RESPONSE OF WEANER PIGS TO FIBRE FEEDSTUFFS SUPPLEMENTED WITH PROBIOTIC COMPLEXES

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ABSTRACT

This study was carried out to evaluate the effects of probiotic supplementation on the utilisation of fibre feedstuffs (corn bran (CB), palm kernel cake (PKC) and rice bran (RB)) by weaner pigs for growth and economics of production. Thirty-six crossbred (Large White x Hampshire) pigs of average weight 14.08±0.33 Kg were randomly distributed into six experimental diets. Diets 1, 3 and 5 contained 30% each of CB, PKC and RB respectively while commercial probiotics (Re3) were added at the recommended rate of 0.75 ml/kg of feed into diets 2, 4 and 6 with the same formulation as diets 1, 3 and 5. The experiment lasted for 28 d. Results showed a significant (p<0.05) increase in final body weight and average daily weight gain of pigs fed CB and RB-supplemented diets while those on PKC without probiotics had higher final body weight (27.50 Kg) and daily weight gain (473 g) than pigs on other dietary treatments. The pigs fed a PKC-based diet without probiotics had the best feed:gain (2.90) while those fed RB without probiotics performed the poorest (3.88). Also, the average daily feed intake was highest in PKC without supplementation (1.165 Kg/d) and least in RB with probiotics (0.947 Kg/d). The feed cost/kg gain was highest (₦1082.40) in RB with probiotics and least (₦811.59) in PKC without probiotics. It was concluded that, probiotics supplementation enhanced the performance of pigs fed CB and RB-based diets. Also, the feed cost kg^{-1} gain was better with pigs fed PKC with and without probiotics supplementation.

Keywords: ***fibre feedstuffs, probiotics, grower pigs, performance***

INTRODUCTION

Weaner pigs are challenged by their poor ability to digest more complex solid feed (fibre-rich diets) due to their improperly developed gut (Szabo *et al.*, 2023). This disturbance could aggravate other related crises such as decreased growth rate, poor feed efficiency, damaged intestinal function and post-weaning diarrhoea which could lead to economic losses (Guevarra *et al.*, 2019; Nguyen *et al.*, 2019). Several antibiotics have been used at therapeutic levels to control post-weaning-related challenges. However, the concerns for the development of antimicrobial resistance strains remained a contentious issue in the use of antibiotics. To this, least-cost alternatives such as probiotics are regularly being explored.

Probiotics are non-pathogenic live organisms, which, when administered in sufficient amounts, produce beneficial health effects on the host (FAO, 2001). Probiotic products may contain single or multiple strains of the bacterial species; *Bacillus* (*B. cereus* var. *toyoi*, *B. licheniformis*, *B. subtilis*), *Enterococcus* (*E. faecium)*, *Lactobacillus* (*L. acidophilus*, *L. casei*, *L. farciminis*, *L. plantarum*, *L. rhamnosus*), *Pediococcus* (*P. acidilactici*), *Streptococcus* (*S. infantarius*), and microscopic fungi such as yeasts *Saccharomyces cerevisiae* and *Kluyveromyces* (FAO, 2016; Dumitru *et al.*, 2018; Sorescu *et al.*, 2019). *Lactobacillus* and *Bacillus* are the most widely used probiotics and they have beneficial roles in balancing intestinal microbiota (Lessard *et* *al*., 2009*)*, improving digestive ability, growth and immunity in pigs *(*Zhang *et al*., 2023*;* Bugenyi *et al*., 2023*).*

Previous studies indicated a positive effect of *Lactobacillus* in weaning piglets (Huang *et al*., 2004; Yu *et al*., 2008; Wang *et al*., 2011; Chiang *et al*., 2015). For example, Ahmed *et al*. (2014) observed higher body weight gain in *Lactobacillus species* fed weaning piglets during the last 3 weeks of the experiment. Studies on *Bacillus* spp. as a direct-fed microbial supplement reported favourable results in a swine diet with beneficial effects on growth and feed efficiency (Leser *et al*., 2008; Wang *et al*., 2011; Link *et al*., 2016). In the study conducted by Liu *et al.* (2014), *Enterococcus faecalis* improved the efficiency of feed utilization and balanced the microbial environment in weaned piglets. Prieto *et al.* (2014) reported that spore suspension of *Bacillus pumilus* reduced the incidence of diarrhoea and improved growth performance post-weaning. *Lactobacillus reuteri* can also promote growth, reduce diarrhoea and regulate the immune system of pigs (Hou *et al.*, 2015).

Moreover, many studies have also shown that different probiotic complexes have various probiotic properties and can be used to improve the health status of weaned piglets. For instance, the combination of *Lactobacillus casei* and *Enterococcus faecalis* was found to significantly increase average daily gain and decreased diarrhoea rate and mortality (Su *et al.,* 2017). Also, supplementation with bacteria–yeast complex was shown to result in better growth performance and lower incidence of diarrhoea compared with supplementation with lactic acid bacteria alone (Giang *et al.*, 2010). Complexes of different strains of probiotics might be more beneficial to weaner pigs.

The objective of this study was to evaluate the effects of dietary probiotic complexes containing *Lactobacillus acidophilus, Bacillus subtilis and Saccharomyces cerevisiae* on growth performance and economics of production of weaner pigs fed different fibre feedstuffs.

MATERIALS AND METHODS

Experimental location, sources of feed ingredients and probiotics

The study was carried out at the Swine Unit of the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife. The feed ingredients were purchased in a reputable feed mill within Ile-Ife. The probiotics were produced by Best Environmental Technology 9610-39 Avenue Edmonton, Alberta, Canada T6E5T9. The active ingredients contained in the probiotics were *Lactobacillus acidophilus*, *Bacillus subtilis* and *Saccharomyces cerevisiae*.

Experimental diets, design, animals and management

Six experimental diets were formulated. Diets 1, 3 and 5 contained 30% each of Corn Bran (CB), Palm Kernel Cake (PKC) and Rice Bran (RB) without probiotics (-P) supplementation. Diets 2, 4 and 6 contained 30% each of CB, PKC and RB with probiotics (+P) supplementation. All the diets were balanced with other nutrients as shown in Table 1. The experimental design was a 3 x 2 factorial arrangement of three fibre sources (CB, PKC and RB) at two levels of (with or without) probiotics supplementations. A total of 36 growing crossbred (Large White x Hampshire) pigs of average initial body weight of 14.08±0.33 Kg were randomly allotted to the diets. In each of the dietary treatments, there were six animals housed in groups of two animals based on their body weight in a concrete floor pen. All routine and occasional management practices were carried out on a treatment basis. Pigs were allowed *ad libitum* access to water while feed was served at 4% body weight in concrete watering and feeding troughs respectively. The experimental duration was 28 days.

Data collection, chemical and statistical analyses

Data were taken on daily feed intake and daily weight gain was evaluated. The cost per kg of the diet was calculated by multiplying the percentage composition of the feedstuffs with the current price per kg of each feedstuff and was summed up. Total feed intake and cost per kg of feed were used to evaluate the total feed cost. Feed cost per kg weight gain was calculated using FCR and cost per kg of diet. The proximate composition of experimental diets was carried out following the procedure of AOAC (2006). Data were subjected to Analysis of Variance using the General Linear Model Procedure of SAS®. Means were separated using Duncan multiple range test at $p<0.05$.

Table 1: Composition of experimental diets fed weanling pigs

	Diets					
Ingredients (%)	**CB - P**	**CB + P**	**PKC - P**	**PKC + P**	**RB – P**	**RB + P**
Maize	40	40	40	40	40	40
Groundnut cake meal	15	15	15	15	15	15
Soybean meal	10	10	10	10	10	10
Corn bran- P	30	-	-	-	-	-
Corn bran + P	-	30	-	-	-	-
Palm kernel cake-P	-	-	30	-	-	-
Palm kernel cake+P	-	-	-	30	-	-
Rice bran-P	-	-	-	-	30	-
Rice bran +P	-	-	-	-	-	30
Fish meal	2	2	2	2	2	2
Bone meal	2.25	2.25	2.25	2.25	2.25	2.25
Salt	0.5	0.5	0.5	0.5	0.5	0.5
*Premix	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100
Calculated analysis						
Metabolisable energy (kcal/kg)	2846.8	2846.8	2949.8	2949.8	2690.8	2690.8
Crude protein (%)	19.55	19.55	19.85	19.85	21.65	21.65
Crude fibre (%)	5.82	5.82	5.97	5.97	8.22	8.22

CB: Corn bran; PKC: Palm kernel cake; RB: Rice bran; P: Probiotics; -/+: without/with

*Vitamin A: 10 000 IU, vitamin D3: 2 000 IU, vitamin E: 30 IU vitamin K3: 3 mg vitamin B1: 2 mg vitamin B2: 6 mg. Vitamin B3: 20 mg, vitamin B5: 13.5 mg, vitamin B6: 3 mg, vitamin B7: 0.06 mg, vitamin B9: 0.8 mg, vitamin B12: 0.05 mg, vitamin C: 10 mg, manganese 30 mg, iron: 110 mg, copper: 25 mg, zinc: 100 mg, iodine: 0.38 mg, selenium: 0.36 mg, cobalt: 0.3 mg, antioxidant: 60 mg per kg of the complete diet

RESULTS AND DISCUSSION

The crude protein contents of the experimental diets increased across treatment groups. The fractional rise between probiotics-free and the supplemented diet could be due to the enrichment of the bacteria species. The findings of this study agreed with those of Apata (2008), Zhang and Kim (2014) who found multi-strain commercial probiotics containing *L. acidophilus, B. subtilis and C. butyricum* as well as *L. bulgaris* improved crude protein digestibility. Also, the crude fibre contents of the probiotics-free and supplemented diets appear to increase across treatment groups. The values ranged between 4.80% and 14.02%. The highest and least values were found in probiotics free corn bran-based diet and probiotics supplemented rice bran-based diet. The rise could be due to the highly fibrous nature of rice bran.

The ash contents also appeared to increase with the least and highest value obtained in CB-P and RB+P diets. The increase could be due to the degradation of the bacteria microorganisms on the fibre diets. This corroborates the reports of Li *et al.* (2008) and Chawla *et al.* (2013) that different probiotic microbes produce different enzymes which could improve livestock nutrition in different ways. Similar trend was found for the ether extract contents of the diets. The *Lactobacillus* and *Streptomyces* species had been reported to improve the crude fat contents of fibre diets (Gheorghe *et al.,* 2020). The variations observed in the NFE values of the fibre diets with or without probiotics supplementation could be due to the variations observed in other proximate components.

Table 2: Proximate composition of experimental diets

Parameters (%)	DIETS					
	CB - P	**CB + P**	**PKC – P**	**PKC + P**	**RB – P**	**RB + P**
Dry matter	91.78	91.78	92.55	92.39	92.55	92.55
Crude protein	19.69	19.70	19.99	20.00	21.79	21.80
Crude fibre	4.80	7.59	11.00	10.57	13.29	14.02
Ash	6.64	6.31	6.42	7.00	9.72	12.24
Ether extract	5.90	5.20	4.60	6.19	4.92	5.34
Nitrogen free extract	62.98	61.22	58.00	56.26	50.29	46.62

-/+: without/with; P: probiotics; CB: Corn bran; PKC: Palm kernel cake; RB: Rice bran

The initial body weight of pigs fed experimental diets varied between 13.75 Kg and 14.67 Kg. The highest and least values were found in pigs fed CB-P and CB+P. Significant relationships ($p<0.05$) existed among fibre sources, the inclusion of probiotic supplementation and their interactions for final weight, daily gain and daily feed intake of pigs fed experimental diets. There was a rise in the values obtained for the final body weight of pigs fed probiotic complexes supplemented diets. The values ranged between 21.33 Kg and 27.50 Kg with the least and highest values found in pigs fed RB-P and PKC-P respectively. Also, there appeared to be a rise in the values obtained for the average daily weight gain of pigs fed experimental diets. Pigs fed PKC-P were 40.17%, 32.56%, 25.79%, 42.71% and 34.46% better than those fed CB-P, CB+P, PKC+P, RB-P and RB+P respectively. This could be due to the high gut-promoting effect of PKC reported in previous studies (Ogunjobi *et al.*, 2021; Towoju, 2021). Pigs fed CB+P and RB+P had 11.29% and 12.58% better daily gain over those fed CB–P and RB-P diets respectively. The rise in average daily weight gain of probiotics-supplemented diets could be due to microbial enrichment of the diets. Liu *et al.* (2017) and Su *et al.* (2017) found a significant rise (5.6% and 84.6%) in daily gains of pigs fed probiotic complexes of *Lactobacillus casei* and *Enterococcus faecalis* as well as three Lactobacillus strains. Kantas *et al.* (2015) in their study observed a 5% rise over a 42-d experimental period when *Bacillus toyonensis* was administered to the diets of weaning pigs. The variations in observed results may be due to the differences in microbial strains administered in the diets of pigs.

The average daily feed intake of pigs fed experimental diets improved (p<0.05) with probiotics enrichment except for the corn bran-supplemented diet. Pigs fed probiotics-enriched diets appeared to have lower intake compared to those fed untreated diets. The decrease could be due to the improvement in nutrient contents of the diets supplemented with probiotics. The findings of this study agreed with those of Lu *et al.* (2018) who fed probiotic complexes of *Enterococcus faecium, Bacillus subtilis* and *Saccharomyces cerevisiae* to weaning pigs and found significant improvement (p<0.05) in daily intake. A similar improvement in average daily intake was reported by Kantas e*t al.* (2015) on weaning pigs fed *L. toyonensis*.

There was a significant effect (p<0.05) of fibre source and inclusion of probiotics on the feed conversion efficiency of weaner pigs fed experimental diets. The feed-to-gain ratio of weaner pigs fed dietary treatments decreased with probiotics treatment of the experimental diets. The values ranged from 2.90 to 3.88. Pigs fed PKC-P had the least value and most efficient converter of feed while those fed RB-P had the poorest feed efficiency. This may be attributed to both the components (especially the ADF and cellulose) of the different sources of fibre and the prebiotic activity exhibited by the fibre sources (Ogunjobi *et al.,* 2021). All the pigs fed probiotics-supplemented diets had comparable (p>0.05) feed efficiency. Lu *et al.* (2018) observed comparable feed efficiency in weaning pigs fed two different probiotic complexes. A significant reduction in values was reported in studies conducted by Veizaj-Della *et al.* (2010) using *L. plantarum, L. fermentum and E. faecium* in diets of weaning pigs. Again, the reduction could be attributed to the nutrient-releasing capacity of the microbial-enriched diets.

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There were significant relationships (p<0.05) among fibre sources, probiotic supplementation and their interactions in the cost of feed and total cost of feeding of the experimental pigs. The cost of feed varies between ₦273.86 and ₦292.04. The PKC-P diet had the least while those of CB+P were the highest. The probiotics-enriched diets were 13.21%, 13.85% and 13.28% costlier than CB-P, PKC-P and RB-P diets respectively. The slight increase may be due to the additional cost of probiotic enrichment. The average cost of feed per day was similar for both probiotic-supplemented and non-supplemented diets. This may be attributed to the similar average daily intake of the experimental pigs. Also, the cost of feed per kilogram weight gain varied non-significantly with probiotic supplementation. Again, this is dictated by the average daily feed intake of pigs fed the experimental diets. Although pigs fed palm kernel cake-supplemented diets (PKC+P) had the lowest feed cost per kilogram weight gain, those fed CB+P and RB+P diets resulted in a higher cost per kilogram gain.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study, it can be concluded that probiotic complexes enhanced the performance of pigs fed CB and RB-supplemented diets and also reduced the feed cost per kilogram weight gain in CB and RB-enriched diets. However, the PKC-P diet promoted the fastest growth in weaner pigs fed the experimental diet.

Table 3: Growth performance of growing pigs fed fibre feedstuffs supplemented with probiotics

Parameters	CB-P	CB+P	PKC-P	PKC+P	RB-P	RB+P	FBR	INCL.	FBRxINCL.	±SEM
	DIETS									
Initial weight (Kg)	13.75	14.67	14.25	14.00	13.75	14.08	0.32	0.68	0.08	0.11
Final weight (Kg)	21.67^{d}	23.08^{c}	27.50^{a}	23.83^{b}	21.33^{d}	22.73^{c}	<0.001	0.04	<0.001	0.61
Average daily gain (Kg/d)	0.283^{cd}	0.319^{bc}	0.473^{a}	0.351^{b}	0.271^{d}	0.310^{bcd}	0.0001	0.012	0.0002	0.02
Average daily intake (Kg/pig/d)	0.999^{c}	0.953^{d}	1.165^{a}	1.110^{b}	0.967^{cd}	0.947^{d}	<0.001	0.02	<0.001	0.03
Feed:Gain	3.56^{ab}	3.35^{abc}	2.90^{c}	3.22^{bc}	3.88^{a}	3.24^{bc}	0.046	0.001	0.058	0.10

-/+: without/with; P: probiotics; CB: Corn bran; PKC: Palm kernel cake; RB: Rice bran; FBR: Fibre source; INCL: Inclusion of probiotics; FBR x INCL: Interaction effects of fibre source and probiotic inclusion.

Table 4: Cost analysis of growing pigs fed fibre feedstuffs supplemented with probiotics

Parameters	CB-P	CB+P	PKC-P	PKC+P	RB-P	RB+P	FBR	INCL.	FBRxINCL.	±SEM
	DIETS									
Cost of feed (₦/Kg)	279.88^{d}	292.04^{a}	273.86^{f}	285.73^{c}	278.97^{e}	291.06^{b}	<0.0001	0.03	<0.0001	1.99
Total feed intake (Kg)	26.68^{d}	27.97^{c}	32.62^{a}	31.08^{b}	27.08^{d}	26.52^{d}	<0.0001	0.17	<0.0001	0.70
Daily feed intake (Kg)	1.00	0.95	1.17	1.11	0.97	0.95	0.65	0.54	0.76	0.05
Total cost of feeding (₦)	7467.20^{c}	8168.36^{b}	8933.31^{a}	8880.50^{a}	7554.51^{c}	7718.91^{bc}	<0.0014	0.001	0.002	186.99
Average cost of feed/day (₦)	266.90	291.73	319.05	317.16	269.80	275.68	0.15	0.88	0.19	8.04
Feed cost/ kg weight gain (₦)	996.37	978.33	811.59	920.05	1082.40	943.03	0.81	0.25	0.89	54.67

1USD = ₦438; = -/+: without/with; P: probiotics; CB: Corn bran; PKC: Palm kernel cake; RB: Rice bran; FBR: Fibre source; INCL: Inclusion of probiotics; FBR x INCL: Interaction effects of fibre source and probiotic inclusion

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