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Effects of pro-vitamin A cassava peel meal on growth performance and nutrient digestibility of weaned pigs

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ABSTRACT: An eight-week study was conducted to determine the effect of graded levels of cassava peel meal obtained from pro-vitamin A variety (PVACPM) on growth performance and nutrient digestibility of weaned pigs. Twenty-four male large white pigs, aged eight weeks, with an average weight of 9 kg, were allotted to four dietary treatments of six animals per treatment in a completely randomised design, involving four levels (0,10,20 and 30%) of PVACPM. Treatments were replicated three times with two pigs per replicate. Experimental diets were fed daily, and data were collected for feed intake and weight gain. During week eight of the feeding trial, three pigs were randomly selected per treatment, housed in metabolic cages for a seven-day digestibility trial. There were significant (p<0.05) differences among treatment means in terms of average final weight, average daily weight gain, average total weight gain, average daily feed intake and average total feed intake. The efficiency of feed utilisation was significantly (p<0.05) improved in pigs fed (Treatment 3) diets containing 20% PVACPM. Nutrient digestibility studies also revealed significant (p<0.05) differences across treatment means in parameters such as dry matter, crude fibre, crude protein, ether extract and nitrogen-free extract. Dry matter and crude fibre were significantly (p<0.05) higher in treatment 1 and lower in treatment 4, crude protein was significantly (p<0.05) higher in treatment 1 and 2 which was comparable with treatment 3 and lower in treatment 4, ether extract was significantly (p<0.05) higher in treatment 1 which was comparable with treatment 2 and lower in treatment 4, while nitrogen free extract was significantly (p<0.05) higher in treatments 1 and 3 which was also comparable with treatment 2. It was concluded that up to 20% PVACPM (Treatment 3) can be included in weaned pigs' diets for enhanced growth performance and nutrient digestibility.

Keywords: Alternative feedstuff, food security, new cassava variety, pigs, protein supply, sustainable production.

INTRODUCTION

The world's population is rapidly increasing, imposing food security challenges, particularly for developing countries (Tavershima *et al*., 2022). Reports of Thornton (2010) indicate that economic growth has also increased the demand for livestock products, putting pressure on the livestock sector to produce more with limited resources. Reports of some authors (Godde *et al*., 2021; Bamaiyi, 2013) show that the livestock sector is one of the fastest-growing agricultural sectors, contributing about 40 per cent of the global value of agricultural production, supporting the livelihood and food security of about 1.3 million people. The use of locally available cheap alternative feed ingredients to feed livestock species that are adapted for their utilisation with optimal growth and high rate of turnover could help to bring down the cost of production, increase animal products and consequently boost the supply of animal protein for the teeming populace (Zijlstra and Beltranena, 2022).

Cassava peels, the ultimate waste of cassava processing, have been reported to serve as an alternative energy source for pigs and other animals depending on the level of inclusion (Oke *et al*., 2017; Poultry World, 2013; Irekhore *et al*., 2006). Despite the consistent incorporation of cassava peels in swine nutrition, there is a dearth of information on the utilisation of the newly improved pro-vitamin A cassava variety as a source of energy for pigs. The proximate composition of pro-vitamin A cassava peels shows the material contains significant amounts of moisture, crude protein, crude fibre, crude fat, and ash. The peels also provide a substantial amount of nitrogen-free extract and metabolizable energy (Jiwuba *et al*., 2021). While the peels contain some essential amino acids, reports by Jiwuba *et al*. (2021) identified histidine and tyrosine as the most limiting amino acids; other essential amino acids like lysine, leucine, methionine, and isoleucine were also found to be present but in relatively low concentrations. Magnesium and iron were identified as the most abundant minerals; minerals like calcium, phosphorus, and potassium were also present in the cassava variety (Jiwuba *et al*., 2021). The use of cassava peel meal from other cultivars as an alternative energy source, though cost effective, is limited by high fibre, low protein, deficiency in some vitamins and minerals as well as the presence of the antinutritional factor cyanide (Aro *et al*., 2020; Bakare *et al.,* 2012). Report of Jiwuba *et al*. (2016) indicates low levels of cyanide, higher levels of crude protein and richness in carotenoids in the new pro-vitamin A cassava roots. Against this backdrop, the present study was designed to evaluate the effect of graded levels of cassava peel meal obtained from pro-vitamin A variety on growth performance and nutrient digestibility of weaned pigs.

MATERIALS AND METHODS

The study was conducted at the pig production unit of SKM® livestock farm located at kilometre 5, Gboko Road, Makurdi, Benue State, Nigeria. Makurdi is located on latitude 7°44'N and longitude 8°54'E. in the Southern Guinea Savannah Region of Nigeria (Annon, 2004; Weather Spark, 2025).

Experimental materials

Cassava peels from pro-vitamin A variety were collected fresh from garri processing units in Makurdi town, washed to remove silica adherents and sun-dried for seven days during the dry season to reduce the moisture content to about 10% or less and detoxify of cyanide content (Aro *et al*., 2020). The peels were ground to particle sizes of 2 mm using a hammer mill, sampled for analysis and stored in bags for incorporation into the diets.

Experimental diets

Four experimental diets designated as T1, 0% Pro-Vitamin A Cassava Peels Meal (PVACPM), served as the control, T2, 10% PVACPM, T3, 20% PVACPM, and T4, 30% PVACPM were formulated. The percentage composition of the diets is shown in Table 1.

Experimental design and management of pigs

A total of twenty-four (24) male weaned pigs (Large White Breed) aged eight (8) weeks were used in a study that lasted for eight (8) weeks. Pigs were randomly assigned to four dietary treatments of six animals each in a CRD design involving four levels (0, 10, 20, and 30%) of PVACPM.

Each treatment group was replicated three times with two pigs per replicate and housed on concrete-floored pens measuring 2 m x 4 m, lined with deep litter material. Prior to the commencement of the experiment, the pigs were dewormed against endo and ecto parasites by subcutaneous injection of ivermectin using the recommended dosage. Pigs were fed a weighed quantity (4% of body weight of pigs) of the experimental diets daily, and drinking water was available through nipple drinkers.

Data collection

The mean weekly body weights and feed intake were recorded throughout the experimental period of eight weeks. Pigs were fed a weighed (4% of body weight) amount of the experimental diets, and the leftover feed was collected every morning and weighed. The leftover was subtracted from the initial quantity offered to determine the actual feed intake per day. Pigs were also weighed at the beginning of the experiment to obtain the initial body weight and subsequently weighed weekly. At weekly weight measurements, the previous weekly weight was subtracted from the current weekly weight to obtain the weekly weight gain and the average daily weight gain was determined by dividing the weekly weight gain by the number of days in a week (7days), as illustrated below;

$$\text{Average Body Weight Gain} = \frac{\text{Final Weight} - \text{Initial Weight}}{\text{Number of Days}}$$

Feed conversion ratio was calculated by dividing the amount of feed intake by body weight gain, as illustrated below;

$$\text{Feed Conversion Ratio} = \frac{\text{Feed Intake}}{\text{Body Weight Gain}}$$

The dietary cost and feed cost/kg gain were calculated from prevailing market prices of feed materials. This was

Table 1. Percentage composition of weaned pig diets Containing PVACPM.

Ingredients	Levels of PVACPM (Dietary Treatments)			
	T1 (0 %)	T2 (10%)	T3 (20%)	T4 (30%)
Maize	35.00	35.00	35.00	27.00
Full-fat Soybean	20.00	22.00	23.00	24.00
PVACPM	0.00	10.00	20.00	30.00
Groundnut Cake	7.00	8.00	9.00	10.00
Maize Offal	20.00	16.00	5.00	3.00
Rice Bran	14.90	5.90	4.90	2.90
Bone Meal	2.00	2.00	2.00	2.00
Common Salt	0.50	0.50	0.50	0.50
Vit/Mineral Premix	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
DL-Methionine	0.10	0.10	0.10	0.10
Total	100	100	100	100
Dietary cost N/Kg	302	300	300	267
Calculated Nutrients				
ME (MJ/kg)	12.82	12.53	12.38	12.18
Crude Protein (%)	18.04	18.04	18.13	18.26
Crude Fiber (%)	6.33	5.86	5.46	5.81
Ether Extract (%)	7.69	7.71	8.15	8.43
Lysine (%)	1.02	1.06	1.07	1.08
Methionine (%)	0.32	0.32	0.33	0.31
Calcium (%)	1.22	1.27	1.30	1.33
Phosphorus (%)	0.58	0.60	0.60	0.59

∗premix supplied the following per kg of diet: vitamin A 12000000IU, vitamin D_3 3000000IU, vitamin B6 3500mg, Biotin 80mg, Antioxidant 125000mg, Cobalt 250mg, Selenium 250mg, iron 40000mg, Manganese 7000mg, Copper 80000mg, Zinc 80000mg, Choline Chloride 200000mg, Calcium 10000mg, Viatimin B_2 5000mg, Vitamin B_1 2000mg, Iodine 1200mg, Niacin 40000mg, Vitamin E 30000mg, Vitamin K 32500mg, Folic Acid 1000mg PVACPM = Pro-Vitamin A Cassava Peels Meal, ME = Metabolizable Energy.

done by calculating the cost/kg of each ingredient used based on the prevailing market prices at the time of the experiment and multiplying by their levels of dietary inclusion, while feed cost/kg gain was calculated as the cost/kg diet multiplied by the feed conversion ratio.

Nutrient digestibility study

A nutrient digestibility study was conducted during the last week of the eight-week experimental period. Three pigs were randomly selected from each dietary treatment (one pig per replicate) and starved for 18 hours. Each replicate pig was housed in a separate metabolic cage. A weighed amount of 4% of the body weight of pigs was offered daily to each pig, and faecal samples were collected daily for seven days. Samples were oven-dried at 105°C for 24 hours, and the dried weight was obtained. Samples from each replicate were pooled, ground and analysed for Dry Matter (DM), Crude Protein (CP), Crude Fibre (CF) and Ether Extract (EE) according to methods outlined by the Association of Analytical Chemists (AOAC, 2005). Nitrogen-Free Extract (NFE) was calculated as 100 - (% moisture + % ash + % CP + % EE + % CF). Coefficient of digestibility was then computed as follows;

$$\text{ANDC} = \frac{\text{Nutrient infeeds} - \text{Nutrient in faeces}}{\text{Nutrient in feeds}} \text{x } 100$$

Where: ANDC = Apparent Nutrient Digestibility Coefficients.

Chemical analysis

Feed and faecal samples were analysed for their proximate components- moisture, crude fibre, crude protein, and ether extract using standard methods (AOAC, 2005).

Ethical statement

Weaned pigs used for this study were humanely handled and cared for in accordance with the United States

Department of Agriculture (USDA) pain and distress category C. This involves no more than momentary or slight pain or distress and no use of pain-relieving drugs, just routine procedure and injections. In this study, pain and distress of weaned pigs included: holding or weighing animals in teaching and research activities, routine physical examination, observation of animal behaviour, routine management, treatment of endo and ecto parasites and feeding studies which do not result in clinical health problems.

Statistical analysis

All data collected were subjected to a one-way analysis of variance (ANOVA) using the procedure of Steel and Torrie (1980) and Statistical Package for Social Sciences (SPSS) version 21. Where significant differences were observed, treatment means were separated using Duncan's New Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical composition of cassava peel meal (PVACPM)

The chemical composition of PVACPM is shown in Table 2. As shown in Table 2, the DM (92.57%), NFE (76.82%), and ME (12.11MJ/kg) content of PVACPM used in this study were higher than values of 91.09%, 62.18% and 11.13MJ/kg, respectively, reported by Torhemen (2017) for the white cassava cultivar. Similarly, the CP value of 4.38% was also higher than the CP values of 3.1, 2.3 and 2.1% reported by Adesehinwa *et al.* (2011), Otache *et al.* (2017) and Torhemen (2017), respectively, for the white cassava cultivar. This could be due to the biofortification of the pro-vitamin A cassava roots, which produced the peels that were used in the present study. However, in comparison to the chemical composition of PVACPM used in the present study, lower values of DM (89.67%), NFE (52.20%) and ME (9.71 MJ/kg) were reported by Jiwuba *et al.* (2021) for the same cassava cultivar. Differences in chemical composition may be attributed to the age of cassava root tubers used in the studies and the soil fertility. Higher values of the chemical composition of PVACPM used in this study may represent a positive effect, indicating the richness of the test material. The result is corroborated by reports of AOAC (2005), which states that high values of NFE in a feed material typically indicate a high concentration of non-structural carbohydrates, such as starches and sugars, which are readily digestible. This can have several implications on animal nutrition, including potential effects on feed intake, energy availability, and overall animal performance. Values of CP (4.38%), CF (6.78%), Ash (3.99%) and EE (0.60%) were lower than values of 7.68%, 17.67%, 9.46% and 2.64% respectively, reported by Jiwuba *et al.* (2021) for the same cassava cultivar. The observed differences may be attributed to the differences in the age of cassava root tubers, processing method of the peels and or the soil fertility.

Table 2. Chemical composition and metabolizable energy of PVACPM.

Parameters	Proximate components (%)
Dry matter	92.57
Crude protein	4.38
Ash	3.99
Ether extract	0.60
Crude fibre	6.78
Nitrogen-free extract	76.82
Energy (MJME/kg)	12.11

Chemical composition of experimental diets

The chemical composition of experimental diets is shown in Table 3. As shown in Table 3, the chemical composition of experimental diets indicate that weaned pigs received adequate nutrients to support growth as evident in the values of DM, CP and ME which were above 90%, 20% and 11MJ/Kg respectively and CF value of below 8% as recommended by NRC (1997) for weaned pigs.

Effect of the experimental diets on the growth performance of weaned pigs

The effect of the experimental diets on the growth performance of weaned pigs is presented in Table 4. Results revealed that pigs fed diets containing 0% PVACPM had significantly (p<0.05) higher average final weight (AFW), average daily weight gain (ADWG) and average total weight gain (ATWG), which was comparable with pigs fed diets containing 10 and 20% PVACPM. Average daily feed intake (ADFI) and average total feed intake (ATFI) of pigs fed diets containing 30% PVACPM were significantly (p<0.05) higher, with the ATFI value being comparable with the pigs fed diets containing 0% PVACPM. This was probably due to the effect of the level of PVACPM, which increased the bulk of the feed, thereby lowering the energy density of the diets and causing an increase in total feed intake and feed conversion ratio in the group of pigs fed diets containing 30% PVACPM. The result of this present study corroborates reports of several authors (Obongekpe *et al*., 2022; Torhemen *et al*., 2018; Adesehinwa *et al*., 2011) who reported that an increase in cassava peel meal levels will increase feed bulkiness and consequently lower the energy content of the diet, thereby influencing total feed intake. Pigs fed diets containing 30% PVACPM had a higher feed conversion ratio (FCR, 3.2) value than pigs fed diets containing 20% PVACPM (2.4).

Table 3. Chemical composition of experimental diets.

Proximate components	Cassava peel meal inclusion			
	T1 (0 %)	T2 (10%)	T3 (20%)	T4 (30%)
Dry matter (%)	90.30	90.45	90.51	90.82
Ash (%)	8.37	10.98	10.23	10.89
Crude protein (%)	23.05	21.00	22.75	21.00
Ether extract (%)	7.38	8.28	6.44	5.72
Crude fibre (%)	7.73	7.01	6.30	7.82
Nitrogen-free extract (%)	43.77	43.18	44.79	44.31
*Metabolizable energy (MJ/kg)	12.41	12.34	12.18	11.59

*= ME MJ/kg = (3.5 x protein) + (8.5 x fats) + (3.5 x nitrogen free extract) x 4.184 (Source = Atwater and Benedict, 1902)

Table 4. Effect of graded levels of pro-vitamin A cassava peel meal on growth performance of weaned pigs.

Parameters	Levels of PVACPM (Dietary Treatment)				SEM	*p*-values
	T1 (0 %)	T2 (10%)	T3 (20%)	T4 (30%)		
Number of pigs	6	6	6	6	-	-
Average Initial Weight (Kg)	9.67	9.83	9.75	10.08	0.43	0.991
Average Final Weight (Kg)	22.83^{a}	22.58^{ab}	21.83^{b}	20.83^{c}	0.90	0.000
Average Daily Weight (Kg)	0.24^{a}	0.21^{ab}	0.22^{ab}	0.19^{c}	0.01	0.032
Average Total Weight Gain (Kg)	13.17^{a}	11.67^{ab}	12.08^{ab}	10.75^{c}	0.77	0.031
Average Daily Feed Intake (Kg)	0.58^{b}	0.52^{c}	0.53^{c}	0.60^{a}	0.02	0.001
Average Total Feed Intake (Kg)	32.57^{ab}	29.60^{c}	29.74^{c}	33.29^{a}	1.19	0.022
Feed Conversion Ratio	2.5^{b}	2.5^{b}	2.4^{c}	3.1^{a}	0.16	0.000
Feed Cost N/kg of gain	776	777	738	849	1.83	0.551

$^{a-c}$Means on the same row with different superscripts are significantly (p<0.05) different, Means on the same row without superscript are not significantly different (p>0.005), SEM =Standard Error of Mean.

However, the FCR of pigs fed diets containing 0% and 10% PVACPM was intermediate, which implies that the efficiency of feed utilisation was significantly (p<0.05) best for pigs fed diets containing 20% PVACPM. This can be attributed to the biofortification of the cassava root tuber which might have increased the nutritive value of cassava peel meal obtained from the test material. Findings of the present study are in line with reports of (Jiwuba and Jiwuba, 2024; Jiwuba *et al*., 2021) who attributed the improved performance of growing rabbits fed PVACPM-based diets to the enrichment of the cassava root tubers with pro-vitamin A. Similarly, reports by some authors (Torhemen *et al*., 2018; Adesehinwa *et al*., 2011) also revealed that the use of cassava-based diets, especially in weaned pigs, will require enzyme supplementation for enhanced feed utilisation by the animals since this group of pigs are still young and lacks the digestive framework to digest fibrous diets. However, this present study showed efficient feed utilisation by pigs fed 20% PVACPM inclusion without an exogenous enzyme supplementation. This performance could also be attributed to the chemical composition of PVACPM, enabling the pigs to handle the level (20%) of fibre in the diets being evaluated. The enhanced chemical compositions in pro-vitamin A cassava peels, as reported by Jiwuba *et al*. (2021), show PVACPM is rich in nitrogen-free extract and metabolizable energy, which may influence the digestibility of these nutrients and consequently the efficiency of feed utilisation. Findings of this study corroborate reports of some authors (Jha and Mishra, 2021; Li *et al*., 2018) who reported that age plays a significant role in fibre utilisation due to the fact that young animals at this stage are tender and lack the digestive framework to handle fibrous diets. Result of this present study indicates that experimental pigs were more comfortable with the 20% PVACPM inclusion, hence the evidence in the efficiency of feed utilisation experienced by pigs fed treatment 3, which were diets containing 20% PVACPM and also the significantly high to comparable nutrient digestibility by pigs fed PVACPM diets. The effects of experimental diets on the digestibility of weaned pigs is presented in Table 5. Digestibility studies revealed a significant (p<0.05) decrease in DM and CF digestibility across treatment groups as levels of PVACPM increased in pig diets. This can be attributed to the increase in fibre

Table 5. Effect of graded levels of pro-vitamin A cassava peels meal on nutrient digestibility of weaned pigs.

Levels of PVACPM	Levels of PVACPM (Dietary Treatment)				SEM	*p*-value
	T1 (0 %)	T2 (10%)	T3 (20%)	T4 (30%)		
Dry matter	89.218[a]	80.382[b]	78.636[bc]	72.626[c]	1.979	0.002
Crude Fiber	91.151[a]	74.980[b]	62.182c	57.675[c]	4.119	0.000
Crude Protein	94.677[a]	92.695[a]	88.836[ab]	84.984[b]	1.393	0.032
Ether Extract	92.481[a]	81.922[ab]	73.503[b]	26.454[c]	7.825	0.000
Nitrogen Free Extract	85.181[a]	81.215[ab]	84.723[a]	73.600[b]	1.725	0.029

[a- c]Means on the same row with different superscripts are significantly (p<0.05) different, SEM =Standard Error of Mean..

as the level of PVACPM increases across treatment groups. The result of this present study is in line with reports of some authors (Thacker, 2001; Jha and Miishra, 2021) who reported that the extent and consistency of animal response to diets are related to the age of the animal and the dietary fibre level. CP digestibility significantly (p<0.05) improved in pigs fed diets containing 0% and 10% PVACPM, which was also comparable with the pigs fed diets containing 20% PVACPM. EE digestibility of pigs fed diets containing 0% PVACPM was also significantly (p<0.05) higher and comparable with the pigs fed diets containing 10% PVACPM. Similarly, NFE digestibility of pigs fed diets containing 0% and 20% PVACPM was significantly (p<0.05) improved and comparable with the pigs fed diets containing 10% PVACPM. This can be attributed to the improvement in the nutritional value of the cassava roots due to the presence of pro-vitamin A. The results of this study are in line with the results of Jiwuba *et al.* (2021), who reported enhanced chemical compositions in pro-vitamin A cassava peels, particularly CP and EE. The abundance of these nutrients in the improved cassava variety may have increased their digestibility. Although the feed cost analysis shows no statistical (p>0.05) difference across treatment groups, the result of this present study, indicating efficient nutrient utilisation by pigs fed diets containing 20% PVACPM is corroborated by the least feed cost/kg weight gain experienced by this group of pigs, thus forming the basis for the conclusion and recommendation.

Conclusion

The nutritional value of any feed material can be evaluated through chemical analysis, digestibility study and animal feeding trial. Based on the results obtained in this study, it can be concluded that up to 20% cassava peel meal originating from pro-vitamin A cultivar can be used as an energy source in weaned pigs' diets for enhanced growth performance and nutrient digestibility.

Further studies may include a comparison between the pro-vitamin A cassava variety and other cassava varieties, especially the consistently used white variety (generally reported to be efficient in pig nutrition when supplemented with exogenous enzymes, though it incurs additional total production cost), to establish the efficient utilization of cassava peel meal originating from pro-vitamin A variety even without supplementation.

CONFLICT OF INTEREST

The authors declare no conflict of interest in the collection, analysis, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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