Performance and carcass characteristics of grower pigs fed enzyme-supplemented dried cassava peel – maize cob composite meal

Daniel Nnadozie Anorue[1]

[1] Department of Animal Science, University of Abuja, Nigeria

Correspondence: Daniel Nnadozie Anorue, Department of Animal Science, University of Abuja, Nigeria. E-mail: anorued@gmail.com

Received: April 17, 2024 DOI: 10.14295/bjs.v3i7.606

Accepted: June 07, 2024 URL: https://doi.org/10.14295/bjs.v3i7.606

Abstract

A 90-day trial was carried out to evaluate the performance and carcass characteristics of grower pigs fed enzyme-supplemented dried cassava peel-maize cob composite meal (CP-MC). A total of 36 crossbreed male grower pigs (Large white) of about 16 weeks old with an initial body weight of 20.31 ± 0.61 kg^{-1} were randomly allotted into four groups of nine animals per treatment. Each treatment was further divided into three replicates consisting of three pigs in a completely randomized design. Pigs in treatment 1 were fed 0% CP-MC while CP-MC was used to replace maize at 40% (T2), 50% (T3), and 60% (T4). Diet was adequate in all nutrients, and clean water and feed were offered ad libitum. Results on growth performance showed that average daily weight gain was higher in T4 (0.34 kg) and T3 (0.33 kg), intermediate in T2 (0.26 kg), and lower in T1 (0.23 kg) ($p < 0.05$). Similarly, the best feed conversion ratio was found among pigs in T4 followed by T3, T2, and T1 ($p < 0.05$). Conversely, average daily feed intake was not influenced by the treatments ($p > 0.05$). Dressing percentages varied from 61.60-71.94% were significantly ($p < 0.05$) different among the treatments. Weights of the head, belly, limbs, back fat thickness, kidney liver, lungs, and spleen were significantly ($p < 0.05$) different among the treatments. In conclusion, the replacement of maize with CP-MC at 60% improved the weight of pigs without compromising the performance of animals.

Keywords: maize, performance, swine, conventional feeds, carcass.

Desempenho e características de carcaça de suínos de crescimento alimentados com casca de mandioca seca suplementada com enzimas e farinha composta de sabugo de milho

Resumo

Foi realizado um ensaio de 90 dias para avaliar o desempenho e as características de carcaça de porcos de crescimento alimentados com farinha composta de casca de mandioca e sabugo de milho seca suplementada com enzimas (CP-MC). Um total de 36 suínos de crescimento machos mestiços (Grande branco) com cerca de 16 semanas de idade e peso corporal inicial de 20,31 ± 0,61 kg^{-1} foram distribuídos aleatoriamente em quatro grupos de nove animais por tratamento. Cada tratamento foi dividido em três repetições compostas por três porcos em um delineamento inteiramente casualizado. Os porcos do tratamento 1 foram alimentados com 0% de CP-MC enquanto o CP-MC foi utilizado para substituir o milho a 40% (T2), 50% (T3) e 60% (T4). A dieta estava adequada em todos os nutrientes e água limpa e ração eram oferecidas ad libitum. Os resultados sobre o desempenho de crescimento mostraram que o ganho de peso médio diário foi maior em T4 (0,34 kg) e T3 (0,33 kg), intermediário em T2 (0,26 kg) e menor em T1 (0,23 kg) ($p < 0,05$). Da mesma forma, a melhor taxa de conversão alimentar foi encontrada entre os suínos no T4, seguido pelo T3, T2 e T1 ($p < 0,05$). Por outro lado, o consumo médio diário de ração não foi influenciado pelos tratamentos ($p > 0,05$). As porcentagens de cobertura variaram de 61,60-71,94% e foram significativamente ($p < 0,05$) diferentes entre os tratamentos. Os pesos da cabeça, barriga, membros, espessura da gordura dorsal, rim, fígado, pulmões e baço foram significativamente ($p < 0,05$) diferentes entre os tratamentos. Conclui-se que a substituição do milho pelo CP-MC a 60% melhorou o peso dos suínos sem comprometer o desempenho dos animais.

Palavras-chave: milho, desempenho, suínos, rações convencionais, carcaça.

1. Introduction

The increasing world population - which is expected to reach eight billion people by November 2022 - has led to a rise in the demand for traditional feedstuff used by both humans and pigs (UN, 2022). This is especially true for developing and underdeveloped countries when there is a food shortage brought on by rapid population growth. The competition between the animal feed industry and human consumers drives up the price of these conventional feedstuffs. Research into alternative feed ingredients that aren't staple meals for human consumption is prompted by this. Agro-industrial by-products damage the environment and are not being used as possible economic feedstuffs if they are burned or allowed to decay in piles (Olowoyeye et al., 2019; Ojediran et al., 2020; Dey et al., 2021).

Pigs and humans have been shown to compete for the same grains and cereals, especially maize (Adesehinwa et al. 2008). The price of maize, a vital source of energy for pig diets, has increased significantly due to growing competition and the effects of climate change, which have reduced production. This shortage has persisted, according to Oladunjoye et al. (2008) and Owen et al. (2009), which has resulted in high production costs, poor profitability, and the inability to satisfy Nigeria's need for animal protein. Peels from cassava and maize cob are one of the many agro-industrial by-products that show potential for usage as a substitute feed substance. It is an essential waste or agricultural by-product that is left over after cassava is processed to make food (Oladunjoye et al., 2010).

Studies involving cassava peel have shown that higher amounts of crude fiber, which functioned as energy diluents and hampered energy utilization, were associated with poorer performance in birds fed cassava peel diets (Ezieshi; Olomu, 2011). Notable researchers Ojediran et al. (2020); and Kanengoni et al. (2004) have shown that cassava peel and maize cob can be used to replace maize up to 50%. The optimal amount of dried cassava peel meal and dried maize cob meal to substitute for maize in pig diets is not well documented (Zavala-López et al., 2018). Evaluating the effect of cassava peel–maize cob meal (CP-MC) mixture will also help to maximize the potential in the environment, help to formulate the least ratio feed, and help to increase the production of animal protein.

Therefore, this experiment was designed to evaluate the performance and carcass characteristics of grower pigs fed enzyme-supplemented dried cassava peel–maize cob composite meal.

2. Materials and Methods

2.1 Site of the experiment

The experiment was carried out at the livestock unit University of Abuja, Gwagwalada, Nigeria, located between latitudes 8o571 and 8o551N and longitudes 7o051 and 7o061E. It was carried out according to the ethical guidelines and procedures of the Animal Science Department (ANS/2024A).

2.2 Collection, authentication, and processing of cassava peel and maize cob

Fresh maize cob and cassava peel were collected from different processing facilities in Gwagwalada, Abuja, and transferred to the Department of Biological Sciences where it was identified and authenticated with a voucher number AA/2004C and AA/2005D. Thereafter, samples were sundried separately on a flat metallic tray for 15 days until a constant weight was achieved. The dried sample was milled separately using a hammer mill and treated with enzymes before it was mixed in a ratio (1:1) before it was sent to the laboratory for further examination.

2.3 Animals and their management

36 – sixteen weeks large white grower male pigs with an initial body weight of 20.31 ± 0.60 kg were used for the study. The animals were purchased from a reputable breeder farm in Abuja and transferred to the University of Abuja teaching and research farm, Gwagwalada, Nigeria. On arrival, pigs were kept in a pen measuring 2.5 m by 1.0 m by 2 m (length, breadth, and width) in an open-sided pen thoroughly disinfected two weeks before the commencement of the experiment. Animals were kept in quarantine for two weeks and fed growers mash (basal diet) formulated to satisfy the nutritional needs of pigs by the NRC's (2002) recommendation. They were also

given prophylactic treatment against endo- and ecto parasites before they were stratified based on their body weight into four treatment groups and each treatment was replicated three times with three animals in each replicate in a completely randomized design. Feed and water were offered ad libitum.

2.4 Experimental set-up

Treatment 1(T1) basal diet without cassava peel-maize cob meal mixture (CP-MC) while in T2, T3, and T4 CP-MC were used to replace maize at 40, 50, and 60% respectively (Table 1).

Table 1. Chemical composition of experimental diets (% DM).

Ingredients	T1	T2	T3	T4
	(0%)	(40%)	(50%)	(60%)
Maize	60.00	36.00	30.00	24.00
Wheat offal	8.00	8.00	8.00	8.00
Soya beans	17.30	17.30	17.30	17.30
Groundnut cake	6.50	6.50	6.50	6.50
CP-MC	0.00	24.00	30.00	36.00
Bone meal	3.03	3.03	3.03	3.03
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
Salt	3.00	3.00	3.00	3.00
Total	100.0	100.0	100.0	100.0
Determined analysis				
Crude protein (%)	15.10	14.34	14.22	14.20
Crude fibre (%)	6.00	8.12	8.87	9.01
Ether extract (%)	2.40	2.37	2.35	2.30
Calcium (%)	1.83	1.83	1.83	1.83
Phosphorus (%)	0.67	0.67	0.67	0.67
Energy (Kcal/kg^{-1})	2801.8	2798.5	2779.6	2765.9

Note: *Vitamin A, 8,000 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 a premix per kilogram meal. Source: Authors, 2024.

2.5 Parameters examined

Feed was weighed daily for pigs in each replicate and the quantity consumed for the day was obtained by the difference between the quantity supplied and the leftover. A weekly record of average feed consumption per bird was obtained for each replicate by dividing the total quantity of feed consumed by the number of pigs in each replicate.

The body weight gain was obtained by calculating the difference between the body weight for the preceding week and the current week while the feed conversion ratio was determined by dividing the quantity of feed consumed by the body weight gain of the birds in each replicate in grams.

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Average daily feed intake (g)}}{\text{Average daily weight gain (g)}}$$

2.6 Carcass quality assessment

Six pigs from each treatment were chosen at random to prevent bias at the end of the experiment. Before being slaughtered, the chosen pigs underwent a twelve-hour feed fast and were weighed. To guarantee full bleeding, the pigs were shocked and killed by jugular vein piercing, while hanging on a rail, eviscerated and carcass weight measured. The head, boston, shoulder, loin, and ham were among the sections of the carcass that were weighed, and separated and their respective weights were then divided by the carcass weight and multiplied by 100 to determine the percentage weights of each component. The dressing percentage was computed by dividing the carcass weight by the live weight and multiplying it by 100.

2.7 Statistical analysis

Data collected from the study was subjected to analysis of variance (ANOVA) using the computer software package SPSS 21.0; differences among treatment means were compared with *Duncan's* multiple range test of the same statistical package.

3. Results and Discussion

Figure 1 presents the results of the physicochemical composition of the mixture of cassava peel and maize cob (CP-MC) where the alkaloid contents presented values of 20 mg g^{-1}, tannins 9 mg g^{-1}, flavonoids 14 mg g^{-1}, saponins 10 mg g^{-1}, cyanide 15 mg g^{-1} and total phenolics 8 mg g^{-1}. Thuppahige et al. (2023) describe cassava peel a high content of elements such as Carbon (C), Oxygen (O), Calcium (Ca), Potassium (K), Nitrogen (N), Iron (Fe), Silicon (Si) and Aluminum (Al) with the capacity to form numerous chemical compounds that are present in different groups of phytomolecules.

Ekeledo et al. (2021) found a total phenolic content of 681.5 GAE mg 100 g^{-1} for yellow-skinned cassava and 442.4 GAE mg 100 g^{-1} for white-skinned cassava. The contents of phytomolecules may vary between cultivars and the method of production, drying by gravimetry considerably reduces the contents of alkaloids, flavonoids, and total phenolic compounds. Significant contents of total phenolic compounds and antioxidant activity are also described for corn cobs from different cultivars in the study by Khamphasan et al. (2018). As observed in our findings, several alkaloids, flavonoids, cyanides, and phenols are involved in cellular protection against several groups of harmful free radicals such as singlet oxygen. The mixture produced in our study has considerable levels of phytocompounds capable of protecting and avoiding the negative action of various oxidizing agents on animals (Jit et al., 2022).

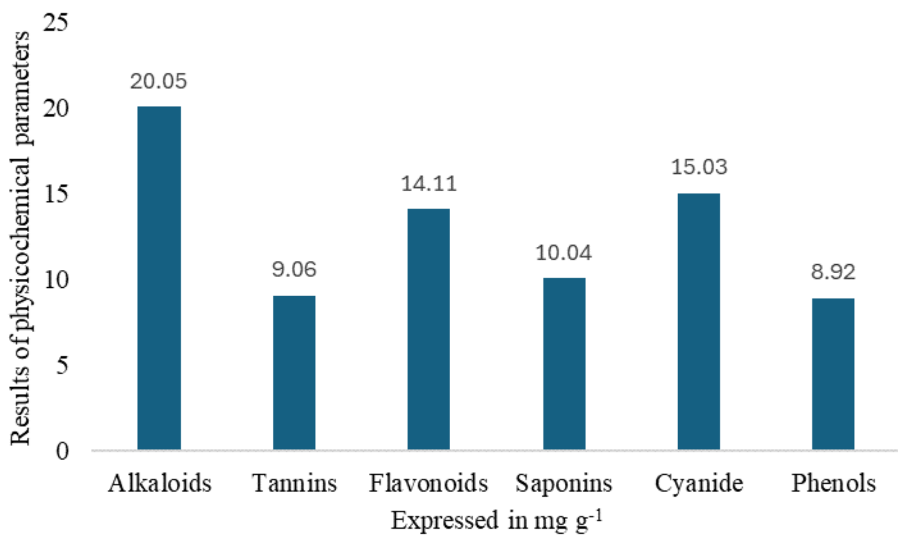

Figure 1. Chemical components in cassava peel and maize cob meal mixture (CP-MC). Source: Authors, 2024.

The growth performance of grower pigs fed CP-MC is presented in (Table 2). Final body weight, weight gain, and average daily weight gain of pigs fed 50% replacement (diet 3) were similar ($p < 0.05$) to those fed diet 60% (diet 4) but significantly higher than those fed diet 2 (40% replacement) and control (T1). Average daily feed intake was similar across the treatments ($p > 0.05$). feed conversion ratio was significantly ($p < 0.05$) influenced by the treatments.

The substitution of CP-MC in the pigs' diet had a significant impact on performance parameters, and the performance indices increased as the amount of CP-MC in the dietary maize increased. This observed performance can be attributed to a synergy between the pigs' digestive systems and their improved utilization of CP-MC diets treated with enzymes by the grower pigs. This is consistent with findings from Ikurior et al. (1996), who reported that as animals age, they tend to handle fiber more efficiently, and Cheson (2001) who noted that enzymes are a rich source of high-quality protein (amino acids), which compensate for the low quality of crude protein in CP-MC.

The similar impact of dietary treatments on the performance of pigs in T3 and T4 indicates that the mix is appropriate for pigs' diets. The results show that developing pigs fed 50% cassava leaf meal instead of maize performed no differently than the studies by William et al. (2022). The experiment's outcomes, however, are consistent with the findings of Irekhore et al. (2015), who found that substituting cassava peel for corn had a considerable impact on the performance indices of growing pigs. In addition, Ly et al. (2010); and Alagbe (2017), found no discernible changes in the final body weight, average daily gain, dry matter intake, or feed conversion ratio of crossbred pigs fed a diet including dried and ensiled cassava leaf.

Pigs fed a CP-MC diet showed an increase in final weight and weight gain; however, this significant difference may be related to the activities of enzymes that promoted weight gain. Beachemin et al. (2003) reported that high-producing or growing animals require high levels of available energy to meet the demand for meat production above and beyond maintenance needs; therefore, adding enzymes to energy/high-fiber diets would help close the gap between the animal's potential and actual performance by helping to release more digestible energy from fibrous fractions for the animals to use. Dietary supplementation of enzymes treated CP-MC, especially among pigs in T3 and T4, enhanced the nutrient content of feeds (Garcia et al., 2008). Overall results showed that CPMC-based diets were able to support as much growth as the maize-based diet in T1.

Table 2. Growth performance of grower pigs fed CP-MC.

Specifications	T1	T2	T3	T4	SEM
Initial weight (kg/pig^{-1})	20.91	20.31	20.80	20.54	1.05
Final weight (kg/pig^{-1})	41.76^{c}	43.72^{b}	50.15^{a}	50.76^{a}	0.91
Weight gain (kg/pig^{-1})	20.85^{c}	23.41^{b}	29.35^{a}	30.22^{a}	1.41
Av. daily weight gain (kg/day^{-1})	0.23^{c}	0.26^{b}	0.33^{a}	0.34^{a}	0.02
Total feed intake (kg/pig^{-1})	51.22	51.10	51.63	51.60	1.96
Av. daily feed intake (kg/day^{-1})	0.57	0.57	0.57	0.57	0.02
Feed conversion ratio	2.46^{a}	2.18^{b}	1.76^{c}	1.71^{c}	0.06
Mortality (%)	0	0	0	0	-

Note: $^{a, b,c}$ Means on the same row with different superscripts are significantly different ($p < 0.05$); T1: 0% CP-MC; T2: 40% CP-MC; T3: 50% CP-MC; T4: 60% CP-MC; SEM: standard error of the mean. Source: Authors, 2024.

Table 3 presents the carcass characteristics of grower pigs fed dried cassava peel-maize cob mixture as a replacement for maize (CP-MC). Carcass weight and dressing percentage values varied from 48.73 - 54.78 kg and 61.61 - 70.49% respectively. Dressing percentage was higher in T3 and T4, intermediate in T2, and lowest in T1 ($p < 0.05$). Dietary treatment influenced ($p < 0.05$) the weights of the head, back, belly, forelimb, hind limb, back fat thickness, liver, lungs, spleen, heart, and gastrointestinal tract except for the weight of kidney ($p > 0.05$). Weights of the head, back, belly, forelimb, hind limb, liver, lungs, spleen, heart, and gastrointestinal tract ranged from 4.88 to 5.85 kg, 6.71 to 8.15 kg, 3.87 to 4.56 kg, 9.96 to 15.36 kg, 10.02 to 15.22 kg, 7.09 to 8.11kg, 0.09 to

1.03 kg, 0.41 to 0.54 kg, 0.10 to 0.15 kg, 0.18 to 0.25 kg and 5.71 to 6.33 kg respectively.

When compared to other treatments, the dressing % of pigs fed the T3 and T4 diet was better, which may have been caused by the meal's ingredients. High-nutrient diets, especially those with readily available energy and protein, exhibit higher tissue accretion and quick protein synthesis (Njoku et al., 2013). Pigs with greater nutritional status consume enough nutrients to support their fast growth and development (Unigwe et al., 2017); Alagbe (2017). Nonetheless, the dressing percentage of pigs fed a diet containing 50% replacement of CP-MC was comparable to that of pigs fed a diet containing 60% T4 diet. This implies that the pigs have access to enough protein and energy.

This also has to do with how enzymes affect CP-MC, helping to release nutrients that have been trapped in the feed material. Pigs fed CP-MC had higher weights in the primal cut portions, such as the belly and hind limbs, than pigs fed the control diet (T1). This supports the findings of Njoku et al. (2013), who found that the weights of the head, ham, feet, and shoulders were higher in pigs with bigger body weights. Additionally, when the weight at slaughter increased, so did the weights of the ham, shoulder, and loin, according to Lo-Fiego et al. (2005), and Latorre et al. (2008). In a similar vein, pigs fed T3 and T4 had significantly higher heart weights than the other groups. This may be explained by the phytochemicals in CP-MC, which provide the body's tissues with an ample supply of oxygen (Hong et al., 2016). The liver is linked to nutrition metabolism and secretes bile (Hong et al., 2016).

Table 3. Carcass characteristics of grower pigs fed CP-MC.

Specifications (kg^{-1})	T1	T2	T3	T4	SEM
Live weight (kg)	41.76^c	43.72^b	50.15^a	50.76^a	0.92
Carcass weight (kg)	25.73^c	29.38^b	36.08^a	35.78^a	1.65
Dressing percentage (%)	61.61^c	67.20^b	71.94^a	70.49^a	1.76
Head (kg)	4.88^c	5.21^b	5.75^a	5.85^a	0.18
Back (kg)	6.71^c	7.53^b	8.00^a	8.15^a	0.23
Belly (kg)	3.87^c	4.10^b	4.49^a	4.56^a	0.02
Forelimb (kg)	9.96^c	11.98^b	14.70^a	15.36^a	0.42
Hind limb (kg)	10.02^c	13.75^b	15.00^a	15.22^a	0.44
Back fat thickness (mm)	7.09^b	7.22^b	8.00^a	8.11^a	0.21
Kidney (kg)	0.10	0.10	0.10	0.10	0.02
Liver (kg)	0.09^b	0.09^b	1.02^a	1.03^a	0.01
Lungs (kg)	0.41^b	0.50^a	0.53^a	0.54^a	0.02
Spleen (kg)	0.10^b	0.10^b	0.10^b	0.15^a	0.01
GIT weight (kg)	5.71^b	5.88^b	6.21^a	6.33^a	0.02

Note: $^{a, b, c}$, Means on the same row with different superscripts are significantly different ($p < 0.05$); T1: 0% CP-MC; T2: 40% CP-MC; T3: 50% CP-MC; T4: 60% CP-MC; SEM: standard error of the mean. Source: Authors, 2024.

4. Conclusions

In conclusion, dried cassava peel–maize cob mixture contains essential nutrients and phytochemicals which are needed for the growth of pigs especially when used to replace maize up to 60%. Phyto-constituents in CP-MC improved the utilization of nutrients in the gastrointestinal tract of pigs without compromising the health of the animals.

5. Acknowledgments

We thank the Department of Animal Science of the University of Abuja, Nigeria.

6. Authors' Contributions

Daniel Nnadozie Anorue: study design, project writing, animal experimentation, data collection, statistical analysis, article writing, post-evaluation corrections, and publication.

7. Conflicts of Interest

No conflicts of interest.

8. Ethics Approval

Yes, applicable. It was carried out according to the ethical guidelines and procedures of the Animal Science Department (ANS/2024A), Nigeria.

9. References

Adesehinwa, A. O. K., Obi, O. O., Makanjuola, B. A., Oluwole, O. O., & Adesina, M. A. (2011). Growing pigs fed cassava peel based diet supplemented with or without Farmazyme® 3000 proenx: Effect on growth, carcass and blood parameters. *African Journal of Biotechnology*, 10, 2791-2796. https://doi.org/10.5897/AJB10.967

Alagbe, J. O., Eimoga, A. A., & Alagbe, O. O. (2017). Growth response and carcass characteristics of weaner grass cutters fed diets supplemented with *Polyalthia longifolia* seed oil as a natural growth promoter. *Greener Journal of Agricultural Sciences*, 7(5), 112-119. http://doi.org/10.15580/GJAS.2017.5.071617086

Alagbe, J. O. (2017). Growth performance and blood parameters of weaner pigs fed diets supplemented with turmeric powder. *Scholarly Journal of Agricultural Science*, 7(2), 57-61.

Alagbe, J. O. (2017). Effect of miadasan as a dietary supplement on performance, carcass characteristic and blood profile of broiler chicken. *Scholarly Journal of Agricultural Science*, 7(2), 27-33.

Alagbe, J. O. (2017). Nutrient evaluation of sweet orange (*Citrus sinensis*) fruit peel as a replacement for maize in the diets of weaner grass cutters. *Scholarly Journal of Agricultural Science*, 6(8), 277-282.

Alagbe, J. O. (2019). Effects of feeding varying levels of tigernut (*Cyperus esculentus*) seed meal on the performance and blood profile of weaner grass cutters. *Scholarly Journal of Agricultural Science*, 7(1), 15-19.

Buchanan, A., Asker, N. E. Aly, M. M., Hala, A.M., Abdel-Wahed, M., & Omar, E. M. (2007). The use of sorghum in broiler and layer diets with reference to enzyme supplementation. *Journal of Agricultural Science. Mansoura University*, 23, 5307-5323.

Dey, T., Bhattacharjee, T., Nag, P., Ritika, Ghati, A., & Kuila, A. (2021). Valorization of agro-waste into value added products for sustainable development. *Bioresource Technology Reports*, 16, 100834. https://doi.org/10.1016/j.biteb.2021.100834

Ekeledo, E., Latif, S., Abass, A., & Müller, J. (2021). Antioxidant potential of extracts from peels and stems of yellow-fleshed and white cassava varieties. *International Journal of Food Science and Technology*, 56(3), 1333-1342. https://doi.org/10.1111/ijfs.14814

García-Valverde, R., Barea, R., Lara, L., Nieto, R., & Aguilera, J. F. (2008). The effects of feeding level upon protein and fat deposition in Iberian heavy pigs. *Livestock Science*, 114(2-3), 263-273. https://doi.org/10.1016/j.livsci.2007.05.005

Hong, T. T. T., van An, L, V., Be, P. T., & Lindberg, J. E. (2016). Effect of fermented rice bran and cassava waste on growth performance and meat quality of crossbred pigs. *World Journal of Agricultural Research*, 4(5), 132-138. https://www.sciepub.com/wjar/abstract/6217

Irekhore, O. T., Adeyemi, O. M., Idowu, O. M. O., Akinola, O. S., Bello, K. O. (2015). Growth performance, haematological indices and cost benefits of growing pigs fed cassava peel meal diets supplemented with Allzyme® SSF. International *Journal of Applied Agriculture and Apiculture Research*, 11(1-2), 51-59. https://www.ajol.info/index.php/ijaaar/article/view/141567

Jit, B. P., Pattnaik, S., Arya, R., Dash, R., Sahoo, S. S., Pradhan, B., Bhuyan, P. P., Behera, P. K., Jena, M., Sharma, A., Agrawala, P. K., & Behera, R. K. (2022). Phytochemicals: A potential next generation agent for radioprotection. *Phytomedicine*, 106, 154188. https://doi.org/10.1016/j.phymed.2022.154188

Khamphasan, P., Lomthaisong, K., Harakotr, B., Ketthaisong, D., Scott, M .P., Lertrat, K., & Suriham, B. (2018). Genotypic variation in anthocyanins, phenolic compounds, and antioxidant activity in cob and husk of purple field corn. *Agronomy*, 8(11), 271. https://doi.org/10.3390/agronomy8110271

Lo Fiego, D. P., Santoro, P., Macchioni, P., & Leonibus, E. (2005). Influence of genetic type, live weight at slaughter and carcass fatness on fatty acid composition of subcutaneous adipose tissue of raw ham in the heavy pig. *Meat Science*, 69(1), 107-114. https://doi.org/10.1016/j.meatsci.2004.06.010

Nrc. (2012). Nutrient Requirements of Poultry. 9th Revised Edn. National Academy of Service Washington DC.

Njoku, C. P., Aina, A. B. J., Sogunle, O. M., Oduguwa, O. O., Adeyemi, O. A., & Ekunseitan, D. A. (2013). Influence of feed quantity offered on linear body measurements, nutrient digestibility, and back fat composition of finishing pigs. *The Pacific Journal of Science Technology*, 14(1), 387-396.

Ojediran, T. K., Olayiwola, S., Adeyeye, M., Ajayi, A. F., & Emiola, I. A., (2020a). Effect of palm kernel meal-based diet with or without enzyme supplementation on growth performance, economic benefits and villi morphometry of weaned pigs. *Polish Journal of Natural Sciences*, 35(2), 129-139.

Oladunjoye, I. O., Ojebiyi, O. O., & Odunsi, A. A (2008). Performance, characteristics and egg quality of laying chicken fed lyre treated cassava peel meal. Proceedings of the Annual Conference of ASAN. 12th -19th September. ABU, Zaria, 355-357 p.

Oladunjoye, I. O., Ojebiyi, O., & Amao, O. A (2010). Effect of feeding processed cassava (*Manihot esculenta* crantz) peel meal based diet on the performance characteristics, egg quality and blood profile of laying chicken. *Agricultural Tropica et Subtropica*, 43(2), 119-126. https://www.cabidigitallibrary.org/doi/full/10.5555/20103313026

Olowoyeye, J. O., Agbede, J. O., Igbasan, F. A., Oloruntola, O. D., & Ayeni, A. O. (2019). Effect of replacing maize with cassava peel-leaf mixture on growth performance of broiler chikens. *Livestock Research for Rural Development*, 31(10). https://lrrd.cipav.org.co/lrrd31/10/olugb31155.html

Owen, O. J., & Amakiri, A. O (2010). Japanese quail (*Coturnix coturnix japonica*): It's potentials, opportunities and challenges. Proceedings of the 31st Annual Conference of the Nigerian Society for Animal Production. 14-17th March, 2010. University of Ibadan, Oyo State. Nigeria, 333-335 p.

Thuppahige, V. T. W., Moghaddam, L., Welsh, Z. G., Wang, T., & Karim, A. (2023). Investigation of critical properties of cassava (*Manihot esculenta*) peel and bagasse as starch-rich fibrous agro-industrial wates for biodegradable food packaging. *Food Chemistry*, 422, 136200. https://doi.org/10.1016/j.foodchem.2023.136200

Unigwe, C. R., Raji, A. M., Ajayi, J. O., Popoola, A. M., Balogun, F. A., & Adekunle, F. O. (2017). Carcass, organ weights and histo-morphology of internal organs of sows fed fermented and enzyme-supplemented cassava peels meal (CPM) based diets. *Journal of Plant and Animal Sciences*, 2(1), 26-36.

Williams, G. A., Akinola, O. S., Adeleye, T. M., Irekhore, O. T., Oso, A. O., Ayansola., E. I., Oke, I. O., Ogunrombi, J. O., Ogunpitan, K. O., & Bamgbose, A. M. (2022). Effect of differently processed cassava peel-leaf blend on growth performance, carcass yield and ileal microflora of growing pigs. *Trends in Agricultural Sciences*, 1(2), 78-86. https://doi.org/10.17311/tas.2022.78.86

Zavala-López, M., López-Tavera, E., Figueroa-Cárdenas, J. D., Serna-Saldívar, S. O., & García-Lara, S. (2018). Screening of major phenolics and antioxidant activities in teosinte populations and modern maize types. *Journal of Cereal Science*, 79, 276-285. https://doi.org/10.1016/j.jcs.2017.11.007

Funding

Not applicable.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.