

WEIGHT GAINS AND ECONOMY OF PRODUCTION OF WEANER PIGS FED DIETS CONTAINING FERMENTED MIXTURE OF CASSAVA ROOT PULP AND PALM KERNEL CAKE AS REPLACEMENT FOR MAIZE.

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ABSTRACT

The need to improve the nutritive value of feed materials containing high levels of non-starch polysaccharides (NSPs) such as lignin, cellulose, mannan among others for monogastric feeding has led to interest in solid state fermentation (SSF) in recent years. In this study, the efficacy of SSF to improve nutritive value of mixture of grated cassava roots and palm kernel cake for pig feeding was evaluated using 40 unsexed crossbred (Large White X Nigerian Indigenous) weaner pigs. The pigs were randomly allotted to five treatment groups and fed experimental diets in which the maize in the control diet was partially (50%) or completely replaced with either solid state fermented mixture of grated cassava root and palm kernel cake (FEMCARPP) or a 1:1 blend of cassava meal and palm kernel cake (CSM-PKC). Data were collected weekly on the live-weight, weight gain, feed intake and feed conversion ratio, and efficiency of protein utilization. The pigs on dietary FEMCARPP consumed significantly ($p < 0.05$) less feed (222.45g) but had superior weight gain (95.92g/day) and similar feed conversion ratio (2.32) when compared to the pigs fed maize based control diets (246.33g, 79.80g and 3.09 respectively). On the other hand, pigs fed dietary CSM-PKC consumed significantly ($p < 0.05$) more feed (283.06g) and were less efficient in utilizing their feed. It is therefore concluded that solid state fermentation improved the nutritive value of mixture of grated cassava roots and palm kernel cake for swine feeding. Further research is however needed to extend the study to growing-finisher phase and to understand the physiological mechanism of the improved performance of the piglets on dietary FERMCAAPP.

Key words: solid state fermentation, cassava, palm kernel cake, weaner pigs, performance indices, returns on investment.

INTRODUCTION

In many countries of sub-Saharan Africa (SSA), there is an increasing demand for and use of unconventional feeding materials to replace maize as feeding materials for pigs. This demand rose primarily due to increasing cost of maize grains in a region which have scarcely produced enough grains to feed its growing population, and meet the needs of her industries for brewing, etc. (Uchegbu et al., 2011; Amata, 2014). The increased use of some of these materials such as cassava by-products and palm kernel cake, wheat offal, fruit processing waste, etc. (Adesehinwa, 2009), has not only created value for but has also reduced environmental pollution resulting from the indiscriminate disposal of these seemingly waste products of agricultural processing in the environments (Wadhwa et al. 2015). The use of these nonconventional feed materials in monogastric feeding is however limited by poor digestibility due to their high

contents of NSPs. To sustain the positive outcomes resulting from their use, it has become necessary to develop technologies and products which will improve their digestibility and hence nutritional value. One of such technologies is fermentation. The use of fermented feeds as a biosafe method of improving the quality of feeds for animals has been reported (Brooks *et al.*, 2008; Niba *et al.*, 2009a). These fermented feed materials are usually rich in lactic acid bacteria (LAB) and short chain fatty acids (SCFAs) which may confer on them some probiotic potentials (Niba *et al.*, 2009a, Niba *et al.*, 2009b). The advantages of solid-state fermentation over submerged fermentation in improving nutritive quality of feed for pigs have been reported (Choi *et al.*, 2011a). Solid state fermentation (SSF) is one in which the microbes are cultured on a moist solid in near absence of free-flowing water. The efficacy of solid-state fermentation in improving nutritive quality of feed materials for pigs have been reported (Choi *et al.*, 2011a). In our previous studies, we have successfully demonstrated that a solid-state fermented mixture of freshly grated cassava roots and palm kernel cake have physicochemical characteristics similar to maize (Aladi *et al.*, 2013), and the product can successfully replace maize in broiler chicken diets without any deleterious effect of carcass and meat quality of broilers and pigs (Aladi 2016, Aladi et al., 2017; Chukwukaelo *et al.*, 2018). In this study therefore, the efficacy of the solid-state fermented mixture of grated cassava roots and palm kernel cake for replacing maize in diets of growing pigs was evaluated using economics of production and performance indices.

MATERIALS AND METHODS

Experimental animals and design

A total of 40 (20 intact males and 20 females) crossbred (large White x Nigerian Indigenous) piglets farrowed at the Teaching and Research Farm of the Federal University of Technology, Owerri, Nigeria, were used for the experiment. The piglets were weaned at 35 days of age with mean weight 4.53 ± 0.13 Kg and stabilized for one week prior to the experiment. During this period, the piglets were fed a maize-soybean based creep diet formulated to provide 21 % crude protein and 2508 Kcal/kg. At 40 days of age, they were prophylactically treated for ecto and endo parasites by subcutaneous administration ivermectin (Ivomec®) at 0.05 ml/kg live weight. At 42 days of age, they were randomly assigned to the five treatment groups of 4 males and 4 females each. Two piglets of the same sex within a treatment were housed and fed together in a pen with dimensions (2m x 2.5 m). The feeding trial lasted for 6 weeks (from 42nd to 85th day of age).

Feed raw material and diets formulation

The FEMCARRP was produced following the method described by Aladi *et al.* (2013). The PKC was pulverized by running it on a locally fabricated hammer mill with sieve size of 0.2 mm and then mixed with freshly grated cassava tubers in a ratio of 1:3 (w/w). The mixture was then transferred into high density polyethylene bags, compressed to exclude as much air as possible and then sealed. The mixture was allowed to ferment for six (6) days before use. Five experimental weaner diets were formulated as shown in Table 1. Diet A (control) contained 44 % maize and in diets B and C, the maize was replaced with 50% and 100% FEMCARPP, respectively. In diets D and E, maize was replaced with 50 % and 100%, respectively, of a 1:1 blend of cassava root meal and palm kernel cake (CRM-PKC). To ensure the moisture content of

all the experimental diets was similar, an amount of water equivalent to the weights of maize in diet A was added to diets A, D and E while half the same amount was added to diet B prior to feeding.

Growth performance

The pigs were weighed individually at the beginning of each week; each treatment group was allowed a daily supply of feed equivalent to 5% of their total body weights. All feed left over was collected in the evening (6.30 pm), air dried and weighed and the difference between the feed given and the weight of feed leftover was calculated. Data was collated on weight gain, feed intake, and feed conversion ratio on replicate basis

Table 1: Ingredients and calculated chemical composition of swine weaner diets

Test Material Diets (Replacement level of maize)	Maize	FEMCARPP		CSM-PKC mix	
	A (0%)	B (50%)	C (100%)	D (50%)	E (100%)
Maize	44.00	22.00	0.00	22.00	0.00
Cassava meal	0.00	0.00	0.00	11.00	22.00
Palm Kernel Cake	0.00	0.00	0.00	11.00	22.00
FEMCARPP	0.00	22.00	44.00	0.00	0.00
Soya bean meal	20.00	20.00	20.00	20.00	20.00
Wheat offal	28.00	28.00	28.00	28.00	28.00
Fish meal	4.00	4.00	4.00	4.00	4.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Mineral / Vitamin premix*	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated chemical composition					
Crude protein (%)	19.64	20.96	22.15	19.86	20.08
Metabolizable energy (Kcal/kg)	2461.04	2262.45	2063.85	2391.74	2322.44
Crude fibre	5.34	7.17	8.99	9.53	13.72
Calcium	1.29	1.34	1.39	1.34	1.39
Phosphorus	1.17	1.27	1.37	1.27	1.37
Lysine	0.95	1.08	1.22	1.08	1.22
Methionine	0.27	0.37	0.47	0.37	0.47

FEMCARPP- Fermented mixture of grated cassava tubers and palm kernel cake *Premix formulated to supply per kg diet: Vit. A 10,000,000 IU; Vit. D3 2,000,000 IU; Vit. E 8,000 IU; Vit. K 2,000 mg; Vit. B1 2,000 mg; Vit. B2 5,500 mg; Vit. B6 1,200 mg; Vit. B12 12 mg; biotin 30 mg; folic acid 600 mg; niacin 10,000 mg; pantothenic acid 7,000 mg; choline chloride 500,000 mg; Vit. C 10,000 mg; Iron 60,000 mg; Mn 80,000 mg; Cu 8,00 mg; Zn 50,000 mg; iodine 2,000 mg; cobalt 450 mg; Selenium 100 mg; mg 100,000 mg and antioxidant 6,000 mg

The cost of feed was determined by multiplying the quantity of each ingredient in the feed composition table with the prevailing market price per kilogram. The ingredient costs were summed up and divided by 100 to get the cost per Kg of the diet. The later was then multiplied by quantify of feed consumed by experimental animals to get the cost of feed per treatment diet. The Gross Income (Ending Investment) was estimated by multiplying the mean live weight of animals in each treatment by the average price per Kg liveweight of pigs. The average price per kg liveweight was estimated by sampling market price. Since cost of feed is usually 60% of the cost of production, the later was estimated as cost of feed consumed multiplied by 1.67. Margin (Gain or Loss) was estimated as the difference between the Ending Investment

(income) and the Opening Investment (cost of production). The Returns on Investment (ROI) was calculated using he formulae

$$ROI = \frac{\text{margin}}{\text{Opening Investment}} \times 100\%$$

$$\text{simple Annual ROI} = \left\{ (1 + ROI)^{\frac{1}{n}} \right\} \times 100$$

Where n is, the period of investment (2 months for weaner pigs)

The compound annual ROI, the rate of return that represents the cumulative effect that a series of gains or losses has on an Original Investment over the period of time, was calculated

using the software, Financial Calculator version-v3.1.3 (Bishinews fncalculator.com)

Experimental Design and Data Analyses

At the end of the experiment, data generated were subjected to analysis of variance (ANOVA) in a Completely Randomized Design (CRD). Significantly different means were separated using Least Significant Difference method (LSD) as described by Little and Hills (1974). The weekly performance data were plotted against age to show the trends in performance indices.

RESULTS AND DISCUSSION

The performance of experimental weaner pigs fed diets containing maize, FEMCARPP and CSM-PKC mix are shown in Table 2. The final live weights (kg) of pigs fed diets containing FEMCARPP (9.86 and 9.42) were significantly higher ($p < 0.05$) than those fed maize based diets (8.56) which was in turn superior to those fed dietary CSM-PKC mix (7.92 and 8.03). Similar pattern was also observed for the average daily weight gain of the experimental pigs. The weekly live weights of pigs in all treatment groups increased progressively with age (Figure 1). The plot of mean weights gained (Figure 2) shows that weaner pigs fed dietary FEMCARPP were consistently superior to those on dietary maize (control) and CSM-PKC based diets. Pigs on the CSM-PKC based diet consumed significantly ($p < 0.05$) more feed (283.06 g) than the control (246.33 g) which in turn consumed more than those fed FEMCARPP (222.45 g)

based diets. Pigs fed diets in which maize was partially replaced (50%) consumed significantly ($p < 0.05$) more feed than those in which maize was completely replaced by FEMCARPP. The feed conversion ratio of the pigs on dietary maize (control) (3.09) was similar ($p > 0.05$) to those fed FEMCARPP based diets (2.68 and 2.32), and both were superior to those fed the CSM-PKC based diets ($p < 0.05$). The live weights and average daily weight gains of the experimental pigs are shown in Figures 1 and 2, respectively. Though the pigs fed diets containing FERMCAAP had higher weight gains throughout the experiments, the values were least at the first week of the experiment all experimental groups. Though pigs fed diets in which maize was completely replaced by FEMCARPP consumed the least amounts of feed throughout the experimental period (Figure 3), they were consistently more efficient in utilizing their feed (Figure 4).

The economics of feed utilization of the experimental pigs are shown in Table 3. The replacement of maize with either FEMCARPP or CSM-PKC mixture in the pig's diets reduced the cost of feed from N128.95 in diet A (control) to N113.55 in diet C (FERMCAP) and N110.25 in diet E (CSM-PKC). At the same inclusion levels, the diets containing the CSM-PKC were cheaper than those containing FERMCAAP. Partially replacing maize with FERMCAAP (Diet B) increased the cost of feed consumed and hence the cost of production. The gross margin and ROI values of pigs fed diets C (100% replacement of maize) were superior to those on the other treatments

Table 2: Performance of weaner pigs fed FEMCARPP or mixture of PKC and cassava root meal as replacement for maize

Test Material Diets (Replacement level of maize)	Maize	FEMCARPP		CSM-PKC mix		SEM
	A (0%)	B (50%)	C (100%)	D (50%)	E (100%)	
Initial live weight (Kg)	4.66	4.80	4.72	4.66	4.91	0.154
Final live weight (kg)	8.57 ^c	9.86 ^a	9.42 ^b	7.92 ^e	8.03 ^d	0.133
Average daily weight gain (g/d/pig)	79.80 ^c	103.27 ^a	95.92 ^b	66.53 ^d	63.67 ^d	4.219
Average daily feed intake (g/d/pig)	246.33 ^b	276.33 ^c	222.45 ^a	294.49 ^c	283.06 ^c	10.32
Feed conversion ratio	3.09 ^a	2.68 ^a	2.32 ^a	4.43 ^b	4.45 ^b	0.231

^{a, ..., d}- values within a row with different superscripts are significantly different ($p < 0.05$)

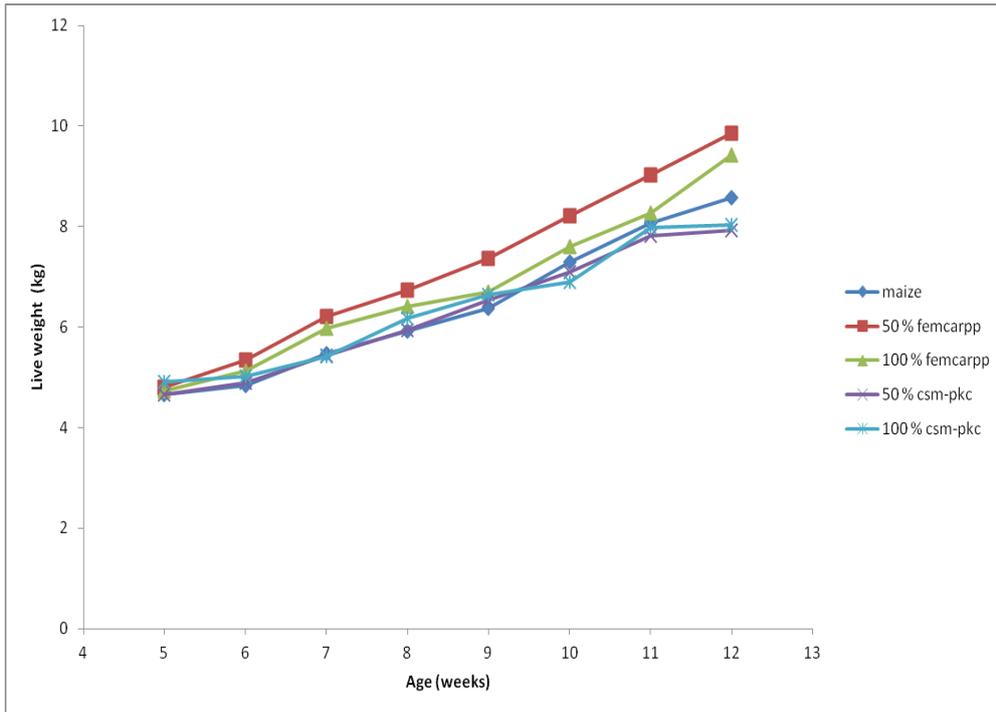


Figure 1: Graph of live weight of weaner pigs fed experimental diets against age

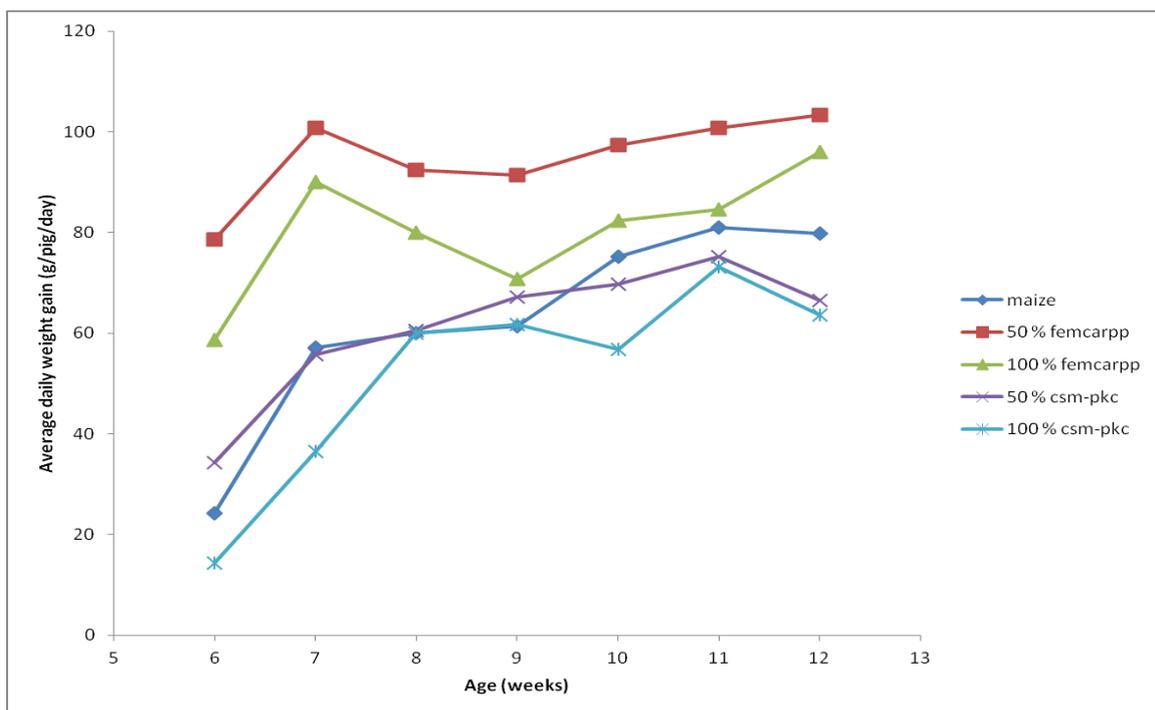


Figure 2: Average daily weight of pigs fed experimental ratios with age

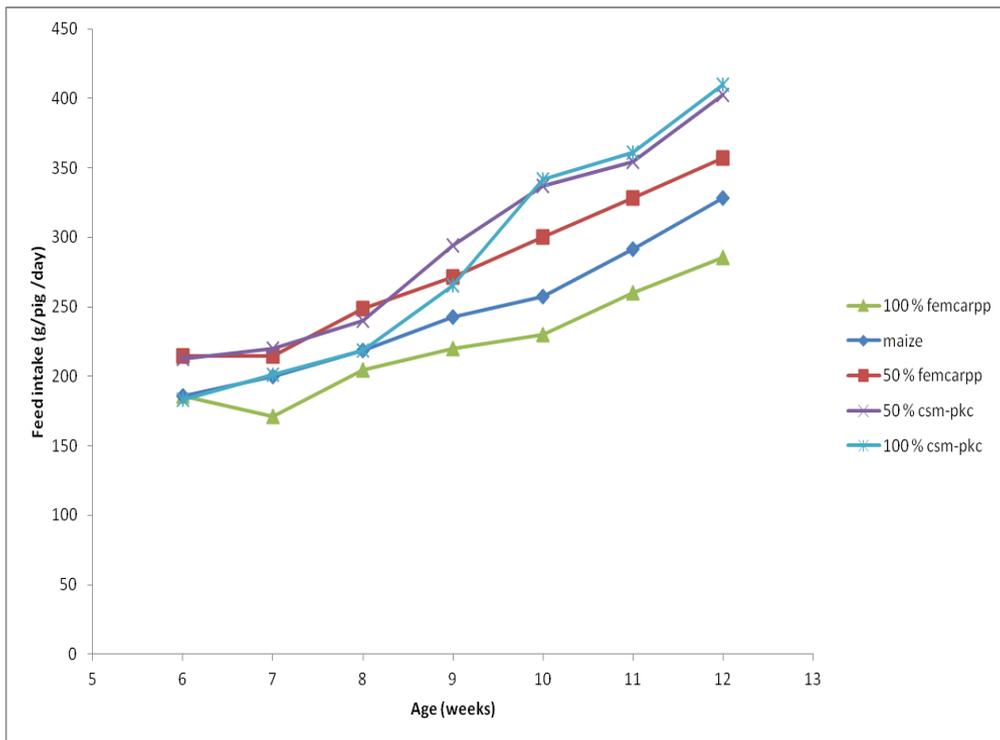


Figure 3: Graph of average daily feed intake of weaner pigs fed experimental rations plotted against age

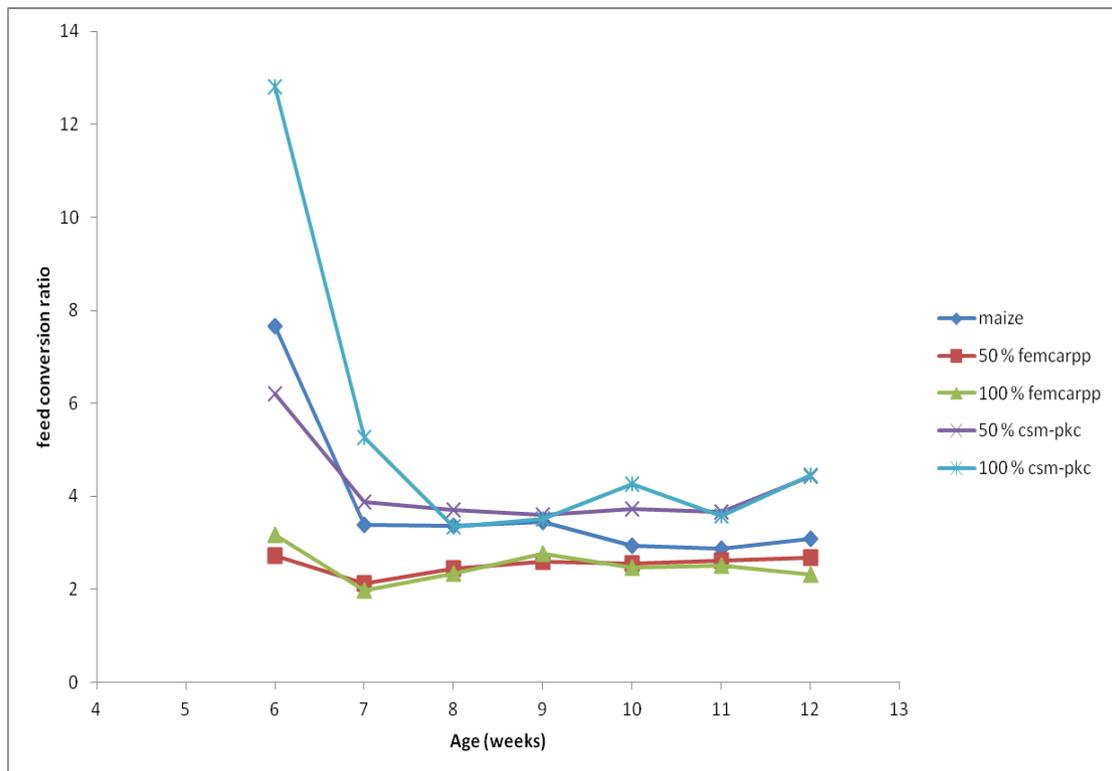


Figure 4: Graph of feed conversion ratio of weaner pigs fed experimental diets plotted against age

Table 3: Cost analysis (₦) and estimated returns on investment of weaner pigs fed FEMCARPP or mixture of PKC and cassava root meal as Replacement for Maize

Test Material	Maize	FEMCARPP		CSM-PKC mix	
		A (0%)	B (50%)	C (100%)	B (50%)
Diets (Replacement level of maize)					
feed cost (N/kg)	128.95	121.25	113.55	119.60	110.25
feed consumed	13794.48	15474.48	12457.20	16491.44	15851.36
Cost of feed consumed	1778.80	1876.28	1414.52	1972.38	1747.61
Cost of production	5929.33	6254.27	4715.05	6574.59	5825.37
Feed cost per kg weight gain)	398.46	324.95	263.44	529.83	490.61
Income ¹	8000.00	8000.00	8000.00	8000.00	8000.00
Gross margin	2070.67	1745.73	3284.95	1425.41	2174.63
Return on Investment (ROI) (%)	34.92	27.91	69.67	21.68	37.33
Simple Annual ROI (%)	139.69	111.65	278.68	86.72	139.32
Compound Annual ROI (%)	231.39	167.70	728.73	119.22	255.69

¹ based on farmgate price for grower pigs of similar weights

The superior performance of weaner pigs fed diets containing FEMCARPP over those fed diets containing CRM-PKC mix indicates that SSF has the capacity to improve digestibility and nutrients utilization of the mixture. The physicochemical characteristics of the mixture of grated cassava roots and palm kernel cake, reduction in cyanogenic glucosides levels and microbial/enzymatic degradation of structural polysaccharides in PKC must have contributed to the higher nutrients' turnover from FEMCARPP. SSF of mixture of grated cassava and PKC have been reported to increased crude protein content from 10 to 17 % and positively enhanced particle size distribution in the final product (Aladi *et al.*, 2013, Aladi, 2016). Increased solubilisation of non-starch polysaccharides and reduction of anti-nutritive effects have been reported to occur in solid state fermented feed materials (Svanberg and Orri, 1997; Marini *et al.* 2008), which in turn increase nutrient digestibility and uptake by animals. Ramin *et al.* (2010) have reported that, treatment of PKC with microbes such as fungus and bacteria have positive effects on digestion of fibre in pigs.

Though the diets containing FEMCARPP had lower apparent metabolizable energy content than the control diets, performance of weaner pigs on diets containing the former was superior to the control. The superior FCR values shown by weaner pigs on FEMCARPP at the end of the first week of the experiment (Fig. 4) is a pointer to the possible physiological mechanism for the improved performance. According to Suiryanrayna and Ramana (2015), a growth lag phase usually occurs in pigs post weaning due to limited digestive and absorptive capacity due to insufficient production of hydrochloric acid, pancreatic enzymes and sudden changes in feed consistency and intake. The microbes implicated in the spontaneous SSF of the mixture of grated cassava and PKC; *Aspergillus oryzae*, *A. niger*, *Rhizopus spp.*, *Lactobacillus plantarum* and *Bifidobacterium spp.* (Aladi, 2016) have been reported to possess probiotic activity (Heres *et al.*, 2003; Niba *et al.*, 2009a, Niba *et al.*, 2009b). The improved FCR in animals on FEMCARPP based diets could

also be attributed to their possible probiotic effect on the intestinal gut microflora and environment. This result agrees with the earlier findings of Chukwukaelo *et al.* (2017) who found improved performance and Aladi *et al.* (2017) that found that the population *Salmonella spp.* and *E. Coli* was lower in the gut of broiler chickens fed FERMCAAPP based diets. According to Lawal *et al.* (2010), fungal SSF of PKC produced enzyme complexes capable of breaking down the cellulose and hemicelluloses and Hu *et al.* (2008) reported that feeding a diet containing solid-state fermented feed resulted to similar performance and nutrient digestibility in growing-finishing pigs fed regular diet with antibiotics. Multi-microbe probiotics prepared by SSF has been to be effective in improving performance, enhancing beneficial gut microflora and reducing harmful gut microflora in pigs (Choi *et al.*, 2011ab; Kim *et al.*, 2017).

The higher cost of feed consumed by pigs on diet B, in which maize was partially replace by FERMCAAPP was principally due to higher quantity of feed consumed by pigs placed on the experimental diet. The pigs on diet B had higher average daily feed intake (276.33 g/day) relative to those fed the control (maize based) diet A (246.33 g/day). Since the diets containing FERMCAAPP were better utilized by the experimental pigs, this resulted in lowered cost per Kg body weight gain and hence superior returns on investment indices. The margin and ROI values of pigs fed diets containing CSM-PKC were comparable to the control, suggesting that though the later had superior growth performance indices, the return on the farmers investment will not be affected and hence resource poor farmers are likely to prefer CSM-PKC over maize as dietary source of energy.

CONCLUSION AND RECOMMENDATION

These results strongly suggest that though using a mixture of cassava and palm kernel meals in a ratio of 1:1 may yield similar economic returns for weanling pigs, the use of solid-state fermented mixture of grated cassava roots and palm kernel cake (FEMCARPP) will yield superior performance

and economic benefit for the farmer. It is therefore recommended that resource poor pig farmers in Sub Saharan African countries can use the technology to optimize performance of their stock and profitability of their farm operations. More studies are however needed to understand the physiological basis of the improved performance of weaner pigs on FEMCARPP based diets.

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