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Research Article

Effect of Sundried Cassava Peel Meal-Based Diet Supplemented with Quadraxyme® on Performance and Blood Profile of Grower Boar Pigs

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ABSTRACT

Introduction: Monogastric animals, such as pigs and poultry, cannot handle cellulose, hemicellulose, and lignin, which form the major components of agro-industrial products. This feeding trial was carried out to evaluate the responses of growing boar-fed sundried cassava peel meal (CPM)-based diet supplemented with the enzyme.
Materials and methods: Thirty-two growing boars (Large white x Landrace), eleven weeks old with an average weight of 25.00 ± 0.30 kg, were allocated randomly to dietary treatments. A basal diet was compounded containing 48% sundried CPM. The dietary treatments were T1 (control) supplemented with 0.0g/100g, and other treatments, including T2, T3, and T4, received 0.5g/100kg, 1.5g/100g, and 2.0g/100g levels of Quadraxyme® supplementation, respectively. Quadraxyme® is a product of Quadragen Veterinary Health Private Limited. Quadraxyme® contains amylase, cellulase, xylanase, pectinase, lipase, arabinose, α-galactosidase, and β -glucosidase.
Results: This study showed significant differences in average feed intakes and daily weight gains across the dietary treatments. Pigs in the T4 group had the highest weight gain, followed by those in T2 and T3 groups, while the minor weight gain was in the diet with no enzyme supplementation. The dietary treatments significantly influenced hematological parameters in almost all the studied indices. The mean corpuscular hemoglobin concentration (MCHC) values of pigs fed the T1 diet recorded significantly higher MCHC and a reduction in concentrations of packed cell volume, red blood cell counts, and a slight increase in mean corpuscular volume concentration. The dietary treatments did not affect the total blood protein and albumin levels of the growing pigs enrolled in this investigation. The result showed that the levels of enzyme supplementation to the SDCPM-based diet did not significantly influence the electrolytes of the growing boars. The PO_4^{2-} increased in enzyme-supplemented diets, and group T4 supplemented with 0.20g/100kg of the enzyme recorded the highest PO_4^{2-} value (6.79mg/100ml) among the other groups.
Conclusion: It is concluded that including 0.20g/100kg in a 48% sundried CPM-based diet for growing pigs enhanced growth and feed conversion, improved phosphorus utilization, and had no adverse effects on growth and blood parameters.

1. Introduction

Pig production has been identified as one of the livestock sub-sectors competing with human beings for conventional energy sources and proteins[1]. In recent years, animal nutritionists have focused on available alternative feedstuffs, which are less competitive with humans and industries and underutilized as livestock feed ingredients[2].

One such alternative feedstuff considered in this study is cassava peel. Several authors have reported that the cassava peel meal (CPM) can be incorporated into the pig diet as an alternative energy source[1]. The cassava peel meal contains 5% crude protein (CP) and 20% crude fiber depending on the variety[3]. Anti-nutritional content such as hydrocyanic acid is an impeding factor against using cassava meal[4]. However, sun-drying cassava peel has been

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reported as an effective method of reducing hydrocyanic acid in cassava peel[5].

CPM's fibrous nature, like any other agricultural by-product, has limited its application in monogastric nutrition[6]. Both digestible energy (DE) and metabolizable energy are decreased due to the high fiber content in pig diets (ME). The quantity of crude fiber required to affect the digestibility of organic matter is highly variable depending on the composition of the diet[7]. The fibrous component of feed, which is rather difficult for pigs to digest, affects the digestibility of the other components[8]. Consequently, manual treatment is required to break down the fiber capsules in CPM to expose more soluble components. This is necessary to make effective use of the CPM in pig feeding.

Many studies have found that adding the enzyme to livestock diets, particularly monogastric animal diets rich in non-starch polysaccharides, enhanced feed efficiency and raised body weight growth and conversion ratio[9,10]. Quadraxyme® is a Quadragen Veterinary Health Private Limited product (Karnataka, India). The enzyme contained amylase, cellulase, xylanase, pectinase, lipase, arabinose, α-galactosidase and β -glucosidase, which could be beneficial in breaking the fiber content of sundried CPM. The use of Quadraxyme® as an enzyme in monogastric nutrition is limited. This study evaluated the effect of feeding grower boar with a sundried CPM-based diet supplemented with varying levels of Quadraxyme®.

2. Material and Methods

2.1. Ethical approval

The study was permitted by the Department of Animal Production and Health trial (Federal University Wukari, located in Taraba State, Nigeria). FU-LR-2022-004 is the ethical number.

2.2. Location

The study was conducted at the Federal University Wukari in Taraba State, Nigeria, under the Swine Unit of the Department of Animal Production and Health. The coordinates for Wukari are 9 degrees 47 minutes east longitude and 7 degrees 51 minutes north latitude. The climate in this region is characterized by two principal seasons include the wet or rainy season, which begins in March or April and continues until October, and the dry season, which begins in November and continues until March or April. The predominant kind of vegetation in the region is savannah[11].

2.3. Processing of cassava peels

Fresh Cassava peels were obtained from a cassava processing center in Wukari, Taraba state, Nigeria. The peels were washed to remove dirt and then sun-dried for seven days to a constant moisture weight of 10%. The peels were milled using a hammer mill to obtain sundried cassava peel meal (SDCPM).

2.4. Experimental animal, management, and design

The experiment involved 32, eleven weeks old, growing boars (Large white x Landrace) with an average weight of 25.00 ± 0.30kg. Before beginning the tests, growing boars were treated for endo- and ectoparasites with Ivermectin subcutaneously at a dose of 1ml/50kg live weight[6]. The animals were randomly assigned to one of four nutritional regimens that were reproduced four times, with two animals kept in a 6 by 6 ft2 concrete. Management of daily routines was carried out as previously stated[7].

2.5. Diets

A basal diet containing 48% sundried CPM and 18% crude protein was compounded as recommended by NRC (1998). The dietary treatments were designated as T1 (control) supplemented with 0.0g/100g, while T2, T3, and T4 contained 0.5g/100kg, 1.5g/100kg, and T4 2.0g/100kg levels of Quadraxyme® supplementation, respectively as shown in Table 1.

2.6. Premix composition (per kg of diet)

The diet included 2500 IU Calciferols, 2.5 mg Vitamin K_3, 6 mg Riboflavin, 40 mg Niacin, 50 mg Vitamin E, 6 mg Pyridoxine, 10 mg Calcium pantothenic, 0.08 mg Biotin, 0.25 mg Cobalamin, 12500 IU Vitamin A, 1 mg Folic acid, 3 mg Vitamin B_1, 45 mg Zinc, 300 mg Chlorine chloride, 50 mg Iron, 2 mg Copper, 1.55 mg Iodine, 0.25 mg Cobalt, 0.10 mg Selenium, 100 mg Manganese, and 200 mg antioxidant.

2.7. Enzyme composition per kg diet

Amylase 110,000 units, cellulase 500,000 units, xylanase 1,000,000 units, lipase 10,000 units, pectinase 30,000.0 units, and 4,000 units of arabinose, α-galactosidase, and β -glucosidase.

Table 1. Ingredients and percentage of the composition in the experimental diet fed to cross-bred (Large white x Landrace) growing boar pigs (Nigeria,2022)

Ingredient	(%) Composition
Cassava	48.00
Soybean meal	26.00
Kapok seed cake	17.00
Blood meal	3.00
Bone meal	3.00
Salt	0.50
Limestone	1.00
Methionine	0.50
Lysine	0.50
Vitamin premix	0.50
Total	100
Calculated analysis	
Crude protein	18.87%
Crude fiber	14.34%
Metabolizable energy (Kcal/kg)	2,713.00

2.8. Chemical analysis

The proximate chemical composition of CPM and experimental baseline diet was determined using the standard protocols[12]. The metabolizable energy (ME) of diet content was measured according to proximate composition formulas[13].

2.9. Blood sampling

Three experimental boars were randomly chosen from each food group for blood collection. Without anesthesia, 10 ml of blood were collected in a serum tube through a jugular vein puncture into two sample bottles using a sterile needle and syringe[14]. The serum was extracted from blood samples and allowed to coagulate before being centrifuged. The serum was then decanted into sterile vials and kept at -20C until being examined. The serum indices examined were total protein, cholesterol, glucose, albumin, globulin, creatinine, and urea. Blood was collected in EDTA-containing sample vials for hematological tests before being analyzed following the standard techniques[15]. Red blood cells (RBC), packed cell volume (PCV), hemoglobin, and white blood cells (WBC) were the hematological properties studied[16].

2.10. Statistical analyses

One-way analysis of variance was used to analyze the data by JMP SAS software (2013), and $p < 0.05$ indicate as statistical significance. The least significant differences (LSD) were used for comparing the means.

3. Results and Discussion

3.1. The composition of experimental diets

Table 2 shows the approximate components of the experimental diet and sundried CPM. The diet's CP and energy contents (EC) are within the range[18]. The hydrocyanic acid (HCN) content in the CPM utilized in this investigation was lower than that reported by a study (27mg/100kg)[19]. This might be due to the study's processing technique, strain, and type of CPMs.

3.2. Performance of growing boar

Table 3 shows the growth performance of growing pigs fed a cassava peel meal-based diet supplemented with different enzyme levels. Substantial variations in average feed intakes and daily weight increases were observed among the dietary regimens ($p < 0.05$). Diets treated with enzymes resulted in significantly ($p < 0.05$) greater weight gain. Pigs fed a 0.20g/100kg 48% SDCPM-based diet gained the most weight, followed by 1.50g/100kg 48% SDCPM diets and 0.1g/100kg 48% SDCPM, while the diet with no enzyme supplementation gained the least. The observed increase in weight may be attributed to the enzyme supplementation's ability to break down and utilize fibrous foods effectively. The discovery supports the earlier findings indicating enzymes as a source of vitamins, high-quality protein, and amino acids[9, 20]. Feed conversion rates differed considerably ($p < 0.05$) across treatment groups. Pigs obtained the greatest results fed a 0.20g/100kg 48% SDCPM diet. The findings of two studies indicate that increasing the amount of enzymes present in diets increases the feed conversion ratio[21,22]. Pigs that were given 0.20g/kg of supplementation had the lowest feed conversion ratio, which indicates higher efficiency.

Table 2. The composition of the diets and sundried cassava peel meal (Nigeria, 2022)

Parameter	Experimental diet	Sundried cassava peel meal
Dry matter	90.45	87.92
Crude protein	19.01	5.78
Crude fiber	14.67	22.18
Ether extracts	4.13	0.67
Ash	8.12	6.18
HCN mg/kg	-	19.00

HCN: Hydrocyanic acid

3.3. Hematology and biochemistry indices

Table 4 shows the hematological characteristics of the growing boar. Hematology and blood biochemistry parameters are frequently employed to assess animal health[23]. Dietary influences on hematological parameters have been widely investigated and established [7,24]. Nonetheless, the acquired data exhibited a substantial impact ($p > 0.05$) on the dietary interventions on the hematological parameters that measured. The MCHC values of pigs fed a 0.0g/100kg 48% SDCPM (T1) diet showed significantly ($p < 0.05$) higher MCHC and a reduction in PCV, RBC counts, and a slight increase in MCV concentration. This finding indicates macrocytic anemia caused by increased destruction and subsequent occurrence of erythropoiesis in organs such as the liver, spleen, and kidneys. This conclusion provided support for a previous investigation[15]. Proteins are the fundamental components that are used in the construction of cells and other substances. These components are essential for maintaining homeostasis in the body, regulating physiological activities, providing energy, and protecting against pathogenic agents. In this experiment, the dietary treatments did not impact the total serum protein or albumin levels of the developing pigs that were investigated ($p > 0.05$). This suggests that the amount of protein in the study was sufficient to maintain the body's existing protein stores in the animals used in this experiment.

3.4. Serum electrolyte of growing boar

Table 5 shows the impact of the food regimen on serum electrolytes. The results showed that the level of enzyme supplementation of the SDCPM-based diet had no significant ($p > 0.05$) influence on serum electrolyte parameters of growing pigs, except for $PO_4^{\ 2-}$, which

Table 3. Performance of growing boar that fed cassava peel meal-based diet supplemented with varying levels of the enzyme (Nigeria,2022)

	Dietary inclusion of enzyme					
Parameter	**T1(0.0g/kg)**	**T2(0.1g/kg)**	**T3(0.15g/kg)**	**T4(0.20g/kg)**	**SEM**	**P-value**
Average initial body weight (kg)	25.09	25.78	25.76	25.65	0.25	0.43
Average total weight gain (kg)	19.81^c	23.09^b	24.69^b	27.78^a	0.23	0.003
Average daily body weight gain (kg)	0.40^d	0.47^c	0.50^b	0.56^a	0.12	0.001
Average daily feed intake (kg)	1.55^a	1.43^b	1.39^c	1.37^c	0.01	0.005
Feed conversion ration	3.87^d	3.04^c	2.78^b	2.44^a	0.03	0.001

^{A,b,c,d} Superscripts in the same row show a significant difference in the means ($p < 0.05$), SEM: Standard error mean

Table 4. Hematology and biochemistry indices of growing boar that fed cassava peel meal-based diet supplemented with varying levels of the enzyme (Nigeria,2022)

	Dietary inclusion of enzyme					
Parameter	**T1(0.0g/100kg)**	**T2(0.1g/100kg)**	**T3(0.15g/100kg)**	**T4(0.20g/100kg)**	**SEM**	**P-value**
Hematology						
Red blood cell x ($10^6/\mu l$)	5.01	5.86	5.89	5.93	0.02	0.23
Haemoglobin (*g/dl*)	11.35^b	12.18^a	12.09^a	12.10^a	0.04	0.004
Packed cell volume (%)	37.21^b	38.12^a	38.62^a	38.40^a	0.15	0.001
White blood cell x ($10^6/\mu l$)	18124^a	16124^b	16210^b	16124^b	66.51	0.05
MCV ($fl, \mu)^3$	67.25^a	65.10^b	65.20^b	66.31^b	0.26	0.003
MCH (*pg*)	22.16	23.17	23.34	23.01	0.09	0.067
MCHC (%, g/100ml)	36.13^a	35.13^b	35.76^b	35.23^b	0.14	0.001
Biochemistry						
Cholesterol (mg/dl)	115.6	121.78	112.87	121.45	0.47	0.21
Total protein (g/dl)	7.72	7.81	7.55	7.82	0.03	0.45
Albumin (g/dl)	4.16	4.28	4.23	4.54	0.01	0.23
Globulin (g/dl)	3.56	3.53	3.32	3.28	0.23	0.56
Creatinine (*mg/dl*)	0.67	0.73	0.73	0.77	0.02	0.78
Urea (*mg/dl*)	16.87	16.13	16.03	16.01	0.06	0.42
Glucose (mg/dl)	82	83	86	88	0.33	0.67

^{A,b,c,d} Superscripts in the same row show a significant difference in the means ($p < 0.05$), SEM: Standard error mean, MCV: Mean corpuscular volume, MCHC: Mean corpuscular hemoglobin concentration, MCH: Mean corpuscular hemoglobin

increased progressively in enzyme-supplemented diets with 0.20g/100kg 48% SDCPM (T4) having the highest ($p < 0.05$) PO_4^{2-} value among the enzyme-supplemented diets. This meant that 0.20g/100kg 48% SDCPM improved dietary PO_4^{2-} consumption, increasing PO_4^{2-} serum value. Phosphorus from plants has limited bioavailability to pigs, poultry, and rabbits because phytate, the major form of Phosphorus storage in plants, is indigestible to non-ruminants[14,18]. Phytate is an abbreviation for phytic acid (myoinositol hexaphosphate), composed of an inositol ring with six phosphate ester groups and its salts, including magnesium, calcium, or potassium phytate[26]. The finding from this study has shown that enzyme supplementation can increase phosphate bioavailability.

Table 5. Serum electrolyte of growing boar that fed cassava peel meal-based diet supplemented with varying levels of the enzyme (Nigeria,2022)

	Dietary inclusion of enzyme					
Parameter	**T1(0.0g/100kg)**	**T2(0.1g/100kg)**	**T3(0.15g/100kg)**	**T4(0.20g/100kg)**	**SEM**	**P-value**
PO_4^{2-} (mg/100ml)	4.43^d	5.32^c	6.12^b	6.79^a	0.06	0.003
HCO_3^- ($Mmol^{-1}$)	21.11	21.34	21.54	21.43	0.21	0.50
Cl^- ($Mmol^{-1}$)	100.12	101.43	102.42	101.22	1.01	0.12
Ca^{2+} (mg/100ml)	10.11	10.13	10.12	10.16	0.10	0.21
Na^+ $Mmol^{-1}$	124.23	126.43	125.34	126.21	1.26	0.13
K^+ ($Mmol^{-1}$)	3.23	3.40	3.67	3.65	0.05	0.21

^{A,b,c,d} Superscripts in the same row show a significant difference in the means ($p < 0.05$), SEM: Standard error mean

5. Conclusion

Adding 0.2g/100kg of sundried cassava peel to a diet consisting of 48% sundried cassava peel for growing boar improved growth and feed conversion, increased the amount of phosphorus utilized, and did not have any negative effects on hematological or biochemical parameters. It has been advised that more research be carried out on varied concentrations of Quadraxyme® with regard to all biochemical parameters and other species of varying ages.

Declarations

Competing interests

The authors declared that no competing interests exist.

Authors' contributions

To accomplish this project, the writers worked collaboratively. Data gathering was devised and handled by Wafar Raphael James. Yakubu and Bobboi developed the technique and analyzed it, and coordinated the study's findings. Obun Clectus Otu wrote the first draft of the manuscript, and Obun Clectus Otu supervised the study. All writers evaluated and approved the final text.

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Availability of data and materials

The authors will provide all necessary data to the editor upon request.

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References

1. Adesehinwa AOK, Dafwang I I, Ogunmodede BK, and Tegbe TSB. A review of utilization of some agro-industrial by-products in pig rations. Nigerian J Agric Ext. 1998; 11(1&2): 50-64.
2. Yakubu B, and Wafar RJ. Effects of processing methods of *Leptadenia hastata* on growth performance, nutrient digestibility and carcass characteristics of weaner rabbits. J Agric Vet Sci. 2014; 7(I&II): 53-58.
3. Aro SO, Aletor VA, Tewe OO, and Agbede JO. Nutritional potentials of cassava tuber wastes: A case study of a cassava starch processing factory in south-western Nigeria. Livest Res Rural Dev. 2010; 22(11): 213. Available at: http://www.lrrd.org/lrrd22/11/aro22213.htm
4. Enneking D, and Wink M. Towards the elimination of anti–nutritional factors in grain legumes. In: Knight R, editor Linking research and marketing opportunities for pulses in the 21st century. Dordrecht, Boston, London: Kluwer Academic Publishers; 2000. pp. 671-683. Available at: https://link.springer.com/chapter/10.1007/978-94-011-4385-1_65
5. Aletor VA, and Fasuyi AO. Nutrient composition and processing effect on cassava leaf (*Manihot esculenta, Crantz*) anti-nutrients. Proceeding 2nd Conference Livestock Production; 1996 September 15-17, Lagos, Nigeria; p. 231- 242.
6. Torhemen LN, Ikurior SA, and Wuanor AA. Growth performance and nutrient digestibility of growing pigs fed cassava peel meal-based diets treated with the exogenous enzyme. Int J Environ Agric Biotech. 2017; 2(6): 2973-2977. DOI: 10.22161/ijeab/2.6.25
7. Wafar RJ, Tarimbuka LI, Sini T, Adi ZA, Lamalang EB, and Bako MI. Growth performance and nutrient digestibility of weaner pigs fed cereal offspring in diets. Niger J Anim Prod. 2020; 47(6): 129-134. DOI: 10.51791/njap.v47i6.2918
8. Sauer WC, Mosenthin R, Ahrens F, and Denhartog LA. The effect of source of fiber on Ileal Amino acid digestibility and bacterial nitrogen excretion in growing pigs. J Anim Sci. 1991; 69(10): 4070-4077. DOI: 10.2527/1991.69104070x
9. Chesson A. Non-starch polysaccharide degrading enzymes in poultry diets: Influence of ingredients on the selection of activities. Worlds Poult Sci J. 2001; 57(3): 251-253. DOI: 10.1079/WPS20010018
10. Yakubu B, Mbahi TF, Bako MI, and Antyev M. Effects of dietary levels of an enzyme (maxigrain®) supplemented yam peel meal on performance and carcass characteristics of weaner rabbits. Glob J Agric Agric Sci. 2017; 16: 11-16. DOI: 10.4314/gjass.v16i1.2
11. Adedibu PA, Opeyemi AA, Lawrence AJ, Paul JI, and Oguntoye E. Savanna Biomes In Nigeria: Indicator Species And Plant Adaptation Strategies. Sci Open Prep. 2022. DOI: 10.14293/S2199-1006.1.SOR-.PPDXHKL.v1
12. Association of analytical chemist. Official methods of analysis. 17th ed. Arlington, Virginia, USA; AOAC Ic: 2010.
13. Pauzenga U. Feeding parent stock. Zootecnica Int. 1985; 34: 22-25. Available at: https://cir.nii.ac.jp/crid/1571698600845198080
14. Wafar RJ, Yakubu B, Yusuf HB, and Antyev M. Effect of feeding raw and differently processed kapok (*Ceiba pentandra*) seed meal on the growth performance and carcass characteristics of weaner rabbits. Niger J Animal Sci. 2018; 20(2): 258-270. Available at: https://www.ajol.info/index.php/tjas/article/view/171221
15. Jain NC. Schalm's veterinary hematology. 4th ed. Philadelphia: Lea & Febiger; 1986. p. 20-86.
16. Tripathi MK, Mondal D, and Karim SA. Growth, hematology, blood constituents, and immunological status of lambs fed graded levels of animal feed grade damaged wheat as a substitute of maize. J Anim Physiol Anim Nutr. 2008; 92(1): 75-85. DOI: 10.1111/j.1439-0396.2007.00712.x
17. SAS Institute. SAS® User's guide: Statistics. Version. 10 ed. SAS Institute Inc; Cary NC; 2000.
18. National research council (NRC). Nutrient requirements of swine. 10th ed. Washington D. C: National Academy Press; 1998.
19. Adesehinwa AOK, Amole TA, Ajayi E, Makanjuola BA, and Okike I. High-quality cassava peel® production and its utilization in pig production: A review. Nig J Anim Prod. 2019; 46(3): 205- 218. DOI: 10.51791/njap.v46i3.973
20. Adesehinwa AOK, Dairo FAS, and Olagbegi BS. Response of growing pigs to cassava peel-based diets supplemented with antizyme 1300: Growth, serum, and hematological indices. Bulg J Agric Sci. 2008; 14(5): 491-499. Available at: https://www.agrojournal.org/14/05-08-08.pdf
21. Wyatt C, Soto-Salanova M, and Pack M. Applying enzyme to Sorghum-based broiler diets. Proceedings of Aust. Poultry Science Symposium; 1997; Sydney, Australia. p. 116-118.
22. Zanella L, Sakomura NK, Silversides FG, Fiqueirdo A, and Pack M. Effect of enzyme supplementation of broiler diets based on corn and soybeans. Poult Sci. 1999; 78(4): 561-568. DOI: 10.1093/ps/78.4.561
23. Fagbemi BO, Otesile EB, Makinde MO, Akinboade OA. The relationship between dietary energy levels and the severity of *Trypanosoma brucei* infection in growing pigs. Vet Parasitol. 1990 Feb;35(1-2):29-42. DOI: 10.1016/0304-4017(90)90114-q
24. Ologhobo AD, Apata DF, Oyejide A, and Akinpelu RO. A comparison of protein fractions prepared from Lima beans (*Phaseolus lunatus*) in starter diets for broiler chicks. J Appl Anim Res. 1993; 4(1): 13-30. DOI: 10.1080/09712119.1993.9705971
25. e Food and agriculture organization of the United Nation/ International zinc nutrition consultative group (FAO/IZiNCG). FAO/INFOODS/IZiNCG global food composition database for phytate version 1.0 – PhyFood Comp 1.0. Rome, Italy, 2018; p. 3. Available at: https://www.fao.org/3/i8542en/I8542EN.pdf