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Performance and Blood Profile of Weaner Pigs Fed Whole Cassava Root Meal Based Diet Supplemented With Enzyme

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ABSTRACT

This study evaluated the performance and blood profile of weaner pigs fed enzyme-supplemented whole cassava root meal (WCRM) as a substitute for maize. A total of thirty-six (36) crossbred weaner pigs (Large White x Berkshire) with an average with of 16.27kg were assigned to four dietary treatments in a completely randomized design (CRD) with three replications and each replicate consists of three pigs. The treatments comprised WCRM replacing maize at 0% (T_1, control), 33.33% (T_2), 66.66% (T_3) and 100% (T_4). A commercial exogenous enzyme preparation containing carbohydrase and other relevant enzymes was added to the cassava-based diets at 50g per 100kg feed. The trial lasted for 42 days. Data collected on growth performance, economic indices, hematology and serum biochemical indices were subjected to analysis of variance. The results revealed significant differences ($P<0.05$) across treatments for average initial weight (AIW), average final weight (AFW), average weight change (AWC), average daily weight gain (ADWG), and feed conversion ratio (FCR). Pigs on T_3 (66.66%) WCRM recorded the highest AFW (34.86kg) AWC (18.41g) and ADWG (435.63g), while the control group (T_1) had the poorest FCR (4.18). Whereas feed cost per kg (FCKG) and feed cost per kilogram weight gain (FCKGWG) reduced with increased WCRM inclusion across the diets. Hematological and serum biochemical indices remained within normal physiological ranges across all treatments, indicating no adverse physiological or health effects. It could be concluded that whole cassava root meal with enzyme supplementation can substitute maize up to 66.66% in diets of weaner pigs without compromising growth, health or economic viability.

Keywords: *Maize, Whole cassava root meal, Weaner pigs, Haematologcal, Serum indices*

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INTRODUCTION

The uncontrollable increase in human population, changing dietary patterns and increasing rivalry between food and feed production unequivocally highlight the urgent need for exploration of innovative and sustainable food production. The most significant concern now is the ever-growing population worldwide, which not only results in rising food demand but also threatens the food chain and supply (Ghosh *et al*., 2024). According to the Food and Agriculture Organization of the United Nations (FAO), with the exponential growth of the global population, it is expected to reach 9 billion people by 2050 (FAO, 2018). This will result in a greater need for food, especially animal protein sources such as pig, poultry, cattle and fish. In addition, the FAO has foreseen that global meat production and consumption will double by 2050 compared to 2000 (Migietta *et al*., 2024).

Pork production plays a vital role in meeting the animal protein demands of the growing population in developing nations like Nigeria. However, high production costs driven by expensive conventional energy feed ingredients, particularly maize, constrain profitability and expansion in the swine industry. Maize competes directly with human food and industrial uses, driving up market prices. Maize is the most widely used energy source worldwide and soybean meal is a popular plant protein source. In certain countries, however, other grains like wheat and sorghum, as well as plant protein meals like canola meal, peas and sunflower meal, are still commonly used. Fishmeal and meat meal are the primary sources of animal protein. Almost all developing countries are net importers of these ingredients; Nigeria's livestock feed industries depend on imports, depleting their foreign exchange reserves. The semi-commercial and commercial industries are often forced to curtail their compounded feed production even with rising demand (Boufennera *et al.,* 2012).

Cassava is one of Nigeria's most common and essential staple crops, recognized as a 21st-century crop primarily for smallholder farmers. Nigeria accounts for about 26% of global cassava production, producing over 63 million tonnes of cassava in 2021. Most of cassava produced in Nigeria are processed as food and consumed locally. The nutritional content in 100g of whole cassava root meal includes 2.5% crude protein, 0.07% fat, 82.06% carbohydrate, 3.1% ash and 3.4% crude fiber. The metabolizable energy of cassava root meal in growing pig is 3680kcal/kg (www.feedtables.com). Furthermore, it contains anti-nutritional substances, namely cyanide (Stephanie and Purwadaria, 2013). Imbalance amino acid profile, dustiness and presence of anti-nutritional factors inhibit the use of this meal as a raw material for pig feed. However, these shortcomings can be resolved through proper processing techniques and the inclusion of feed additives such as enzymes in the diet. Research has consistently shown that enzyme supplementation in diets enhances nutrient digestibility (Kiarie *et al*., 2013;

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Irekhore *et al*., 2015). Therefore, enzyme use may improve the utilization of whole cassava root in pig rations.

Haematological and serum parameters are known to be influenced by diets. Blood examination gives the opportunity to investigate the presence of several metabolites and other constituents and helps detect conditions of stress, which can be nutrition, environmental or physical (Aderemij, 2003).

The present study aimed to evaluate the performance of weaner pigs fed different levels of whole cassava root meal based diet and its effects on blood profile and production cost.

MATERIALS AND METHOD

Experimental Site

This research was conducted at the Research and Demonstration Farm of Federal Polytechnic Ekowe, Southern Ijaw Local Government Area of Bayelsa State, located by the coast of the Nun River, with a geographical position of 4º 48'17N and 6º 04'44E. It has about 2,682km2 surface area and a coastline of 60km on the Bight of Benny (Soluap, 2023).

Whole Cassava Root Meal Preparation

Freshly harvested cassava roots were obtained from cassava farmers within Ekowe community. The whole cassava were washed thoroughly to remove adhering soil and contaminants. They were subsequently chopped into smaller sizes and crushed with hammer mill. The resulting cassava paste was bagged and dewatered for about 24hours using hydraulic press. The whole cassava root meal was then sieved into fine granules and toasted on open fire for about 10-15 minutes to dry. The dried meal was spread to cool under ambient temperature before being bagged and stored until needed for feed formulation.

Experimental Animals

A total of thirty six (36) crossbred weaner pigs (Large white x Berkshire) with an average weight of 16.27 were used. The pigs were selected based on sound physical appearance by an animal scientist.

Experimental Design

The experimental pigs were weighed to obtain the initial weight and then assigned randomly allocated to four dietary treatments. Each treatment was replicated thrice with 3 pigs per replicate. The animals housed in floored pens equipped with watering and feeding facilities. Each group will be replicated three times in a completely randomized design (CRD).

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Experimental Diet and Feeding

The four dietary treatments, T_1, T_2, T_3 and T_4, were equivalent to 0% (control), 33.33%, 66.66% and 100% whole cassava root meal replacement for maize. Exogenous enzyme was added according to manufactures recommendations into the whole cassava root meal diets. Other ingredients were added to balance the diets as shown in Table 1. The ingredients were thoroughly mixed using a motorized feed mixer to obtain a homogenous mass. Thereafter, they were packaged in polyethylene bags and labelled accordingly for ease of identification. The pigs were offered 5% of their body weight in feed daily. Body weight samples were taken weekly and the feeds offered were adjusted to the new body weights. Also, wet feeding was adopted to reduce dustiness. Fresh clean water was supplied daily. There pigs were treated against ecto and endo parasites with ivermec injection 0.5ml/kg body weight prior to the experiment. Other management practices were carried out throughout the trial period of 42 days.

Data collection

Growth parameters

i. Average daily feed intake of each replicate was measured by subtracting the leftover feed from the supplied feed divided by number of birds, divided by number of days.
ii. Final weight was measured as the weight of birds at the termination of either experiment phase.
iii. Average daily weight gain was calculated by subtracting the Initial weight from the Final weight divided by number of experimental days.
iv. The feed conversion ratio (FCR) was calculated thus;
FCR = Average daily feed intake/ Average daily weight gain.
v. Mortality rate was calculated thus; Number of dead birds divided by Number of birds stocked then multiplied by 100.

Economic analysis

Feed cost per kg was calculated by summing the cost of the feed ingredient on the formulation and dividing it by 100kg. The cost of each ingredient was based on prevailing market prices as at the time of the experiment.
Feed cost per Kg weight gain was calculated thus; Feed cost per kg weight gain = FCR x Feed cost/kg.

Hematological and Serum biochemical indices

At 3 days prior to the end of the feeding trial, blood sample (5ml) were collected from the vains on the ear lobe of one randomly selected pig per replicate. 2ml of the blood sample was transferred into Bijou bottles containing ethylene diamine tetra acetic acid

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(EDTA) to avoid blood coagulation for analysis of hematological parameters such as packed cell volume (PCV), red blood cell (RBC) count, mean cell haemoglobin (MCH), mean cell volume (MCV), mean cell haemoglobin concentration (MCHC), haemoglobin (Hb) and white blood cell count (WBC). The remaining 1ml of blood was transferred into plain vial bottles to separate serum for analyses of total protein, albumin, globulin, urea, creatinine, total cholesterol, serum glutamic pyruvic transaminase (SGPT), alkaline phosphatase (ALP), serum glutamic oxaloacetic transaminase (SGOT).

Data analysis

Data collected were subjected to analysis of variance using the SPSS software (Version 26). Where analysis of variance indicted significant treatment effects, means were separated using Duncan New Multiple Range Test.

RESULT AND DISCUSSION

The Crude protein of the experimental diets fell between 18.70-19.41% (Table 1) in order to meet the protein requirement of weaner pigs recommended by NRC (1997). Similarly, the metabolizable energy of the diets (2,437.45 - 3,135.45kcal/kg) though reducing as the level of WCRM increased in diets, were also within the energy requirement of weaner pigs.

The proximate composition of the whole cassava root meal (WCRM) showed adequate nitrogen-free extract (71.70%), supporting its potential as an energy feedstuff. Other nutrients were crude protein 4.07%, crude fiber 5.80%, crude fat 3.27% and ash 4.33%. The low protein content of WCRM was augmented by other rich protein sources such as blood meal and fishmeal. Phytochemical analysis confirmed the presence of residual anti-nutritional factors but at safe levels. This could be attributed to the processing methods (grinding, dewatering, toasting) adopted in this study.

Growth performance parameters (Table 4) revealed that AIW range from 15.35kg (T_2) to 16.84kg (T_1) with T_1 showing superiority ($P0<0.5$) compared to other treatments. The AFW was 29.10kg, 32.66kg, 34.86kg, and 30.96kg from T_1 to T_4 respectively. AWC varied between 12.26kg in T_1 to 18.41kg in T_4 while ADWG were 291.66g, 412.14g, 435.63g and 346.42g from T_1 to T_4. It was observed that T_3 (66.66%) recorded significantly ($P<0.05$) higher values in AFW, AWC, ADWG. T_3 (1234.78g) and T_1 (1211.78g) had statistically similar ($P>0.05$) higher values while T_2 (1112.05g) had the least in ADFI. Furthermore, there was significant difference ($P<0.05$) in FCR among the treatment groups. T_2 (2.67) and T_3 (2.4) were similar ($P>0.05$) while T_4 (4.18) had the highest ($P<0.05$) value. From the various metrics under investigation, it could observed that the replacement of maize at WCRM 66.66% (T_3) gave significantly ($P<0.05$) improved growth performance and feed efficient compared to the control diet (T_1) in diets weaner pigs. This enhancement can be attributed to the synergistic effect of enzyme

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supplementation, which improved nutrient digestibility and energy release. However, total replacement (100% in T_4) caused a slight depression in growth performance, likely due to elevated fiber content or physical bulkiness limiting total nutrient intake. The findings of the study did not align with that of Igene (2006) which suggested that cassava inclusion above 50% in pig diets negatively impacts live weight and feed conversion ratio.

Economic evaluations demonstrated a progressive decrease in feed cost per kilogram (FCKG) as WCRM inclusion increased, reflecting the lower market cost of cassava compared to maize. Feed cost per kg weight gain was optimized at T_2 (₦1,143.72) and T_3 (₦1175.70) dietary groups.

The hematological and serum biochemical parameters are presented in Tables 5 and 6. Significant differences ($P<0.05$) were observed in white blood cell (WBC) counts and mean corpuscular hemoglobin (MCH). These parameters fell within normal ranges for healthy weaner pigs, as established by Jozica *et al.* (2018). Irekhore *et al.*, (2015) opined that elevated MCH values, exceeding normal ranges, suggested macrocytic anemia, likely due to increased red blood cell destruction and subsequent enhanced erythropoiesis in the liver, spleen and kidneys. Packed cell volume (PCV) which measures the proportion of red blood cells in the blood and is crucial for assessing oxygen transport and nutrient absorption. Normal PCV in weaner pigs ranges from 26-43% (Smith *et al*., 2019). Low PCV levels can indicate anemia due to nutritional deficiencies or parasitism, while high levels suggest dehydration (Brown, 2023). Reduced PCV may also reflect toxic factors or physiological adjustments impairing blood formation (Esonu *et al.*, 2001).

Hemoglobin and red blood cell (RBC) counts were also with normal hemoglobin levels of 9-14 g/dl and RBC counts of 5-8 million/µl (Smith *et al.*, 2019). Low values often indicate anemia caused by iron deficiency, parasitism, or weaning stress, leading to lethargy, poor growth,and increased disease susceptibility (Taylor, 2020; Jones & Allison, 2021). High hemoglobin or RBC counts may signal dehydration, polycythemia, or hypoxia, potentially straining the cardiovascular system (Wilson & Carter, 2022; Brown, 2023). These parameters are essential for early diagnosis and guiding interventions like iron supplementation (Miller, 2021).

White blood cells was significantly ($P<0.05$) different across the treatment means. It could be observed that that WCRM had no effect on diets. WBC was critical for assessing immune status. Normal ranges are 8.7-37.9 $x10^3$/mm for WBC (Smith *et al.*, 2019). However, low WBC or lymphocyte counts may indicate immunosuppression from viral infections like porcine circovirus or weaning stress, reducing disease resistance (Taylor, 2020). High WBC indicate bacterial infections or inflammation, potentially causing tissue damage if prolonged; while elevated lymphocytes may reflect chronic infections, straining energy reserves (Wilson & Carter, 2022; Adams & Lee,

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2020). Regular monitoring of these indices ensures early detection of health issues, guiding treatments to enhance weaner pig welfare and farm productivity.

Subsequently, serum biochemical parameters assessment was conducted to evaluate effect of WCPM based diets on metabolic, health, nutritional status, and organ functions. Total protein, ranging from 6.0-8.0 g/dl, indicates liver protein synthesis capacity. High levels suggest dehydration or inflammation from infections, while low levels point to malnutrition or liver dysfunction, hindering growth (Smith *et al.*, 2019; Etim *et al*., 2014). Albumin, at 2.5-4.0 g/dl, reflects nutritional and hepatic health. Elevated albumin indicates dehydration, while low levels suggest protein deficiency or liver disease, leading to edema and poor performance (Taylor, 2020; Etim *et al.*, 2014). Globulin, ranging from 2.5-4.5 g/dl, assesses immune function. High levels indicate chronic infections or parasitism, diverting energy from growth, while low levels suggest immunosuppression, increasing disease risk (Wilson and Carter, 2022; Jones and Allison, 2021).

Alkaline phosphatase (ALP), ranging from 50-150 μ/l, was evaluated for its role in bone growth and liver health. Elevated ALP may indicate rapid skeletal development in weaners or hepatic stress from toxins or infections, while low levels suggest nutritional deficiencies affecting bone health (Taylor, 2020; Jones and Allison, 2021). Creatinine, at 0.5-1.5 mg/dl, assesses kidney function and muscle metabolism. High levels indicate renal dysfunction or dehydration, while low levels suggest muscle loss or inadequate protein intake, impacting growth efficiency (Brown, 2023; Miller, 2021).

CONCLUSION

The study demonstrates that whole cassava root meal can successfully replace maize up to 66.66% in enzyme-supplemented diets for weaner pigs without impairing growth and also maintained normal haematological and serum biochemical parameters, indicating no negative impact on health. The processing method (grinding, dewatering and toasting) likely mitigated anti-nutritional factors and the supplementation with enzyme made WCRM a safe and cost-effective alternative energy feed source for pig producers looking to mitigate high maize prices.
Further research is advised to assess long-term effects for sustainable pig farming.

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APPENDIX

Table 1: Ingredient and Nutrient Composition of the Experimental Diets

Ingredient (kg)	**Inclusion Level**			
	T_1 (0%)	**T_2 (33.33%)**	**T_3 (66.66%)**	**T_4 (100%)**
Maize	18.00	12.00	6.00	0.00
WCRM	0.00	6.00	12.00	1.00
Soyabeans meal	15.00	15.00	15.00	15.00
Fishmeal	2.00	2.00	2.00	2.00
Blood meal	2.00	2.00	2.00	2.00
Palm kernel cake	45.00	45.00	45.00	45.00
Wheat bran	12.75	12.75	12.75	12.75
Oystershell	4.00	4.00	4.00	4.00
Salt	0.50	0.50	0.50	0.50
*Premix	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15
Methionine	0.10	0.10	0.10	0.10
Biozyme	0.00	0.50	0.05	0.05
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Nutrient Composition				
Crude protein	19.41	19.23	19.05	18.87
Crude fibre	9.48	9.60	9.72	9.03
Crude fat	4.96	4.32	4.54	5.14
ME (Kcal/kg)	2,280.18	2,256.18	2,232.18	2,220.18
L-Lysine	2.38	2.36	2.35	2.34
DL-Methionine	0.46	0.45	0.45	0.44
Ca	1.75	1.75	1.75	1.75
P	0.39	0.38	0.36	0.35

**Micro-mix (Chemiconsult International Ltd) provided the following per kg of feed; Vitamin A, 1000iu; Vitamin D3, 1500iu; Vitamin E, 51mg; Vitamin K, 2mg; Riboflavin, 3mg; Pantothenic acid, 10mg; Nicotinic acid, 25mg; Choline, 350mg; Folic acid, 1mg; Mg, 56mg; Iodine, 1mg; Fe, 20mg; Zn, 50mg; Co, 1.25mg*.

Table 2: Proximate Composition of Whole Cassava Root Meal

Parameters	Nutrient values
Moisture (%)	10.83
Crude protein (%)	4.07
Crude fibre (%)	5.80
Crude fat (%)	3.27
Ash (%)	4.33
NFE (%)	71.70

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Table 3: Phytochemical Composition of Whole Cassava Root Meal

Parameters	Qualitative	Quantitative
Alkaloids	+	2.3
Flavonoids	+	2.87
Saponins	+	3.50
Glycoside	+	2.60
Phytate	+	0.29
Oxalate	+	0.05
Tannin	-	-
Phenol	-	-

Table 4: Performance of weaner pigs fed Whole Cassava Root Meal based diets as replacement for maize

Parameters	Inclusion Level				
	T_1 (0%)	T_2 (33.33%)	T_3 (66.66%)	T_4 (100%)	SEM
AIW (kg)	16.84^{a}	15.35^{c}	16.45^{b}	16.42^{b}	0.31
AFW(kg)	29.10^{d}	32.66^{b}	34.86^{a}	30.96^{c}	0.98
AWC (kg)	12.26^{d}	17.31^{b}	18.41^{a}	14.55^{c}	0.75
ADWG (g)	291.66^{d}	412.14^{b}	435.63^{a}	346.42^{c}	17.26
ADFI (g)	1211.78^{ab}	1112.05^{c}	1234.78^{a}	116.06^{b}	13.19
FCR	4.18^{a}	2.67^{c}	2.84^{c}	3.42^{b}	0.21
Mortality	0.00	0.00	0.00	0.00	0.00
Economic analysis					
FCKG	429.50	423.36	413.98	397.01	NA
FCKGWG	1,795.31	1,143.72	1175.70	1357.77	NA

NA = Not Analyzed; SEM = Standard Error Mean; AIW = average initial Weight; AFW = Average Final Weight; AWC = Average Weight change, ADWG = Average Daily weight Gain; ADFI = Average Daily Feed Intake; FCKG = Feed Cost/kg; FCKGWG = Feed Cost Per Kg Weight Gain

Table 5: Haematological indices of weaner pigs fed WCRM based diets

Parameters	Inclusion Level					
	T_1 (0%)	T_2 (33.33%)	T_3 (66.66%)	T_4 (100%)	SEM	NR
PCV (%)	38.02	38.30	39.67	35.23	1.65	26-43
RBC ($X10^6/mm^3$)	5.70	5.77	5.23	5.06	0.23	
HB (g/dl)	12.66	12.46	12.33	12.01	1.96	9-14
WBC ($x10^3$/ul)	25.25^{a}	17.50^{b}	20.58^{ab}	17.70^{b}	2.89	8-37.9
MCV (fl)	61.75	61.25	58.25	60.85	0.58	42-62
MCHC (g/dl)	33.00	33.28	33.41	32.96	0.31	29-36
MCH (pg)	22.50	22.11	21.70	32.95	0.31	14-24

^{a,b,c} means within the same horizontal row having different superscripts are significantly different ($P<0.05$). SE = Standard Error Mean; NR = Normal Range

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Table 6: Serum biochemical indices of weaner pigs fed WCRM based diets

Parameters	Inclusion Level						
	T_1 (0%)	T_2 (33.33%)	T_3 (66.66%)	T_4 (100%)		SEM	NR
T.Protein (g/dl)	7.6	7.21	7.7	6.90	0.16	4.4-7.4	
Albumin (g/dl)	2.88	2.71	2.75	2.82	0.14	1.9-3.9	
Globulin (g/dl)	4.29	4.33	4.01	4.22	1.12	2.5-3.5	
Creatinine (mg/dl)	0.89	0.64	0.68	0.58	0.11	0.8-2.3	
Urea (mg/dl)	22.10	20.29	18.67	17.43	0.86		
Cholesterol (mg/dl)	119	116	104	102.5	6.45	81-134	
Alkaline phosphate (μ/l)	75.78^{b}	33.47^{c}	40.23^{c}	91.83	7.45	41.7-176	
SGOT	8.60	8.10	7.89	7.81	0.78	15.3-56	
SGPT	13.00	9.11	10.20	11.66	0.69	21.7-46	

SEM = Standard Error Mean; NR = Normal Range

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