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Growth Performance, Nutrient Digestibility and Ceacal Microbial Population of Weaned Pigs Fed Maize Cob-Cassava Peel Mixture as Partial Replacement for Maize

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This study was carried out to determine the growth performance, nutrient digestibility and ceacal microbial population of weaned pigs fed maize cob-cassava peel mixture as partial replacement for maize. A total of 32 cross bred weaned male pigs were stratified based on their body weights into four treatments of eight pigs each in a completely randomized design. Animals in treatment 1 (T1) were fed 0 % maize cob-cassava peel mixture (CPMCM) while CPMCM was used to replace maize at 10 %, 20 % and 30 % in T2, T3 and T4 respectively. Feed and clean water were offered to pigs throughout the experiment that lasted for 60 days. Results obtained revealed that average daily weight gain, average daily feed intake, feed conversion ratio and mortality were not significantly (P>0.05) influenced by the treatments. Nutrient digestibility of crude protein, crude fibre, ether extracts, dry matter and nitrogen free extract were not significantly (P>0.05) different among the treatment. Microbial population of Escherichia coli and Lactobacillus sp were significantly (P<0.05) different among the groups. Conversely, Salmonella sp and Micrococcus luteus counts were not significantly (P>0.05) different among the treatments. It was concluded that CPMCM can be used to replace maize up to 30 % in the diet of weaned pigs without causing any deleterious effect on the performance of animals.

1. Introduction

Rising feed cost and competition between human and animals for food items strongly suggest that alternative energy sources should be used partially or wholly to replace maize in livestock diet to reduce cost of meat production and to make available the major cereals for human consumption (Ngou and Mafeni, 1983; Adesehinwa et al., 2011). In developing countries, labour is cheap and climatic conditions require simple and inexpensive housing for pigs but feed cost is the most important component accounting for 60 to 75 % of total production cost (Alagbe, 2019).

The bulk of the feed cost arises from conventional feedstuffs such as maize, wheat, groundnut cake, fishmeal and soybean meal amongst others (Adesehinwa, 2016; Fanimo et al., 2006). Prices of these conventional feedstuffs have soared so high in recent times that it is becoming uneconomical to use them in swine feeds (Njoku et al., 2013). According to Alagbe and Daniel (2023), most experiments on pig nutrition simply deal with the substitution of one ingredient by another but making sure of maintaining a well-balanced diet. This situation warrants the evaluation of agricultural by-products (nonconventional feeds) and incorporation of suitable ones in pig feeds (Moghazy and Elwatak, 1982; Unigwe et al., 2017). This is one of the solutions to increase the supply of animal protein. Pig production should be supported with efficient techniques of incorporating locally available agricultural by-products. The use of agricultural by-products in poultry nutrition represents valuable means of the indirect production of food from waste (El Boushy and Vanderpoel, 2000). There is the need therefore to look for locally available and cheap sources of feed ingredients particularly those that do not attract competition in consumption between humans and livestock (Alagbe, 2019).

These agricultural byproducts, maize cobs and cassava peels, possess the potential to be used as replacement feed ingredients; however, the low amounts of protein and high levels of anti-nutritional elements, like cyanide, oxalate, and saponin in cassava peels, limit their suitability for feeding animals with monogastric stomachs (Anakebe, 2006). Conversely, maize cobs have minimal nutritional value and are inadequate suppliers of protein, minerals, and vitamins (Akinfemi et al., 2009). Bumbie et al. (2021) carried out a research to ascertain the impact of feeding corncobs to weaner pigs on performance. Maize cob was used to replace maize at 25 % and the outcome of the experiment revealed that average intake and total intake did not change significantly ($p > 0.05$) across treatments. Olufemi et al. (2021) used ten crossbred male pigs to examine the feed value of processed and enzyme-supplemented cassava peel in developing pigs. The basal diet (BD), BD + fermented cassava peel (FCP), BD + retted cassava peel (RCP), and BD + unprocessed cassava peel (UCP) and with (UCP+E) enzyme addition.

There was no significant (P>0.05) improvement in the energy values of the diets UCP+E, FCP, and RCP. The findings showed that pigs' utilisation of CRP can be enhanced by both retting and enzyme supplementation; however, retting is less expensive than providing a multi-enzyme mix in the diet of the pigs.

Despite the extensive research on the effect of dried cassava peel meal on the performance of pigs. Presently, there is insufficient information on the effect of maize cob-cassava peel mixture as partial replacement for maize in pigs. This work will further address the challenges of protein insufficiency and reduce the competition for maize and other conventional feedstuffs between human and animals.

2. Research Method

Location of the experiment

This study was conducted at the University of Abuja Teaching and Research Farm, Main Campus, along Airport Road, Gwagwalada, Abuja, Nigeria; the Department of Animal Science, Faculty of Agriculture. Gwagwalada, situated between latitudes 8^o57^1 and 8^o55^1N and longitudes $7^o\ 05^1$ and $7^o\ 06^1$E, serves as the headquarters of the Gwagwalada Area Council. Within the Federal Capital Territory (FCT) are six (6) area councils, one of which is Gwagwalada. With a population of more than 157,770, Gwagwalada is the largest settlement in the study area and one of the FCT's fastest expanding urban centres. It is also the third largest urban centre and one of the major satellite towns (NPC, 2006).

Obtaining and getting ready test materials

Fresh corn cobs and cassava peels were gathered from several Gwagwalada processing facilities. For a duration of 14 days, the samples were exposed to sunlight in order to lower their anti-nutritional factors and prevent microbial responses that could cause spoiling and nutrient leaching. After being individually ground into meals in a hammer mill, the dried cassava peels and maize cobs were brought into the laboratory for additional examination.

Procedures before the experiment

For the experiment, standard pen dimensions of 2.0 m × 1.5 m × 1.2 m were employed. Two weeks prior to the start of the experiment, pens were cleaned with Morigad. Water and feeding troughs were cleaned thoroughly, and pens were marked for convenience of identification. In order to maintain appropriate biosecurity, a foot bath was also supplied at the pen's entrance.

Experimental animals, design and management

32 male piglets that had been weaned and were 8 weeks old were purchased from a reputed farm in Abuja. The animals were placed in quarantine for a period of two weeks, given a basal diet designed to fulfil the nutritional needs of weaned pigs in accordance with the NRC's (2002) recommendation, and given preventive treatment, which included injections of long-acting oxytetracycline at a rate of 1 mL/10 kg body weight and subcutaneous Ivermectin® at a rate of 0.25 mL/12.5 kg of body weight to control ecto and endo parasites. Pigs were divided into four treatment groups according to their body weight, and each treatment was fully randomized and repeated three times with three animals in each replicate. Feeding was place twice a day at 8:00 and 16:00, and everyday access to clean, fresh water was provided. All other management procedures were rigorously followed during the three-month duration of the investigation.

Experimental diets

Four experimental diet were formulated to meet the nutrient requirements for swine according to NRC (2002). Enzyme supplemented sundried cassava peel and maize cob meal (CPMCM) at ratio 1:1 was incorporated into the experimental diet to replace maize as follows: treatment 1 (T1) control diet (0 % CPMCM), T2 (10 % CPMCM with enzymes), T3 (20 % CPMCM with enzymes), T4 (30 % CPMCM with enzymes) as presented in Table one.

Data collection

The following data were collected and determined over a period of twelve weeks.

Intake of feed (kg)

Every day, the pigs in each treatment group had their feed given to them and their leftover feed weighed. By calculating the disparities between the amount of feed that was initially given and what was left over, the daily feeds consumed were ascertained. By dividing the total amount of feed consumed by the total number of pigs in each replicate, the weekly records of average feed consumed for each replicate were acquired.

Body weight gain (BWG)

Body weight gain was calculated by subtracting the final body weight from the initial body weight.

BWG (kg) = Final body weight (kg) – Initial body weight (kg)

Average body weight gain (kg)/pig (ABWG)

$$\text{ABWG (kg)} = \frac{\text{Final body weight of replicate (kg)} - \text{Initial body weight of replicate (kg)}}{\text{Number of pigs in the replicate}}$$

Average daily feed intake (ADFI)

Average daily feed intake was calculated by dividing the daily feed intake of the replicate by the number of pigs in the same replicate.

$$\text{ADFI (g)} = \frac{\text{Daily feed intake of the replicate}}{\text{Number of pigs in the replicate}}$$

Feed conversion ratio (FCR)

Feed conversion ratio (FCR) was calculated by using the formula below:

$$\text{FCR} = \frac{\text{Feed consumed (g)}}{\text{Body weight gain (g)}}$$

Trial of nutrient digestibility

On the twelfth week of the experiment, a nutrient digestibility trial was conducted. Two pigs were chosen from each replicate pen, for a total of six pigs per treatment. The pigs spent seven days getting acquainted to their new surroundings in wire-bottomed cages. Throughout the experiment, the pigs received clean water and a certain amount of meal every day for seven days. Feed consumption was calculated by daily subtracting the amount of feed supplied from the weight of the leftover feed. For seven days, faeces were gathered, dried, and then properly blended. Contaminants were carefully removed and the faeces stored in containers. Samples were subsequently oven dried at 80 ^{o}**C** and taken for proximate composition in the laboratory using the methods described by Association of Analytical Chemist (AOAC, 2000). The percentage digestibility was calculated using the equation below:

$$\text{Nutrient digestibility} = \frac{\text{Nutrient intake (DM)} - \text{Nutrient output (DM) in the faeces}}{\text{Nutrient intake (DM)}} \times 100$$

Microbial examination of the caecal materials

Caecal samples were taken for microbiological analysis from six pigs per treatment (those utilised for carcass evaluation) during the 12th week of the trial. To identify the caecal bacteria, examination was done using a Microplate Reader (DR – 200 BC – LED bulb). Samples were combined with salt water and incubated for eight hours at 35 degrees Celsius. The parameters of the equipment include the following: ambient temperature range of 15 to 40 o C; input voltage of 100 to 200 VAC at 50 to 60 Hz; output voltage of 24 VAC with direct current; visible chamber made of OG550 glass filter; LED protector made of transparent polycarbonate with a 1. 4462 stainless steel body and lever.

Proximate composition of experimental diet and test ingredients

Proximate composition of experimental diet and test ingredients were carried out according to the standard laboratory procedures outlined by AOAC (2000).

Statistical analysis

All the data collected were statistically analyzed using the General Linear Model Procedure of Statistical Analysis (SAS, 2002) software package. Significant difference between treatments means were separated by Duncan's Multiple Range Test.

The model used for this design is as follows: Yij = + ti + eij Where Yij = Individual observation. = Overall mean. ti = Effect of treatment diets. eij = Experimental error

Table 1: Ingredient and chemical composition of the experimental diets (%DM)

Ingredients	T1 (0 %)	T2 (10 %)	T3 (20 %)	T4 (30 %)
Maize	55.00	49.50	44.00	38.50
Wheat offal	6.97	6.97	6.97	6.97
Soya beans	24.00	24.00	24.00	24.00
Groundnut cake	7.00	7.00	7.00	7.00
CPMCM	0.00	5.50	11.00	16.50
Bone meal	3.00	3.00	3.00	3.00
Limestone	1.50	1.50	1.50	1.50
Methionine	0.20	0.20	0.20	0.20
Lysine	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25
Enzymes	0.00	0.03	0.03	0.03
Salt	1.80	1.80	1.80	1.80
Total	100.0	100.0	100.	100.0
Determined analysis (%)				
Crude protein	18.30	18.00	17.90	17.80
Crude fibre	4.00	4.38	4.50	4.71
Ether extract	3.00	2.92	2.90	2.87
Calcium	0.45	0.45	0.45	0.45
Phosphorus	0.30	0.30	0.30	0.30
Energy (Kcal/kg)	2601.8	2558.7	2556.0	2550.1

* vitamin A, 13,000 I.U., vitamin E, 5 mg, vitamin D3, 3000 I.U., vitamin K, 3 mg, vitamin B2, 5.5 mg, niacin, 25 mg, vitamin B12, 16 mg, choline chloride, 120 mg, Mn, 5.2 mg, Zn, 25 mg, Cu, 2.6 mg, folic acid, 2 mg, Fe, 5 mg, pantothenic acid, 10 mg, biotin, 30.5 mg, and antioxidant, 56 mg are provided as premix per kg diet.

3. Result and Discussion

The test components' chemical makeup

Table 2 displays the approximate content of the test substances. The content of cassava peel included dry matter (85.13 percent), energy (2796.3 Kcal/kg), acid detergent fibre [ADF] (31.0 %), neutral detergent fibre [NDF] (40.2 %), crude protein (3.87 %), crude fibre (13.84 %), ether extract (1.87 %), ash (5.7%). Dry matter (87.50%), crude protein (2.10%), crude fibre (15.17%), ether extract (0.63%), ash (4.20%), ADF (33.4%), NDF (43.7%), and energy (1200.7 Kcal/kg) for maize cob. The enzyme mixture of cassava peel, and maize cob meal shows the following: ether extract (2.11%), ash (7.23%), crude protein (6.00%), crude fibre (12.05%), dry matter (89.02%), NDF (38.5%), ADF (29.12%), and energy (3308.7 Kcal/kg).

Weaned piglets' growth performance when fed a dry mixture of cassava peel and maize cob in place of maize

Table 3 shows the growth performance of weaned pigs fed a mixture of dried maize cob and cassava peel in place of maize. The initial weight, final weight, weight gain, average daily weight gain, total feed intake, average daily feed intake, and feed conversion ratio have varied, ranging from 6.07 - 6.09 kilogramme, 19.80 - 21.96 kilogramme, 14.72 - 15.89 kilogramme, 0.16 - 0.17 kilogramme, 30.09 - 30.97 kilogramme, 0.46 - 0.47 kilogramme, and 2.60 - 2.85 kilogramme, respectively. There were no significant differences ($P>0.05$) in any of the values between the treatments. Moreover, there was no observed mortality during the trial ($P>0.05$).

Nutrient digestibility of weaned pigs fed maize cob-cassava peel mixture as partial replacement for maize

Nutrient digestibility of weaned pigs fed maize cob-cassava peel mixture as partial replacement for maize is presented in Table 4. Values of dry matter, crude protein, crude fibre, ether extract, organic matter and nitrogen free extract digestibility varied from 70.80 – 72.12 %, 65.00 – 66.21 %, 32.00 – 33.67 %, 55.01 to 56.44 %, 62.71 – 63.67 % and 47.00 – 47.18 % respectively. All the values were not significantly ($P>0.05$) influenced by the diets.

Caecal microbial population of weaned pigs fed maize cob-cassava peel mixture as partial replacement for maize

Table 5 represent the caecal microbial population of weaned pigs fed maize cob-cassava peel mixture as partial replacement for maize. *Lactobacillus spp* and *Escherichia coli* population were significantly (*P*<0.05) different among the treatments. Conversely, *Staphylococcus spp*, *Salmonella spp* and *Micrococcus luteus* population were not significantly (P>0.05) affected by the treatments.

Table 2: Chemical composition of test ingredients

Specifications	Cassava peels	Maize cob	CPMCM + enzyme
Dry matter (%)	85.13	87.50	89.02
Crude protein (%)	3.87	2.10	6.00
Crude fibre (%)	13.84	15.17	12.05
Ether extract (%)	1.87	0.63	2.11
Ash (%)	5.10	4.20	7.23
ADF (%)	31.0	33.4	29.12
NDF (%)	40.2	43.7	38.5
Energy (Kcal/kg)	2796.3	1200.7	3308.7

CPMCM: Cassava peel – maize cob meal; ADF: Acid detergent fibre; NDF: neutral detergent fibre

Table 3: Weaned pigs' growth performance on dried maize using a mixture of cob and cassava peel in place of maize (CPMCM)

Specifications	T1	T2	T3	T4	SEM
Initial weight (kg/pig)	6.08	6.07	6.09	6.07	0.21
Final weight (kg/pig)	20.80	21.25	21.96	21.62	0.80

Weight gain (kg/pig)	14.72	15.18	15.87	15.89	0.75
Av. daily wgt gain (kg/pig/day)	0.16	0.17	0.17	0.17	0.01
Total feed intake (kg/pig)	41.97	41.80	41.33	41.09	1.72
Av. daily feed intake (kg/pig/day)	0.47	0.46	0.46	0.46	0.02
Feed conversion ratio	2.81	2.81	2.80	2.80	0.04
Mortality (%)	0	0	0	0	-

SEM: standard error of the mean; T1: 0 % CPMCM; T2: 10 % CPMCM; T3: 20% CPMCM; T4: 30% CPMCM

Table 4: Nutrient digestibility of weaned pigs fed maize cob-cassava peel mixture as partial replacement for maize

Specifications (%)	1	2	3	4	SEM
Dry matter	72.12	70.80	71.45	70.90	0.69
Crude protein	66.21	65.18	65.00	64.87	0.42
Crude fibre	33.67	33.08	32.19	32.00	0.30
Ether extract	56.44	54.20	55.01	55.22	0.41
Nitrogen free extract	47.18	47.12	47.10	47.00	0.23

SEM: standard error of the mean; T1: 0 % CPMCM; T2: 10 % CPMCM; T3: 20% CPMCM; T4: 30% CP MCM

Table 5: Caecal microbial population of weaned pigs fed maize cob-cassava peel mixture as partial replacement for maize

Specifications (Cfu/g)	T1	T2	T3	T4	SEM
Lactobacillus sp.	2.18[c]	3.00[b]	3.95[a]	4.01[a]	0.04
Escherichia coli	3.30[a]	1.72[b]	1.50[b]	1.43[b]	0.01
Staphylococcus sp.	1.78	1.56	1.53	1.51	0.01
Salmonella sp.	3.36	3.10	3.04	3.00	0.03
Micrococcus luteus	1.44	1.42	1.40	1.31	0.01

[a,b,c]Means in a row without a similar superscripts differ (P<0.05); SEM: standard error of the mean; T1: 0 % CPMCM; T2: 10 % CPMCM; T3: 20% CPMCM; T4: 30% CPMCM

Discussion

At the conclusion of the experiment, processed cassava peel-maize cob mixture (CPMCM) incorporation had no discernible ($p>0.05$) impact on average daily weight gain, average daily feed intake, feed conversion ratio and mortality rate. This result suggests that the animals were able to utilize CPMCM when replaced with maize up to 30 %. Drying of cassava peels in the experiment could also prevent the interference of nutrient absorption in the gut of pigs giving room for efficient enzymatic production (Alagbe et al., 2023). Mortality was no recorded in all the treatments indicating that animals were raised under a good and hygienic conditions. The outcome of this experiment was consistent with the findings of Ojediran *et al*. (2022), who found no evidence of a substantial impact on the performance indices of weaned pigs when fermented high quality cassava peel was used to replace maize at 100 %. Additionally, Ly *et al*. (2010) found no discernible effects on final body weight, average daily gain, or feed conversion ratio (FCR) of dried and ensiled cassava leaf in the diet of cross bred weaned pigs. Pigs that were fed cassava root peel had lower feed intake, according to research by Fatufe *et al*. (2007). These variations can be attributed to the age and size of the animal utilized, as well as variations in the way the cassava by-product is processed. Overall, this study's findings about the weight increase of pigs fed CPMCM-based diets in comparison to the control diet show that these diets were able to support growth on pigs with those based on maize.

For dry matter (DM), crude protein (CP), ether extract (EE), and nitrogen free extract, the digestibility was comparable ($P>0.05$). This suggests that regardless of the processing technique, the enzyme-supplemented CPMCM was able to provide nutrients that were comparable to those in the control diet. The similarity in digestibility raises the possibility that diets' nutritional availability has been impacted by ingredient processing. According to the current study's findings, the digestibility values for dry matter and crude protein, respectively, range from 70.90 to 72.12 % and 64.87 to 66.21%. This goes against the findings of Madalla *et al*. (2016), who reported that the CP and gross energy digestibility of cassava leaf meal were, respectively, 45% and 44.17 %. Additionally, Ziemer *et al*. (2012) found that an increase in total dietary fiber led to an increase in fiber digestibility. In the current investigation, the digestibility of the nitrogen free extract was comparable (P > 0.05) throughout treatments. The study found that the addition of CPMCM to meals improved their nutritional digestibility when compared to the control diet. This increase was linked to the test ingredient's processing effect, as demonstrated by the diets' similar energy utilization.

The occurrence of *Staphylococcus sp.*, *Salmonella sp.*, *Micrococcus luteus* and *Escherichia coli* in the caecum of the pigs confirms the existence of a normal microbiota environment as these organisms exist under the normal microbiota of the vertebrate gastrointestinal tract (Willey *et al*., 2008). There was a significant (P<0.05) difference in total bacteria count across treatments for *Lactobacillus sp* and *Escherichia coli*. *Escherichia coli* was higher (P<0.05) in control (T1) relative to the other group. Conversely, *Lactobacillus sp* count were higher in CPMCM group compared to T1 while *Salmonella sp* and *Micrococcus luteus* counts were not significantly (P>0.05) different among the treatments. The outcome of this study suggests that CPMCM can influence the proliferation of beneficial bacteria while suppressing the activities of pathogenic organisms to prevent dysbiosis in the gut of pigs. According to Daniel *et al*. (2023); Alagbe *et al.* (2023), lactic acid produced by lactobacilli fights against pathogens by lowering the pH in the gut. So by stimulating the lactobacilli, the pathogens will consequently be reduced among pigs fed CPMCM. This mechanism is also known as competitive exclusion and may be attributed to the presence of phytochemicals in maize cob and cassava peels. The results of this experiment is in consonance with the findings of Aro et al. (2017) when feeding microbe-fermented cassava tuber wastes.

4. Conclusion

In conclusion, cassava peel – maize cob mixture (CPMCM) are loaded with nutrients and can be used to replace maize up to 30 % without causing any negative effect on the performance and health status of weaned pigs.

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