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Economic Analyses and the Growth Performance of Broiler Starter Birds on High Fibre-low Protein Industrial Plant By-products

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Authors' contributions

This work was carried out in collaboration between all authors. Author OAA designed the aspect of economic evaluation of this study. Author AOF supervised and edited the manuscript. Author TOO was part of the research team 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: Economic parameters from the production of broiler starter birds in which composites of bio-fermented industrial plant by-products were used as crude protein supplements were determined by investigating their growth performance vis-a-vis the total net revenue derivable.
Study Design: 288 birds were picked and randomized into 6 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. The composite was fermented and dried before incorporation in dry

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matter basis into experimental diets as protein supplement. Data on growth parameters were collected and economic analyses were carried out at the end of the broiler starter phase.
Results: The feed conversion ratio (FCR) was lowest in the control diet (without PBMC) with a value of 1.60±0.01 and significantly lower ($P<0.05$) than FCR values obtained for other birds on other diets. Other FCR values were similar ($P>0.05$) for birds on diets 2 (10% PBMC), 3 (15% PBMC), 4 (20% PBMC), 5 (25% PBMC) and 6 (30% PBMC) at 1.76±0.21, 1.79±0.01, 1.90±0.01, 1.88±0.08 and 1.90±0.04, respectively. Birds on the zero PBMC inclusion level had the highest net returns/bird.
Conclusion: The fermented PBMC had better nutritional quality than the unfermented. The economic analyses of the PBMC inclusions in broiler starter diets revealed a net loss in returns as PBMC inclusions increased across the experimental diets. The incorporation of PBMC into broiler starter diets is not recommended especially for commercial production of broilers at the starting phase (0-28 days) of production.

Keywords: Growth performance; economic evaluation; net return indices.

1. INTRODUCTION

The abundance of waste from homes, markets, allied agro-industries, schools and various institutions is the proof of the rapid boom in the population of the world. Wastes are the so-called useless or unwanted remnants after the useful part of the material in question has been annexed. It has been posited that agricultural waste will continue to increase due to the increase in agricultural production arising as a result of the attempt to feed the ever growing population [1].

Among common agro-industrial wastes are wood wastes, brewing wastes, paper wastes, cassava wastes, cotton wastes and cereal wastes [2,3]. In West Africa especially Nigeria, rice, maize, millet and sorghum are among the staple food of the inhabitants. After the harvest of main grains, the remains of these cereals usually constitute a nuisance to agricultural environment and are often being dispose-off by burning which further compound environmental pollution inadequacy and kill useful microorganisms in the soil which usually maintain soil fertility cycle [4].

The high cost of procuring feed for poultry is on the increase by the day due to the combined effect of the more bulky and conventional components of the feed i.e. protein sources and carbohydrates sources. This has led poultry producers to re-examine their feed and feeding program. However, the availability of high quality feed for poultry is constrained by high cost of the significant conventional feed ingredients due to a competition of these materials between human and livestock [5,6,7]. Therefore it is necessary to exploit other non-competitive and economical plant and or ‘‘waste’’ resources.

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 [8] therefore making the nutrients more available in poultry feed [9]. This study aims to investigate the growth performance and economic viability of broiler birds at starting phase (0-28 days) fed fermented composite of palm kernel meal (PKM), brewer dried grains (BDG) and molasses.

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.

2.2 Site Preparation

Prior to the arrival of broiler chicks, the poultry house and metabolism cage were thoroughly washed and fumigated with Diskol (a disinfectant containing 4% benzalkonium chloride, 3% glutaraldehyde, 14% formaldehyde, stabilisers, antioxidants and activators). The house was well covered to prevent heat loss and brooding equipment was put in place. The entire floor of the pens was covered with dry wood shavings. The site was partitioned into 12 separate pens containing 8 birds each.

2.3 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 50 litres 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 [10,11]. 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 [10]. 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 analysed for proximate composition before incorporation into feed formulation. The metabolisable energy was calculated by estimation [12].

2.4 Management of Experimental Birds

Two hundred and eighty-eight were randomly picked after sexing on the 3rd day of the arrival of chicks for the experiment [13]. The chicks were brooded in a brooder house using electricity continuously supplied by 1KVA stand-by power generating plant at the Ekiti State University Teaching and Research Farms. A 5-day acclimatisation 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 this phase of the experiment. Appropriate veterinary routines were observed from day old. The experimental birds were randomly allocated into the 6 experimental treatments with 48 birds in each treatment while each treatment was replicated 3 times. Each replicate had 16 birds as designed.

2.5 Experimental Ration Formulation

Samples of the BDG, PKM and PBMC were taken for proximate analyses (AOAC, 1995) 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 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.

All diets were made isocaloric and isonitrigenous with ample supplementation of L-lysine and DL-methionine synthetic amino acids at required level. Experimental diets were also taken into the laboratory for determination of proximate analyses [14].

2.6 Cost Implications/Economics Analysis

A major objectives 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:

$$\Pi = TR - TC \quad \ldots\ldots 1$$
$$TR = P * Q \quad \ldots\ldots 2$$
$$TC - TVC + TFC \quad \ldots\ldots 3$$

Where:

Π = Net profit; TR = Total Revenue from broiler; TC = Total Cost involved; P = Price for the starter phase of broiler production; Q = Total output for the starter 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.

2.7 Statistical Analysis

All recorded and calculated data were statistically analyzed with the standard procedure of analysis of variance (one-way ANOVA) technique using Minitab statistical computer software package (2016 version). Results were expressed as mean ± standard deviation of the two measurements.

3. RESULTS AND DISCUSSION

3.1 Proximate Compositions of PBMC and Experimental Feed Formulation

The proximate compositions of palm kernel meal (PKM), brewers dried grains, molasses, PBMC (unfermented) and fermented PBMC are presented in Table 1. Compositions of the experimental diets are presented in Table 2. Growth performance of the broiler starter birds are presented in Table 3 while the economic analysis of broiler chicks (starter phase) fed PBMC is shown in Table 4.

The proximate analyses of the fermented composite of palm kernel meal (PKM), brewers dried grains (BDG) and molasses (PBMC) had a better mean crude protein value of 23.1±4.2% significantly higher ($P<0.05$) than 20.2±4.5% obtained for the unfermented PBMC. The average CP value for the fermented PBMC was also higher than the separate average CP values for PKM at 19.1±3.0% and BDG at 22.1±2.7%. The crude fibre (CF) component of the fermented PBMC at 10.1±3.3% was significantly lower ($P<0.05$) than for the unfermented PBMC at 13.5±2.1%. Ditto for the ether extract component of 3.5±3.1% obtained for the fermented PBMC which was also lower than 7.4±4.1% obtained for the unfermented PBMC. Ash contents were similar ($P>0.05$) for both fermented and unfermented PBMC. Nitrogen free extracts (NFE, soluble sugars) were significantly higher ($P<0.05$) for fermented PBMC at 54.8±3.4% than 49.8±3.2% for the unfermented PBMC. The dry matter (DM) content was higher, although not significantly, for the fermented PBMC at 89.5±3.1% against 87.1±2.1% for the unfermented PBMC.

The results of the proximate compositions of the fermented and unfermented PBMC agreed with previous studies [10,11] that the process of ensiling/fermentation facilitated the activities of proteolytic microorganisms mainly clostridia while the pH is still relatively high resulting in the breakdown of complex protein to amino acids, amines and NH_3. Other authors found out that the fiber content in PKC reduced from 15.47 to 12.44% while the protein level increased from 20.04 to 23.42% [9].

The increase in the dry matter (DM) of the fermented PBMC was also corroborated by previous study [11] where significant increase in water-extractable DM particularly ith increased addition of molasses was reported in the study with Taro leaves (Colocasia esculenta L. Shott). The study revealed an increase of about 100% in water-extractable DM at 4% and 6% molasses addition.

The formulation and compositions of the experimental diets in Table 2 ensured isocaloric and isonitrogenous contents of the diets as the major variation among the diets was meant to be derived from the fermented PBMC protein supplementation. However, the fibre level increased as the inclusion levels of the fermented PBMC increased across the experimental diets.

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)	Unfermented PBMC	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 fibre	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) 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) [12]; Palm kernel meal, PKM; brewers dried grains, BDG; palm kernel meal-brewer dried grain-molasses composite, PBMC

Table 2. Experimental diets (starter phase)

Ingredients	**Diets and % inclusion levels of PBM composite)**					
	Diet 1 0%	**Diet 2 10%**	**Diet 3 15%**	**Diet 4 20%**	**Diet 5 25%**	**Diet 6 30%**
Maize (11.0% CP)	50.40	47.85	47.00	45.50	44.50	43.05
Wheat offals	10.00	10.00	10.00	10.00	10.00	10.00
Soyabean meal	33.50	26.00	24.00	19.00	15.00	11.00
Fish meal	2.00	0.00	0.00	0.00	0.00	0.00
Palm oil	0.00	0.00	0.00	1.00	1.00	1.00
*PBMC	0.00	10.0	15.0	20.0	25.00	30.0
Bone meal	2.50	2.5	2.5	2.5	2.5	2.5
Oyster shell/limestone	0.50	0.5	0.5	0.5	0.5	0.5
Nacl	0.30	0.3	0.3	0.3	0.3	0.3
DL-methionine	0.15	0.1	0.1	0.1	0.1	0.1
L-Lysine	0.15	0.1	0.1	0.1	0.1	0.1
**Premix	0.50	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, %	23.06	23.07	23.06	23.06	23.05	23.04
Crude Fibre, %	4.54	5.64	5.82	6.02	7.85	9.24
Ether Extract, %	7.21	7.01	7.03	9.21	9.43	9.32
***ME, Kcal/Kg	2893.3	2889.7	2884.0	2885.8	2879.1	2886.8
Proximatelydetermined composition						
Crude Protein, %	22.86	22.90	23.01	23.04	23.10	23.10
Crude Fibre, %	4.87	5.02	5.31	6.34	7.56	8.12
Ether Extract, %	6.09	6.52	6.64	7.24	7.87	8.14

**PBMC, Palm kernel meal+Brewers dried grains+Molasses ensiled composite;*
***Premix contained vitamins A(10,000,000iu); D(2,000,000iu); E(35,000iu);K(1,900mg); B12 (19mg); Riboflavin(7,000mg); Pyridoxine(3,800mg); Thiamine(2,200mg); D Panthotenic acid(11,000mg); Nicotinic acid(45,000mg); Folic acid(1,400mg); Biotin (113mg); and trace elements as Cu(8,000mg); Mn(64,000mg); Zn(40,000mg); Fe(32,000mg); Se(160mg); I_2(800mg); and other items as Co(400mg); Choline(475,000mg); Methionine(50,000mg); BHT(5,000mg) and Spiramycin(5,000mg) per 2.5kg; CP:Crude Protein,*
****ME, metabolizable energy = (0.860+0.629(GE-0.78CF) [12]*

3.2 Growth Performance of Broiler Starter Birds

The average feed intake (AFI) indicated that there was no significant difference (P>0.05) among the six treatments for the broiler starter birds. The AFI ranged from 29.25±1.52 g/b/d for birds in diet 1 (control diet without PBMC) to 27.47 ±1.70 g/b/d in birds on diet 6 (30% PBMC inclusion). The average weight gain was highest at 18.28±1.01 g/b/d for birds on the control diet (without PBMC) and similar (P>0.05) to 16.55±0.48 g/b/d obtained for birds on diet 2 (10% PBMC). Others AWG values obtained for birds on diets 3 (15% PBMC), 4 (20% PBMC), 5 (25% PBMC) and 6 (30% PBMC) at15.83±0.21 g/b/d, 15.33±0.30 g/b/d, 15.17±0.06 g/b/d and 4.45±0.59 g/b/d, respectively were similar (P>0.05) to 16.55±0.48 g/b/d obtained for birds on diet 2 (10% PBMC). The feed conversion ratio (FCR) was lowest in the control diet (without PBMC) with a value of 1.60±0.01 and significantly lower (P<0.05) than FCR values obtained for other birds on other diets. Other FCR values were similar (P>0.05) for birds on diets 2 (10% PBMC), 3 (15% PBMC), 4 (20% PBMC), 5 (25% PBMC) and 6 (30% PBMC) at 1.76±0.21, 1.79±0.01, 1.90±0.01, 1.88±0.08 and 1.90±0.04, respectively.

Previous studies [15,16,17] corroborated that feed intakes were not significantly affected by the inclusion of palm kernel meal into broiler chick diet. Weight gain was observed to be highest in the treatment with zero inclusion level of PBMC with a progressive decline as the inclusion level of PBMC increased. This may be associated with the crude fibre content of PKM, ranging from 16%-18%, which has been suggested to be acceptable to most ruminants, but considered high for non-ruminants [15]. The fibrous component of PKM is composed of mainly insoluble mannose-based polysaccharides (mannan) and has been shown that the cell wall consisted of 58% mannan, 12% cellulose and 4% xylan [18]. The amino acid content also revealed that lysine appears to be the first limiting amino acid, followed by the sulphur amino acids (methionine, cystein) and tryptophan. Fibre has been reported to resist enzymatic digestion in the gastrointestinal tract of monogastrics [19]. Likewise, the disadvantages of BDG, apart from its widely acknowledged high fibre content, include nucleic acid toxicity, palatability and limitation of sulphur amino acid in the product [20,21].

The similarities among the FCR values obtained for birds on the PBMC diets even with the highest inclusion PBMC level of 30% laid credence to the viability of PBMC as a supplementary protein source in broiler diets especially when further processed by fermentation. This result agreed with previous study [16] that revealed an effective utilization

Table 3. Performance characteristics of broilers (1-28 days) fed with fermented brewer dried grain, palm kernel meal and molasses composite

Parameters	Diets and percentage PBMC inclusion					
	1	**2**	**3**	**4**	**5**	**6**
	0%	10%	15%	20%	25%	30%
AFI	29.25±1.52	29.05±1.25	28.33±0.37	29.11±0.64	28.44±1.03	27.47±1.70
AWG	18.28^{a}±1.01	16.55^{ab}±0.48	15.83^{b}±0.21	15.33^{b}±0.30	15.17^{b}±0.06	14.45^{b}±0.59
FCR	1.60^{b} ±0.00	1.76^{a} ±0.21	1.79^{a} ±0.00	1.90^{a} ±0.01	1.88^{a} ±0.08	1.90^{a} ±0.04

Mean ± Standard deviation; (a, b, c) Means in the same row with the different superscript are significantly different at (P>0.05). AFI, average feed intake; AWG, average weight gain; FCR, feed conversion ratio

Table 4. Economic analysis of broiler chick fed fermented palm kernel cake and brewer dry grain mixture

Parameters	Inclusion rate in diets					
	1	2	3	4	5	6
Total feed intake (Kg/bird)	0.032	0.031	0.031	0.029	0.029	0.027
Feed cost/Kg of diet (₦/Kg)	169.87	132.82	130.57	131.04	125.57	119.42
Cost of feed intake/bird (₦/bird)	5.44	4.12	4.05	3.80	3.64	3.22
Cost of starter chick (₦/bird)	170	170	170	170	170	170
Total cost of production (₦)	175.44	174.12	174.05	173.80	173.64	173.22
Av. Body Wt. at 28 days (Kg/bird)	0.60	0.54	0.52	0.51	0.50	0.48
Cost of 1kg of chicken (₦)1200	1200	1200	1200	1200	1200	1200
Total revenue/bird (₦/bird)	720	648	624	612	600	576
Total net returns/bird (₦)	544.56	473.88	449.95	438.2	426.36	402.78

₦, Nigeria Naira currency; other occasional costs that are uniform for all diets are not considered

when rice husk was fermented for 21 days and included at 10% level in broilers. Growth performance, haematology and cost benefit analyses were all favoured in this study [16]. Another study [17] also revealed that ensiled and enzyme fortified PKM had comparative advantage in broilers even at the highest inclusion level of 30%. Further corroboration of the present study revealed that 15% to 30% inclusion rates of brewer dried grain did not affect the FCR of broiler at starter phase [22]. However, some studies emphasized the fact that fish meal and/or synthetic amino acids (methionine and lysine) must be used to compliment the incorporation of ingredients with high fibre contents such as PKM as a protein source in broiler diets [23,24].

3.3 Economic Analysis

Even though the feed cost per kg and the total cost of production decreased with increasing levels of PBMC across the diets, the total net returns per bird was the reverse (Table 4). The decreased feed cost per Kg and reduced total cost of production with increased levels of PBMC is corroborated by previous studies [25,26]. However, this contradicts another report [27] that significant differences were not found in the cost of feed per kg, rearing cost and selling price as BDG increased in the diets where graded levels of BDG with or without probiotics supplementation were fed as a replacement for groundnut cake in the diet of weaner rabbits. However, this can be explained by the possibility of more utilization of high fibre diets by the extended ceaca of the rabit.

Total revenue (Nigerian Naira/bird) and total net returns/bird reduced with the increasing inclusion levels of PBMC. Birds on the control diet had the best and highest net returns/bird. It has been earlier reported that the rate of inclusion of PKM increased the total cost of production particularly at the broiler starter phase [17]. However, a conflicting report [28] informed that incorporating 15% to 30% levels of maize/sorghum-based brewers' grains, cocoyamcorms and cassava root meals as replacement for maize reduced the cost of broiler production to about 50%.

4. CONCLUSION

There is incontrovertible empirical evidence that the fermented PBMC had better nutritional quality than the unfermented PBMC judging from the proximate compositions. Even though the feed intake was not significantly affected even at a maximum of 30% PBMC inclusion for the broiler starter birds, weight gain and feed conversion ratio were affected considerably to the disadvantage of birds in which PBMC were included and such detriments increased as the inclusion levels of PBMC increased. The economic analyses of the PBMC inclusions in broiler starter diets revealed a net loss in returns as PBMC inclusions increased across the experimental diets.

5. RECOMMENDATION

Strictly for economic consideration, the incorporation of PBMC into broiler starter diets may not be economically viable and therefore not recommended especially for commercial production of broilers at the starting phase (0-28 days) of production. The growth parameters investigated all indicated shortfalls when PBMC were liberally included from start of broiler production.

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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