM) and brewers dried grains (BDG) are feed ingredients from plant origin; they are high in crude fiber, which has been identified as a major limitation to their digestibility and utilization. These industrial plant by-products from the oil palm and brewery industries may be relatively cheap as livestock feed ingredients but being plant origin, they have cell walls composed of approximately 15–40% cellulose, 30-40% hemicellulose and pectin, and 20% lignin [17] which make it difficult for monogastric animals to digest and utilize. Therefore, the inclusions of high fibrous feed ingredients like PKM and BDG have been cautiously used. The fermentation process in the PBMC has significantly reduced the fiber content of the composite, and the addition of molasses probably increased the palatability of the diets containing PBMC thereby inducing broiler feed intake in the PBMC diets. It has been posited that the addition of molasses at 4-6% inclusion in silages increased palatability [18]. In another study, a level of 4% molasses and 14-21 days ensiling period appeared optimum and most effective for ensiling *Tithonia diversifolia* (wild sunflower) leaves [9]. The present study agreed with a previous study where *Aspergillus niger* fermented palm kernel cake was used as substitute for soybean meal protein in broiler diets [19] and also agreed with another study [20] where feed intake of hens provided 12.5% PKC-based diets with enzyme supplementation at 1 kg/t did not differ from the controls. However, this study differed from the findings in the study where broiler chickens were fed with *Aspergillus niger* degraded BDG and significant (P<0.05) differences were observed in feed intake [21].

Table 1. Proximate analysis of palm kernel meal (PKM), brewers dried grains (BDG) and palm kernel meal-brewer dried grain-molasses composite (PBMC)

Proximate composition, %	PKM	BDG	Molasses (cane)	PBMC (unfermented)	Fermented PBMC
Dry matter	86.5±2.1	87.5±4.3	22.9	87.1^{b}±2.1	89.5^{a}±3.1
Crude protein	19.1±3.0	22.1±2.7	0.3	20.2^{b}±4.5	23.1^{a}±4.2
Crude fiber	14.4±1.7	12.3±3.2	0.0	13.5^{a}±2.1	10.1^{b}±3.3
Ether extract	7.3±1.8	7.6±2.1	0.0	7.4^{a}±4.1	3.5^{b}±3.1
Ash	11.1±2.1	4.7±3.3	1.1	8.2±2.5	8.5±2.0
Nitrogen-free extract	48.1±2.7	53.3±2.1	74.8	49.8^{b}±3.2	54.8^{a}±3.4
Metabolisable energy, Kcal-kg	2719	2485	1958	2634	2789

Mean ± Standard deviation; (a, b, c). Proximate analysis values obtained for fermented and unfermented PBMC were compared using T-Test of Minitab (Ver. 16) statistical model [12]. Means in the same row with the different superscript are significantly different at (P>0.05)

ME, metabolizable energy = (0.860+0.629 (GE-0.78CF) [13]; Palm kernel meal, PKM; brewers dried grains, BDG; palm kernel meal-brewer dried grain-molasses composite, PBMC

Table 2. Experimental diets (finisher phase)

Ingredients	Diets and % inclusion levels of PBM composite					
	Diet 1 0%	Diet 2 15%	Diet 3 20%	Diet 4 25%	Diet 5 30%	Diet 6 35%
Maize (11.0% CP)	55.5	42.0	42.0	41.0	40.0	40.0
Wheat offals	10.0	10.0	10.0	10.0	10.0	10.0
Soyabean meal	29.0	29.0	24.0	19.0	15.0	10.0
Fish meal	2.0	0.0	0.0	0.0	0.0	0.0
Palm oil	0.0	0.0	0.0	1.0	1.0	1.0
*PBMC	0.0	15.0	20.0	25.0	30.0	35.0
Bone meal	2.5	2.5	2.5	2.5	2.5	2.5
Oyster shell/limestone	0.5	0.5	0.5	0.5	0.5	0.5
Nacl	0.3	0.3	0.3	0.3	0.3	0.3
DL-methionine	0.1	0.1	0.1	0.1	0.1	0.1
L-Lysine	0.1	0.1	0.1	0.1	0.1	0.1
**Premix	0.5	0.5	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0
Calculated composition						
Crude protein, %	20.13	20.07	20.01	20.02	19.65	19.60
Crude fibre, %	5.14	5.78	6.12	7.21	8.91	9.89
Ether extract, %	7.34	7.41	7.53	9.34	9.43	9.43
***ME, Kcal/Kg	3101.4	3210.3	3120.3	3103.8	3134.4	3103.8
Proximately determined composition						
Crude protein, %	19.76	20.01	20.12	20.21	20.01	19.86
Crude fibre, %	3.86	5.82	6.45	7.32	9.23	9.34
Ether extract, %	6.10	7.52	7.64	8.86	8.90	8.60

**PBMC, Palm kernel meal+Brewers dried grains+Molasses ensiled composite;*
***Premix contained vitamins A (10,000,000 iu); D (2,000,000 iu); E(35,000 iu);K (1,900 mg); B12 (19 mg); Riboflavin (7,000 mg); Pyridoxine (3,800 mg); Thiamine (2,200 mg); D Panthotenic acid (11,000 mg); Nicotinic acid (45,000 mg); Folic acid (1,400 mg); Biotin (113 mg); and trace elements as Cu (8,000 mg); Mn (64,000 mg); Zn (40,000 mg); Fe (32,000 mg); Se (160 mg); I_2 (800 mg); and other items as Co (400 mg); Choline(475,000 mg); Methionine (50,000 mg); BHT (5,000 mg) and Spiramycin (5,000 mg) per 2.5 kg; CP: Crude Protein, ME: Metabolized Energy; ***ME, metabolizable energy = (0.860+0.629) (GE-0.78CF) [13]*

Table 3. Performance characteristics of broilers (28-56 Days) fed with fermented brewer dried grain, palm kernel meal, and molasses composite

Diets	1	2	3	4	5	6
BDG-PKM composite	0%	15%	20%	25%	30%	35%
Average Feed intake	96.9±0.19	96.2±0.07	97.1±0.06	96.3±2.42	95.0±4.24	94.6±0.08
Weight Gain	$37.5±0.82^b$	$34.6±2.77^c$	$35.6±1.05^c$	$38.3±4.02^b$	$44.5±6.19^a$	$38.8±1.52^b$
Feed conversion ratio	$2.59±0.60^b$	$2.79±0.23^c$	$2.73±0.70^c$	$2.53±0.21^b$	$2.15±0.21^a$	$2.45±0.90^b$
Protein efficiency ratio	$1.92±0.50^b$	$1.79±0.60^c$	$1.83±0.40^b$	$1.81±0.60^{bc}$	$2.39±0.50^a$	$2.09±0.70^{ab}$

Means with different superscripts in the same horizontal rows are significantly different (p<0.05)

The weight gain value obtained for birds on 30% PBMC (diet 5) had the highest significant (P<0.05) value of 44.5±6.2 g/bird/day. Birds on diets 1, 4 and 6 (0%, 25% and 35% PBMC, respectively) had similar (P>0.05) weight gain values of 37.5±0.8 g/bird/day, 38.3±4.0 g/bird/day and 38.8±1.5 g/bird/day, respectively while birds on diets 2 and 3 (15% and 20% PBMC, respectively) had 34.6±2.8 g/bird/day and 35.6±1.0 g/bird/day, respectively. It is noteworthy that the weight gain value of the birds on the control diet without the inclusion of PBMC, was similar (P>0.05) to the weight gain value obtained for birds on a diet 6, with the highest inclusion level of 35% PBMC.

The feed conversion ratio (FCR) of birds on 30% PBMC (diet 5) had the lowest and most optimum significant (P<0.05) value of 2.15±0.21. Birds on diets 1, 4 and 6 (0%, 25% and 35% PBMC, respectively) also had similar (P>0.05) FCR values of 2.59±0.60, 2.53±0.21 and 2.45±0.90, respectively while birds on diets 2 and 3 (15% and 20% PBMC, respectively) had 2.79±0.23 and 2.73±0.70, respectively. The protein efficiency ratio (PER) of birds on 30% PBMC (diet 5) had the highest significant (P<0.05) value of 2.39±0.50 albeit similar (P>0.05) to 2.09±0.70 obtained for birds on 35% PBMC (diet 6). The PER values obtained for birds on diets 1, 3, 4 and 6 were however similar (P>0.05) at 1.92±0.50, 1.83±0.40, 1.81±0.60and 2.09±0.70.

The birds on 30% PBMC (diet 5) had the highest significant weight gain value and also the lowest and most optimum significant value for feed conversion ratio (FCR). Noteworthy to mention that the weight gain value of the birds on the highest inclusion level of 35% PBMC was similar to the weight gain values obtained for the control diets without the inclusion of PBMC. The performance characteristics investigated such as weight gain, feed conversion ratio, protein efficiency ratio (PER), all indicated that birds on a diet 5 (30% PBMC) had the best performance indices.

The remarkable growth performance of birds fed with 30% inclusion level of PBMC in diet five could be attributed to the enormous benefits of ensiling BDG-PKM composite with molasses. The ensiling process has been identified as a means of improving the nutritional value of food/feed resource while reducing the pH and fiber contents [18]. Ensiling also increases digestibility of crude protein by breaking linkages between protein and fiber [15]. Ensiling has been associated with improvement of palatability and reduction of toxic substances present in fresh leaves and plant by-products to safe level concentrations [22]. The process of ensiling allows the further degradation of fiber and release of locked-up of nutrient for utilization by broiler birds [22,23]. It has been posited that fermentation is one of the recent advances in the use of high fibrous feed ingredient in monogastric diets which makes it better digested, lessen the crude fiber, increase the protein value and pose no fear when the inclusion is raised above 20% [24].

3.2 Economic Analysis

The economic analysis of feeding broilers with the diets at various inclusion levels of PBMC is shown in Table 4, Figs. 1 and 2. Expectedly, the cost of the control diet was higher due to additional cost from fish meal, a protein source and inclusion levels of other conventional ingredients. However, birds fed with diet 5 (30% inclusion level of PBMC) had the highest total net returns of N1511.86 followed by birds on diets 1, 6, 3, 2 and 4 (control diet without PBMC, 35%, 20%, 15% and 25% PBMC inclusion levels, respectively) at ₦1259.03, ₦1245.40, ₦1201.98, ₦1181.86 and ₦1156.64, respectively. It is evident from Table 4 and Fig. 1 that the cost of feed reduced as the inclusion levels of PBMC in the diets increased. Expectedly, diet 1 (control diet) had the highest cost while diet 5 (30% inclusion level of PBMC) had the lowest cost. Birds fed with diet five at the broiler finisher phase generated more total net returns per bird and would be more profitable for commercial broiler production. It is generally accepted that inclusion of non-conventional sources of diets can help to reduce the cost of feeding broilers which is a major constraint in broiler production.

The average cost of feed consumed per broiler bird and the total cost of production decreased with increasing level of PBMC inclusion in the diets except for diet in which 35% PBMC was incorporated. This is in agreement with several studies that reported that feed cost per Kg and total cost of production decreased with increased levels of BDG [26,27]. However, another study [28] had a contradictory report that no significant difference was observed in broilers fed supplemented BDG in their diets when the cost of feed per kg of diet, rearing cost and selling price were investigated.

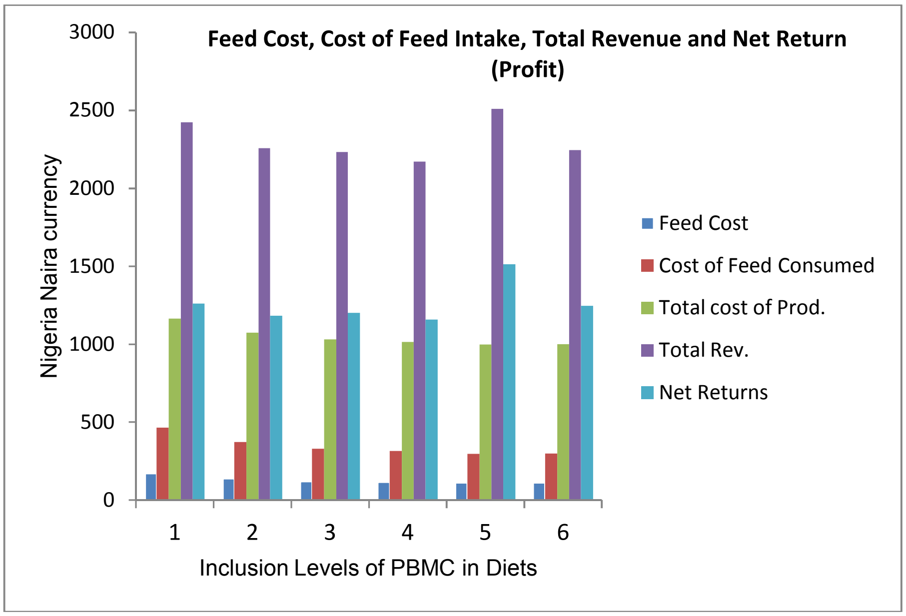

Fig. 1. Feed cost, cost of feed intake, total revenue and net returns of broiler production using PBMC as protein supplement

Table 4. Economic analysis of broilers (28-56 days) fed with ensiled palm kernel meal, brewer's dried grain, and molasses composite

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
BDG-PKM composite	**0%**	**15%**	**20%**	**25%**	**30%**	**35%**
Total feed intake (kg/bird)	2.71	2.70	2.72	2.70	2.66	2.65
Feed cost/kg of diet (₦/kg)	171.57	138.57	121.33	116.80	111.30	112.68
Cost of feed intake (₦/bird)	464.97	374.14	330.00	315.36	296.14	298.60
Cost of broilers at 4 weeks	700.00	700.00	700.00	700.00	700.00	700.00
Total cost of production (₦/bird)	1164.97	1074.14	1030.02	1015.36	996.14	998.60
Average body weight at 56th day	2.02	1.88	1.86	1.81	2.09	1.87
(kg/bird)	1,200	1,200	1,200	1,200	1,200	1,200
Cost of 1 kg poultry meat (₦/kg)	2424	2256	2232	2172	2508	2244
Total revenue/ bird (₦/bird)	1259.03	1181.86	1201.98	1156.64	1511.86	1245.40
Total net returns/bird (₦/kg)						

Naira, ₦, is the currency in Nigeria; 1United States Dollar is equivalent to ₦352 Nigeria naira as at March 6, 2018 [25]

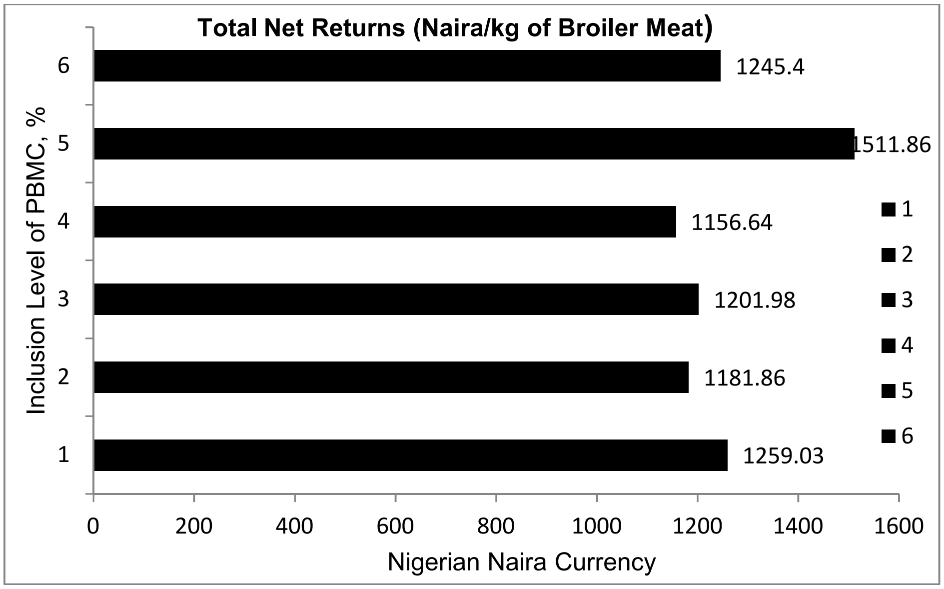

Fig. 2. Total net returns (Profit) of broiler production using PBMC as protein supplement

- *1, 0% PBMC inclusion level in diet; 2, 15% PBMC inclusion level in diet;*
- *3, 20% PBMC inclusion level in diet; 4, 25% PBMC inclusion level in diet;*
- *5, 30% PBMC inclusion level in diet; 6, 35% PBMC inclusion level in diet.*

Nigeria Naira, N, currency is 0.0028 US Dollar

4. CONCLUSION

The best growth performance and net economic returns were obtained for birds fed with a diet containing 30% inclusion level of PBMC. The protein supplementary value of PBMC in broiler finisher ration was sustained and even surpassed the growth performance and economic indices obtained for birds on the control diets where PBMC was not incorporated. The investigated response criteria pointed to the sustained good performance of broiler birds on 35% supplementary level of PBMC at the finisher phase of production.

5. RECOMMENDATION

The use of molasses as an ensiling additive of PBMC is a remarkable prelude before incorporation into poultry rations. This is highly suggested to facilitate the fermentation process and possibly overcome the nutritional limitations encountered as a result of the presence of relatively high fiber in PBMC. After that, fermented PBMC can be incorporated at levels within 30% inclusion rates in broiler diets at the finisher phase of production where PBMC can be significantly utilized and converted to broiler meat. For practical poultry feed formulation, PBMC is recommended at inclusion level of 30% and ensiling period of 21 days to achieve optimum performance in poultry birds.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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