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Effect of Feeding Open-Air Dried Broiler Litter on Nutrient Digestibility, Growth and Carcass Composition in Growing-Finishing Pig Diets

[*]Komolafe, A. A. and Sonaiya, E. B.

Department of Animal Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria
[*]Corresponding author's e-mail: ayodeji.komolafe@yahoo.co.uk

Abstract

Fifty-four (Large White strain) grower pigs were used to evaluate broiler litter as potential feedstuff for growing-finishing pigs. Pigs were randomly allotted to one of three dietary treatments; O, 15 and 30 % broiler litter inclusion levels. Each treatment was replicated six times with three pigs/replicate in a completely randomized block design. Test diets were formulated to contain 20% crude protein and 3200 kcal/kg digestible energy. Pigs were housed in total confinement in a concrete-slatted floor house containing twenty pens; each measuring 7.4 × 1.75 m and equipped with feed and water troughs that were about 3.6 m apart. The apparent digestibility of nutrients decreased with increasing incorporation of broiler litter in the diets of growing-finishing pigs, especially crude protein. The apparent digestibility of crude protein and the daily growth rate were depressed by the increasing inclusion of broiler litter in the diet. Daily feed intake was increased and the feed conversion ratio was highest at 30% broiler litter feeding. Animals on broiler litter-based diets had lower body weight at slaughter while carcass length and backfat thickness decreased with increasing level of broiler litter inclusion. Percent spleen was increased by the inclusion of broiler litter. Ash content of the muscles increased whereas ether extracts and crude protein decreased with increase in the levels of broiler litter in the diet. Feeding broiler litter at 30% level gave higher moisture content (3.8%), calcium (0.04%), phosphorus (0.8%) and a lower gross energy (5649 kcal/kg) content for muscle composition. The inclusion of broiler litter in growing-finishing pigs' rations reduced growth performance; but improved the carcass quality when fed at 30% inclusion level and reduced feed cost at 15% inclusion level. Appropriate feeding strategies are required to optimise performance, carcass quality and feed cost.

Keywords: Carcass quality, feed cost, muscle composition.

Introduction

Sansoucy (1995) described livestock as the driving force for food security and sustainable development. However, livestock production in many developing countries is constrained because of poor nutrition, short supply of animal feeds and poor quality of available feeds (IAEA 2012). Furthermore, it was recognized that utilization of alternative feedstuffs, which are mostly by-products of production operations, may play a crucial role in livestock production; especially as substitute for the traditional feedstuffs that are not readily available or are expensive. However, for a sustainable development of the livestock sector, it is essential to secure sufficient supply of balanced feed from resources that have no use in human nutrition.

Research results have shown that there are benefits of an efficient use of poultry waste (PW) from the standpoint of reducing the biomass of nutrients (i.e. nitrogen and phosphorus) into the soil. PW is not a product of uniform quality (Fontenot, 1996); it comprises of poultry litter (PL) and poultry manure (PM). PL can also be an excellent source of supplemental protein, calcium, phosphorus, and roughage (Muller, 1975) in formulated feeds. PL is especially valuable as a source of N per unit of litter in comparison to dairy and swine manures (Ferket *et al.*, 2002) and often contains greater than 2000 mg/kg water-soluble P (Moore and Miller, 1994). Adesehinwa *et al*. (2010) fed PL from growing pullet to growing-finishing (G-F) pigs as a replacement for maize, an ingredient used as a source of energy. Kwak and Kang (2005) used vacuum-dried broiler litter (BL) as source of nitrogen and minerals for aerobic microbes and as a water absorbent in the diet of finishing pigs, while Aro and Tewe (2007) fed dried poultry droppings to barrows as a total replacement for palm kernel cake.

BL, a by-product of broiler production, contributes to environmental pollution and degradation, with a concomitant high cost of disposal. However, it is presumably valuable as a source of nutrients to livestock animals, especially ruminants. Bagley and Evans (1998) recommended the incorporation of poultry or pig waste in the rations of ruminants so as to reduce the cost of supplementing N and P; noting that mineral supplements particularly phosphates have become very expensive. Myer and Hall (2004) noted the role of pigs in recycling and “adding value” to many by-products and wastes; thus, they become increasingly important as a viable waste management option. The major costs in a formulated pig diet are ingredients that provide energy, protein and P. The objective of this study, therefore, was to evaluate the effects of open-air dried BL-based diets on the growth performance, apparent faecal digestibility of nutrients and carcass composition in G-F pigs.

Materials and Methods

Location of study

This study was carried out at the Swine Unit of the Obafemi Awolowo University Teaching and Research Farm, Ile-Ife, Osun State, Southwest Nigeria.

Source of broiler litter

Broiler litter was collected fresh from broiler houses as from 4 weeks of production to the end of the production cycle at 8 weeks. The litter was stacked on the concrete floor of a half open-sided roofed-structure for 4 days to sustain the heat produced by the litter. The litter was spread out in the same shed for another 3 days to allow for proper drying, before it was sieved using metal sieves of 5 mm^2 mesh size, in order to remove caked material and unwanted items. Sieved BL was bagged in jute sacs, stacked and stored in a cool, dry and secured place (a storehouse) under ambient conditions.

Diet formulation

Three experimental diets, with O, 15 and 30 % broiler litter inclusion levels, were formulated to be iso-caloric (3200 kcal/kg DE) and iso-nitrogenous (20% CP) with the aid of Microsoft® Excel Spreadsheet using generated formulae, nutrient composition of the ingredients and the nutrient requirements of the experimental animals. All diets met or exceeded NRC (1998) nutrient requirement recommendations for 20 kg pig.

Experimental animals, sample collection and analysis

A total of fifty-four grower pigs (Large White strain), with an average body weight of 23.5 ± 3.3 kg were used in a 90-d feeding trial to evaluate the effects of open-air dried BL as a feedstuff on growth performance, nutrient digestibility and carcass quality. The pigs were randomly allotted to the three experimental treatments, with three pigs penned together. The design was a complete randomized block design with six replications per treatment. Pigs were allowed access to feed and water *ad libitum*. During a 7-d collection period (day 80-90), total faeces were collected and weighed while fresh-grab faecal samples were collected, labelled and frozen (-20 ºC) until the samples were analysed. Records of feed intake and orts were taken throughout the study. Body weights were recorded fortnightly. Samples of feed were taken weekly and stored at -20 ºC for later analysis. Feed cost savings were analysed as feed costs required for 1 kg of body weight gain.

Carcass analysis

Two animals were selected from each of the experimental diets and were slaughtered at the end of the study (on day 94) for carcass characteristics and meat quality evaluation. Selected pigs were taken off feed for 18 h but without restriction from water. Animals were stunned using an iron bar, hoisted and blood vessels of the neck completely severed to ensure thorough and complete bleeding. A long cut was made down the belly from the breast to the hams to allow evisceration. Carcasses were cut longitudinally into two equal parts.

Meat samples were taken at three different parts of the carcass – the ham (the hind leg), the fore leg and at the dorsal region. Meat samples were placed in well-labelled plastic containers and stored in a chest freezer at about -20 ºC until they were analysed for proximate, energy and mineral composition. Conventional carcass measurements were taken using a steel tape and a ruler, according to the methods of Matthews *et al.* (2001). The liver, spleen, lungs, heart and kidney were individually weighed at slaughter. Dressing percentage was calculated using the hot carcass weight and the final body weight.

Chemical analysis

Proximate composition of samples of BL was analysed using the methods of AOAC (2005). The NDF, ADF and cellulose, hemicelluloses and lignin contents were determined according to the methods of Van Soest *et al*. (1991). Soluble carbohydrate (SCH_2O) were calculated as described by NRC (1998). Mineral analysis was by wet digestion of samples in $HNO_3/HClO_4$. Mineral elements were determined using Atomic Absorption Spectrophotometric (AAS) method (BUCK Scientific Atomic Absorption Spectrophotometer Model 210 VGP, USA. Gross energy concentration was determined using adiabatic bomb calorimeter (e2k Combustion Calorimeter, S.A., version 2.0, 2008).

Statistical analysis

Differences in performance factors between diets within pens were analysed with the 2-way analysis of variance using the General Linear Means procedure of SAS (2000). Animals within a pen were the experimental unit for the analysis of performance and digestibility study data. The data were treated within a completely randomized block design with diet as the main treatment effect and replicates within treatments as blocks. The replicate was considered as the block in order to increase the sensitivity of the experiment by reducing the residual error. The model used was:

$$Yijk = \mu + Vi + ßj + \varepsilon ijk$$

Where Yijk is the performance factor; μ is the overall mean of performance values; Vi is the diet effect; ßj is the replicate effect and εijk is the residual experimental error. Differences in performance factors between diets within treatments were resolved by Duncan's NMRT of SAS® statistical package (SAS, 2000). Statistical significance was established when probability was less than 0.05 level of significance. Graph was plotted using GraphPad Prism (2007).

Results

Table 1 shows the chemical and energy contents of the experimental diets. The CP content of the experimental diets increased with increasing inclusion level of BL (P=0.001). Other nutrients that increased with increasing level of BL were ash (10.5%) and CF (7.9%). Ether extract and the NFE content decreased as BL level increased in the diets (P=0.001). Increasing inclusion levels of BL in the diets significantly increased NDF (21.8%), ADF (8.6%) and the lignin (1.9%) contents (P=0.001). Diet 1 (0% BL) had the highest total digestible nutrient (TDN) content of 75.8% and DE content of 3059 kcal/kg. Diet 3 (30% BL) had highest values for the seven minerals considered, in addition to having the highest Ca: P ratio of 2.3: 1 (P=0.001)

Table 1: Proximate, fibre, energy and mineral contents of experimental diets[1] (dry matter basis)

Parameters	**Diet 1**	**Diet 2**	**Diet 3**	**SEM**	**Prob.**
Proximate					
Moisture, %	14.5[a]	13.4[b]	11.6[c]	0.3	<.0001
Crude Protein, %	19.7[c]	19.9[b]	20.0[a]	0.03	<.0001
Ash, %	5.8[c]	8.4[b]	10.5[a]	0.5	<.0001
Ether extract, %	7.6[a]	6.3[b]	5.1[c]	0.3	<.0001
Crude fibre, %	4.6[c]	5.8[b]	7.9[a]	0.3	<.0001
Nitrogen-free extract, %	47.9[a]	46.4[b]	45.0[c]	0.3	<.0001
Fibre					
Neutral detergent fibre, %	18.5[c]	20.6[b]	21.8[a]	0.3	<.0001
Acid detergent fibre, %	6.9[c]	7.7[b]	8.6[a]	0.2	<.0001
Lignin, %	1.4[c]	1.6[b]	1.9[a]	0.1	<.0001
Hemicellulose, %	11.7[c]	12.9[b]	13.3[a]	0.2	<.0001
Cellulose, %	5.5[c]	6.2[b]	6.7[a]	0.1	<.0001
Soluble carbohydrate, %	48.5[a]	44.9[b]	42.6[c]	0.6	<.0001
Total digestible nutrient, %	75.8[a]	72.0[b]	68.4[c]	0.8	<.0001
Digestible energy, kcal/kg	3059[a]	2884[b]	2787[c]	27.0	<.0001
DE: CP	155[a]	145[b]	139[c]	1.6	<.0001
Minerals					
Calcium, %	0.8[c]	1.2[b]	1.5[a]	0.1	<.0001
[a]Phosphorus, %	0.60[c]	0.61[b]	0.67[a]	0.01	<.0001
Manganese, %	0.15[c]	0.17[b]	0.21[a]	0.01	<.0001
Iron, %	0.3[c]	0.5[b]	0.6[a]	0.03	<.0001
Copper, %	0.0029[c]	0.0032[b]	0.0042[a]	0.0001	<.0001
Zinc, %	0.14[c]	0.20[b]	0.21[a]	0.01	<.0001
Magnesium, %	0.30[c]	0.40[b]	0.53[a]	0.02	<.0001
Ca: P	1.3[c]	2.0[b]	2.3[a]	0.1	<.0001

[a,b,c]Means with different superscript are significantly different at $P<0.05$
SEM = standard error of the mean
SCHO = soluble carbohydrate (Non-fibrous carbohydrate)
TDN = total digestible nutrient; DE = digestible energy
[a]total phosphorus
Ca = calcium; P = phosphorus
[1]Diet 1 = 0% BL; diet 2 = 15% BL; diet 3 = 30% BL

The incorporation of BL in the diets of G-F pigs decreased the AD of nutrients, especially CP (P=0.01) (Table 2). The AD of CF (55.9%) of the diet 2 (15% BL) compared favourably with the value of 56.5% reported for the control diet. Likewise, the 83.0% AD for DE in the control diet compared well with 82.3% for diet 2.

Table 2: Apparent digestibility of nutrients in broiler litter-substituted diets[1] by growing-finishing pigs

Parameters	Diet 1	Diet 2	Diet 3	SEM	Prob.
Crude Protein, %	89.6[a]	87.4[b]	87.8[b]	0.3	0.01
Crude fibre, %	56.5[a]	55.9[a]	50.1[b]	1.3	0.003
Ether extract, %	88.8[a]	87.7[b]	81.9[c]	0.8	<0.0001
Ash, %	39.9[a]	35.2[b]	32.4[c]	1.2	0.02
Nitrogen-free extract, %	86.8[a]	84.7[b]	80.7[c]	0.7	0.001
Calcium, %	87.3[a]	83.7[b]	82.6[c]	0.9	<0.0001
[a]Phosphorus, %	87.1[a]	83.8[b]	82.4[c]	0.9	<0.0001
DE, kcal/kg	83.0[a]	82.3[a]	79.9[b]	0.5	0.01

[a,b,c]Means with the same superscript are not significantly different at P<0.05
SEM = standard error of the mean
DE = digestible energy
[a]total phosphorus
[1]Diet 1 = 0% BL; Diet 2 = 15% BL; Diet 3 = 30% BL

The DFI by pigs was increased with BL feeding, with animals fed diet 3 consuming 2.1 kg of feed/pig/day while the pigs on diet 2 consumed 1.8 kg of feed/pig/day, which compared with 2.0 kg of feed/pig/day consumed by animals on diet 1 (Table 3). The DGR was also depressed by feeding BL (P=0.01). Pigs fed the control diet (diet 1) gained 0.6 kg body weight/day compared with the 0.5 kg body weight gain/day by pigs on diets 2 and 3. Figure 1 depicts the growth rate pattern of growing-finishing pigs fed on broiler litter-based diets. The Feed conversion ratio of 4.2 was recorded for pigs fed diet 3 while 3.6 and 3.7 were recorded for pigs fed diets 1 and 2 respectively. Consequently, the cost of feed (N216.8) consumed by pigs on diet 3 per kg weight gain was higher when compared with those of the pigs fed diets 2 and 1, with values of N193.1 and N194.4, respectively (*p=0.03*).

Table 3: Effect of broiler litter on performance and cost of feed in growing-finishing pigs

Response	**Diet 1**	**Diet 2**	**Diet 3**	**SEM**	**Prob.**
Initial body weight, kg	23.6	23.4	23.5	0.5	0.99
Final body weight, kg	54.8[a]	50.8[ab]	48.9[b]	1.1	0.07
Ave. daily feed intake, kg	2.0[ba]	1.8[b]	2.1[a]	0.1	0.05
Ave. daily growth rate, kg	0.6[a]	0.5[b]	0.5[b]	0.02	0.01
Feed conversion ratio	3.6[b]	3.7[b]	4.2[a]	0.1	0.10
Ave. daily energy intake, kcal/kg	58.6	54.7	56.3	2.0	0.33
Energy conversion ratio	106.1[b]	109.3[b]	115.0[a]	2.8	0.05
Ave. daily protein intake, kg	0.4[a]	0.3[b]	0.4[a]	0.01	0.01
Protein efficiency ratio	0.7[a]	0.6[b]	0.7[a]	0.02	0.01
DE :CP	156.1[b]	174.6[a]	157.5[b]	4.0	0.01
Ca :P	1.2[c]	2.2[b]	2.3[a]	0.1	<0.0001
Cost of feed/kg	53.8[a]	52.5[b]	51.3[c]	0.3	<0.0001
Cost of feed consumed/d, ₦	107.2[a]	96.4[b]	105.2[ba]	3.0	0.06
Percent reduction	12.8[b]	21.6[a]	14.4[ba]	2.5	0.06
Cost of feed/Wt. gain,₦/kg	194.4[b]	193.1[b]	216.8[a]	4.9	0.03
Percent reduction	17.2[a]	17.7[a]	7.7[b]	2.1	0.03
Mortality, %	1.8	1.8	0	.	.

[a,b,c]Means with different superscript are significantly different at P<0.05
SEM = standard error of the mean; Ave. = average
BL = broiler litter
DE = digestible energy; CP = crude protein; Wt. = weight
[1]Diet 1 = 0% BL; diet 2 = 15% BL; diet 3 = 30% BL

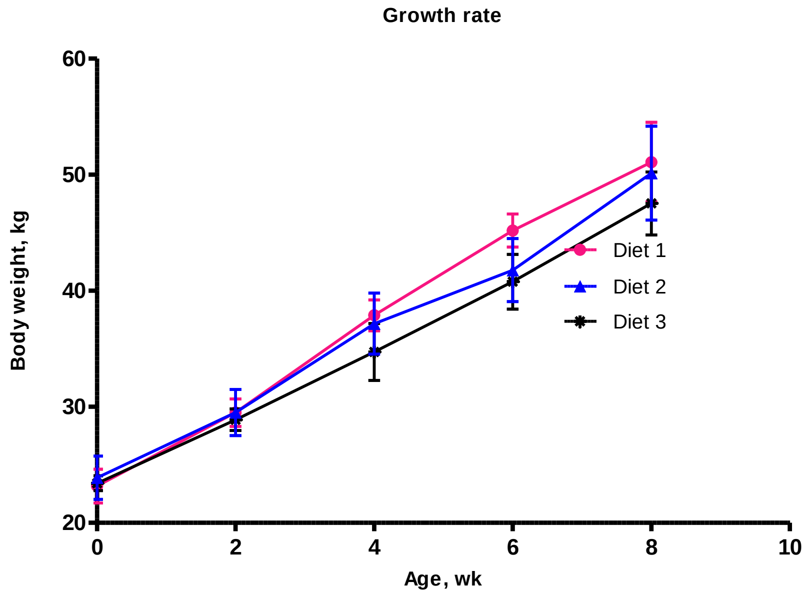

Fig. 1: Growth rate pattern of pigs on broiler litter-based diets

Table 4 shows that there existed decreasing differences in the BW at slaughter, BFT and carcass length. Animals on BL-based diets had lower BW at slaughter while carcass length and BFT decreased with increasing level of BL inclusion. The relative organ weights of animals showed that feeding BL-based diet increased the percent spleen (P=0.05).

Table 4: Carcass and organ measurements of growing-finishing pigs fed broiler litter-substituted diets[1]

Response	Diet 1	Diet 2	Diet 3	SEM	Prob.
Carcass measurements					
[1]Body weight, kg	66.5[a]	59.50[b]	58.0[b]	1.8	0.04
Hot carcass weight, kg	22.5	20.3	20.3	0.8	0.4
[2]Back fat, cm/kg BW	0.021[a]	0.016[b]	0.012[c]	0.001	0.01
Hot carcass length, cm	92.3[a]	87.8[b]	65.8[c]	2.6	0.03
Ham length, cm	37.5	30.5	30.5	1.7	0.3
Eat-to-snout length, cm	42.3	42.5	42.5	0.6	0.2
[3]Dressing, %	67.7	68.1	69.6	1.2	0.7
Organ measurements					
Liver,%	1.8	1.9	1.9	0.02	0.3
Heart, %	0.4	0.4	0.4	0.03	0.7
Spleen, %	0.19[b]	0.23[ab]	0.25[a]	0.01	0.05
Kidney, %	0.3	0.3	0.4	0.02	0.6
Lungs,%	0.8	0.8	0.9	0.02	0.2

[a,b,c]Means with different superscript are significantly different at P<0.05

SEM = standard error of the mean

[1]Body weight at slaughter
[2]Average of back fat thickness at the first rib, the last rib and lumbar vertebra
[3]Percent dressing and organ measurements as a percentage of live body weight at slaughter
[1]Diet 1 = 0% BL; diet 2 = 15% BL; diet 3 = 30% BL

Diet 3 gave higher moisture content of 3.8% than 3.3% and 3.5% observed in the muscles of pigs fed diets 1 and 2 (P=0.01) (Table 5). The ash content of the muscles increased with increase in the level of BL in the diet (P=0.001). On the contrary, EE and CP content of the muscle decreased with increase in the levels of BL in the diet (P=0.001). The GE content of 5649 kcal/kg in the muscle of pigs fed diet 3 was lower than 6414 and 6263 kcal/kg in the muscles pigs fed diets 1 and 2 (P=0.001). Calcium content was 0.02% in the muscles of pigs on the control diet, the observed value of 0.04% in the muscle of pigs fed diet 3 was higher (P=0.002). Pigs fed diet 3 gave higher value of 0.8% for P compared with 0.6% and 0.7% for pigs on diets 1 and 2 respectively (P=0.02*)*.

Table 5: Nutrients and energy content (on dry matter) of muscles[1] from growing-finishing pigs fed experimental diets[2]

Parameters	**Diet 1**	**Diet 2**	**Diet 3**	**SEM**	**Prob.**
[3]Body weight, kg	66.5^{a}	59.5^{b}	58.0^{b}	1.8	0.04
Proximate					
Moisture, %	3.3^{b}	3.5^{b}	3.8^{a}	0.1	0.01
Ash, %	4.0^{c}	4.4^{b}	4.7^{a}	0.1	0.0001
Ether extract, %	17.0^{a}	16.0^{b}	13.3^{c}	0.9	<0.0001
Crude protein, %	63.2^{a}	61.3^{b}	60.3^{c}	0.4	<0.0001
Energy					
GE, kcal/kg	6414^{a}	6263^{a}	5649^{b}	134	0.001
Mineral					
Calcium	0.02^{b}	0.03^{ba}	0.04^{a}	0.002	0.0002
Phosphorus	0.6^{b}	0.7^{b}	0.8^{a}	0.004	0.01

[a,b,c]Means with different superscript are significantly different at P<0.05
SEM = standard error of the mean
[1]Muscles were taken from the hind leg, the fore leg and at the dorsal region
[2]Diet 1 = 0% BL; diet 2 = 15% BL; diet 3 = 30% BL
[3]Body weight at slaughter

Discussion

The control diet (diet 1) had the highest TDN content of 75.8%, as well as DE content of 3059 kcal/kg compared with 68.4% TDN and 2787 kcal/kg DE in diet 3. Jacob *et al*. (1997) reported 50% TDN for BL while Vest and Merka (2004) reported TDN range of 25 to 60% for BL, which explain the low energy content of the BL diets. DeGoey and Ewan (1975) and Kennelly and Aherne (1980b) all reported that the addition of fibre (crude fibre, neutral detergent fibre, acid detergent fibre) to swine diets decreased the DE concentration of the diet. The Ca: P ratio of diets 2 and 3 were not too far away from the National Research Council (NRC, 1998) recommendations of 1 to 2:1 in compounded diets for growing (20-55 kg) pigs. This is due to the reported high content of Ca and P in BL. Payne and Zijlstra (2007) asserted that with every change in the crude nutrient (protein, fat, fibre, ash, etc) profile of a feed ingredient, there was also a change in the other nutrients available from that ingredient, most especially energy. The change could be due to variations in the origin of the feed ingredients; variability within feed ingredients; variability in the handling and processing methods of feed ingredients and feeds; and variability in the storage time. NRC (1998) observed that the chemical composition of feed ingredients is a major determinant of DE, with positive effects of EE and negative effects of fibre and ash. The result of this study shows that inclusion of BL in the diets resulted in proportionate increase in ash content, crude fibre and fibre detergent and mineral contents. The levels of ash and fibre content in a feed are also known to be proportionate to the energy content of such feed because of their nutrient dilution effect (Calvert, 1991). However, it is believed that the dilution effect of fibre on energy is noticed only when the energy content is inadequate.

Feeding open-air dried BL to growing pigs promoted growth and did not adversely affect the health and performance of the pigs. Contrary to the findings of Harper *et al.* (1997) and Matsui *et al.* (2000), there were no incidences of leg weakness or rib fractures, which were indicative of rickets. The highest Ca: P ratio value of 2.3 in the diets used in this study was slightly higher than 2.0 in a low P corn-soybean diet reportedly fed to weanling and growing pigs by Lei *et al.* (1994) and Qian *et al.* (1996). The AD of nutrients and energy by G-F pigs fed diets containing BL showed that incorporating BL in their diets decreased the AD of most nutrients considered. Noblet and Le Goff (2001) reported that dietary fibre lowered digestibility of dietary energy and protein; probably due to its influence on several aspects of the digestive processes (Noblet and Perez, 1993). Cellulose, hemicellulose, arabinoxylans, and oligosaccharides reduced the pigs' ability to digest feed completely (Gabert *et al*., 2001). It can be said that high fibre in the diets reduced the DE value of the diet by lowering the AD of the various dietary components. Energy and nutrient utilisation were reduced in the pigs fed diet 3 because the dietary fibre induced a more rapid rate of passage through the alimentary canal, increased fibre-mineral interactions, decreased nitrogen and energy utilization (Calvert, 1991). Just (1982) reported that an increase of one percent in dietary CF depressed digestibility of GE by approximately 3.5 percent. In addition, Moeser and van Kempen (2002) asserted that increasing levels of dietary NDF linearly decreased dry matter and energy digestibilities (r^2=0.99, $p<0.05$) in grower pigs. The influence of fibre on protein digestibility is still not clear. Several reports suggest that when the source of fibre does not contribute significant amounts of protein to the diet, then, an increase in the level of fibre does not affect protein digestibility significantly (Eggum, 1973; Kennelly and Aherne, 1980a). Other researchers have observed, however, that an increase in the dietary level of fibre decreased protein digestibility (Kass *et al*., 1980; Noblet and Perez, 1993). Li *et al.* (1994) and Lien (1995) reported cellulose negative effect on protein digestibility in pig. While Lenis *et al.* (1996) showed that higher level of NDF in a feed reduced protein digestibility, Moeser and van Kempen (2002) reported that lowering dietary NDF from 222 to 121 g/kg improved N digestibility by 13% (p<0.01). The results of this study support the findings that fibre, and more importantly, the source of the fibre negatively influenced the AD of CP, EE, and energy. Bell and Shires (1982) reported that the addition of high-fibre feedstuff reduced AD of DM, CF and NFE. Rerat (1978) reported that the digestibility of CF vary between 0 and 97 percent while Stanogias and Pearce (1985) showed that the extent of fibre digestibility depends predominantly on the origin of the fibre and to a lesser extent on the amount of fibre in the diet. It has also been reported that the capacity of the pig to digest and utilise fibre is affected by the source of the fibre (Ehle *et al*., 1982) and lignin content (Mitaru *et al.*, 1984). The AD of EE, NFE, Ca and P decreased with increasing BL in the diet. Just (1982) had reported that apparent fat digestibility decreased by 1.3 to 1.5 percent for each additional 1 percent of crude fibre in the diet. O'Doherty *et al.* (2002) reported that supplemented fat had no effect in diets with higher levels of CF (60 and 70 g/kg). Pond *et al.* (1962) reported that the apparent digestibility of nitrogen-free extract was significantly reduced by the addition of 12.4% corncobs to the ration. Wilfart *et al.* (2007) asserted that the influence of roughages on mineral availability is poorly elucidated. The results naturally depend on the amount and type of fibre used, and the extent to which the intake of minerals has been limiting. Literature reports also indicate contradictory effects of the impact of fibre on the mineral balance of the pig (Noblet and Perez, 1993; Le Goff and Noblet, 2001). However, the result of this study showed that AD of Ca and P decreased with increased dietary fibre level. Research findings have shown that high lignin concentration of NDF reduces digestibility of diet. Pigs do not digest lignin consequently; it depresses the rate and extent of fermentation by the gut microbes (Shi and Noblet, 1993; Johnston *et al.*, 2003).

The fibre levels in diets were also observed to have a diluting effect on the ration and the pig compensated for this effect by increasing the amount of feed consumed (Dinusson *et al.*, 1969). Kanis (1988) also reported lower growth rate (GR) from fibrous diets and a significantly high relationship between feed intake (FI) and GR. Fibre was observed to affect GR and feed conversion ratio (FCR) of the animals used in the study. The negative effect of fibre on AD of nutrients was noticed in the growth performance. The general view is that fibre in excess of 7 to 10% of the diet for growing pigs has an inhibitory effect on growth (Kass *et al.*, 1980). On the contrary, Dinusson *et al*. (1969) reported that added fibre in the ration (up to 14-16% total fibre) did not significantly affect weight gain unless the pigs were fed the high-fibre rations at an early age. The effect of FI on FCR in this study was found to be high, which corroborated the report of Kanis (1988) and Campbell *et al.* (1985). Contrary to the findings of this study, Adesehinwa *et al.* (2010) reported that graded levels of sun-dried on-farm generated poultry litter did not significantly influence daily weight gains and the efficiency of feed utilization of the growing pigs. The amount of digestible protein required per kilogram of weight gain differed with animals on diet 2 having a lower value of 0.6 kg than 0.7 kg for those on diets 1 and 3. The report of this study also supported the findings of Dinusson *et al.* (1969) that DEI was not affected by fibre level. Clawson *et al.* (1962) also found little correlation between rate or efficiency of gain and the protein-to-energy ratio. The Ca to P ratio of the test diets were 1.3: 1 for diet 1, 2.0: 1 for diet 2 and 2.3: 1 for diet 3. A suggested ratio of total Ca to-total P for grain–soybean meal diets is between 1:1 and 1.25:1. When based on available P, the ratio is between 2:1 and 3:1 (Jongbloed, 1987; Qian *et al.*, 1996). However, Prince *et al.* (1984) and Hall *et al.* (1991) observed that the ratio is less critical if the diet contains excess P. On the contrary, Reinhart and Mahan (1986) asserted that excess levels of Ca and P may reduce performance of pigs and the effect is greater when the Ca: P ratio is increased (NRC, 1998). This explains the poor performance that was observed in pigs on diet 3. There is the need to reduce the Ca level when formulating ration with broiler litter so as to maintain a balance, safe ratio.

The cost of feed (N216.8) consumed by pigs on diet 3 per kg weight gain was higher than N193.1 (10.9% reduction) for the pigs fed diet 2 and N194.4 (10.3% reduction) for those on diet 1. This supports the observation of Dinusson *et al.* (1969) that increasing the fibre content of the diet will result in more feed required per kilogram of gain. The result also showed that feeding BL above 30% to pigs within 20 to 60 kg was not cost effective. On the contrary, Aro and Tewe (2007) reported a lower feed cost per kilogram of diet from dried poultry waste diet and higher monetary returns per kilogram of meat produced while Adesehinwa *et al.* (2010) reported 14.48% and 25.06% reduction in the cost of feed to weight gain in diets replaced with 33% and 66% sun-dried on-farm poultry litter, respectively. The cost savings analysis showed that in terms of cost of feeding; there was significant reduction in feed cost by feeding BL at 15% to this category of pigs, but none in terms of performance.

Feeding of BL-based diet resulted in reduced backfat thickness (BFT). Previous findings have shown that higher levels of DE and protein in dry matter of feed mixtures did not favour economic expenditure of feed and cause large deposition of fat in carcasses. However, the addition of fibre (CF, NDF and ADF) to swine diets decreases the DE concentration of the diet (NRC, 1998), thereby reducing fat accretion as observed in this study. The effect of BW on BFT was removed by presenting the BFT relative to the BW at slaughter. This finding agreed with the reports of Adesehinwa *et al.* (2010); Aro and Tewe (2007), except that BFT was significantly affected in this study. Fat deposition is a reflection of the available energy in the diets. Shriver *et al.* (2003) observed that feeding high fibre diet improved carcass leanness due to the lower net energy (NE) content of the diet. High fibre diets given *ad libitum* usually cause reduced carcass fat measurements or increased carcass lean (Hochstetler, 1959). The higher fibre content of BL had no significant ($p>0.05$) effect on the weights of organs considered. Anugwa *et al.* (1989)

observed that diet composition plays a more specific role in visceral organ hypertrophy than can be explained by the normal relative changes in organ size as body weight increases. Sonaiya (1981) reported that slaughter weight had a highly significant effect on the weight of all organs. The results of this study showed that age rather than diet nor BW can influence visceral organ development. The observed differences in percent spleen may be due to an increased activity to resist pathogenic organisms by producing antibodies, being one of its functions in the body (Frandson, 1981).

Fontenot and Hancock (2001) reported that feeding of BL did not have any adverse effect on the carcass quality. Findings in this study indicated that diet had effect on body (muscle) composition. The inclusion of BL at 30% in the diets of G-F pigs gave higher moisture content of 3.8% than 3.3% and 3.5% observed in the muscles of pigs fed diets 1 and 2. The ash content of the muscles increased with increase in the level of BL in the diet. On the contrary, the content of EE and CP decreased with increase in the level of BL in the diet. The GE content of 5649 kcal/kg in the muscle of pigs fed diet 3 was lower than 6414 and 6263 kcal/kg in the muscles pigs fed diets 1 and 2 respectively. However, it is known that body composition represents the interaction of genetics, including hormonal and biochemical peculiarities, and the environment especially nutritional treatments. It serves as a criterion for the measurement of animal response to environmental treatments, especially those of nutritional nature (Sonaiya, 1984). Shelton (2004) concluded that protein deposition, fat deposition, and retained energy are increased when energy level is increased in the diet for growing swine, as observed in this study. In growing pigs, greater rates of N retention were associated with greater rates of feed efficiency because of the associated water deposition (Just, 1984). Contrary to the findings of Fortin (1982), the result of this study showed that the protein percentage in the carcass decreased ($p<0.0001$) with decreasing slaughter weight. Again, this may be adduced to the negative effect of high fibre in the diet of growing pigs, resulting in decrease nitrogen and energy utilization (Calvert, 1991).

Conclusions and Recommendations

Broiler litter, though not as palatable as most other feedstuffs (Fontenot and Hancock, 2001), was suitable for growing pigs, as an inclusion level of 30 % led to increased daily feed intake. Nutrient composition was high, although the availability was hindered probably due to a high fibre content. Important carcass parameters (hot carcass weight and dressing percentage) were, however, improved with broiler litter inclusion in the diets of growing-finishing pigs. Utilization of broiler litter as livestock feed could alleviate problems associated with its management as a farm waste, with a resultant positive effect on the environment.

Further studies are required to improve bioavailability and utilization of nutrients from broiler litter. Longer-term feeding trials to determine the optimum inclusion levels of broiler litter in the diets of different categories of pigs for optimum performance and economic returns are also required.

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