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GROWTH PERFORMANCE OF POST-WEANED PIGS FED WITH DIETS CONTAINING HIGH QUALITY CASSAVA PEEL AND SOYA BEAN MEAL

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ABSTRACT

A major challenge facing profitable swine production in Sub-saharan Africa is the high cost of conventional feed ingredients such as maize. High Quality Cassava Peel (HQCP) has demonstrated considerable potential as an alternative energy source. However, inclusion of HQCP in swine diets often results in crude protein deficit, necessitating supplementation. This study evaluated the growth performance of post-weaned pigs fed diets containing HQCP with and without soya bean meal (SBM) supplementation. In a completely randomized design, 30 post-weaned pigs were assigned to 5 dietary treatments. Each treatment had 3 replicates with 2 animals per replicate. The 5 treatments were T1: (Control diet) which had no HQCP; T2: 15% HQCP without soya bean meal supplementation; T3: 30% HQCP without soya bean meal supplementation; T4: 15% HQCP with soya bean meal supplementation and T5: 30% HQCP with soya bean meal supplementation. The study lasted 42 days during which performance and economic indices were recorded. Final body weight, total weight gain, average daily weight gain and feed conversion ratio did not differ ($p<0.05$) significantly with the dietary treatments. Feed intake was significantly ($p< 0.05$) influenced, with highest intake from the pigs on the control diet (88.50 kg) and the lowest from pigs on 30% HQCP without soya bean meal supplementation (74.40 kg). Back fat thickness varied significantly; with leaner carcasses observed in pigs fed HQCP-containing diets than pigs on the control diet. Blood Urea Nitrogen (BUN) levels differed ($p<0.05$) significantly across treatments; with the lowest levels in pigs on the control diet (13.11 mg/dL) and highest in pigs on 30% HQCP with soya bean meal supplementation (15.61 mg/dL). White Blood Cell count was significantly ($p<0.05$) reduced from 4700.00 × 10^3/μL in pigs on the control diet to 3416.67 × 10^3/μL in pigs on 30% HQCP with soya bean meal supplementation Total feed cost and cost/kilogramme weight gain were affected by dietary treatments; with the most economical performance from pigs on 30% HQCP without soya bean meal supplementation (₦1,705.68/kg gain). Inclusion of 30% level of

HQCP (without soya bean meal supplementation) in diets of post-weaned pigs is a safe, cost-effective and physiologically compatible alternative to maize in post-weaned pig diets.

Keywords: Piglets; Back fat; Blood Urea Nitrogen; White Blood Cells; Feed cost.

INTRODUCTION

The high and fluctuating cost of conventional feed ingredients, particularly maize, continues to pose a major constraint to profitable pig production in sub-Saharan Africa (Adesehinwa *et al*., 2024). This has necessitated the exploration of alternative, locally-available feed resources that are cost-effective and do not compete directly with human food. One of such alternatives is High Quality Cassava Peel (HQCP), a value-added by-product derived from cassava processing which has gained traction in recent years for its potential in livestock feeding.

The International Livestock Research Institute (ILRI), in collaboration with local processors, has developed a standard method for the production of HQCP which involves mechanical pressing and drying to reduce moisture and cyanogenic glycoside content (ILRI, 2020). The resulting product has a relatively high energy value and low fibre content, making it suitable for partial replacement of maize in pig diets. Adesehinwa *et al.* (2016) have demonstrated that HQCP can replace up to 30% of maize in the diets of growing pigs without adverse effects on growth performance or nutrient digestibility. However, partial replacement of maize with HQCP can result in protein deficit, especially in post-weaned pigs with high crude protein requirements. Some studies (Ball *et al*, 2013; Van Milgen and Dourmad, 2015; Ogunjobi *et al*., 2021) however have reported acceptable performance when protein levels are balanced. Few though, have examined the role of strategic soya bean meal supplementation to correct this protein imbalance in HQCP-based diets. Despite its promising nutritional and economic potential, HQCP is still underutilized in post-weaning pig diets due to uncertainties surrounding its optimal inclusion levels and the need for protein balancing. Most existing studies focus either on grower or finisher phases, with limited research addressing post-weaning phase; an important stage marked by heightened sensitivity to dietary changes. This study therefore evaluated the effects of partially replacing maize with HQCP in the diets of post-weaned pigs, with and without soya bean meal supplementation on the performance, haematological and serum biochemical indices. This was done to verify the potential inclusion and economics of HQCP in the diets of post-weaned pigs without eliciting any adverse effects on health.

MATERIALS AND METHODS

Experimental Site and Animal Management

The experiment was conducted at AK Research Farm, Ibadan, Nigeria. A total of 30 healthy mixed sex post-weaned pigs (Large White × Landrace crosses) were used for this study. The pigs were 11 weeks old, with an average 14.37 kg ± 1.92. They were housed in well ventilated pens with concrete floors. Each pen was equipped with feeding and watering troughs. Strict biosecurity measures were observed throughout the trial. Fresh feed and clean drinking water were provided *ad libitum*.

Experimental Design and Diets

The pigs were randomly allotted to five (5) dietary treatments. Each treatment was replicated three (3) times with two (2) pigs per

replicate in a completely randomized design (CRD). The treatments were
T1: control diet which had no HQCP.
T2: diet with 15% HQCP without soya bean meal supplementation.
T3: diet with 30% HQCP without soya bean meal supplementation.
T4: diet with 15% HQCP with soya bean meal supplementation.
T5: diet with 30% HQCP with soya bean meal supplementation.

Soya bean meal supplementation in T4 and T5 refers to the addition of extra soya bean meal beyond the basal 25 % level used in the control to offset the protein dilution effect that may be caused by HQCP inclusion. The basal diet was formulated to meet the NRC (2012) nutrient requirements for growing pigs. The major constituents of the diet included maize, HQCP, soya bean meal, corn bran, wheat bran and fish meal (Table 1).

Table 1: Gross Composition of Experimental Diets

Ingredient	T1	T2	T3	T4	T5
Maize	45.00	30.00	15.00	30.00	15.00
HQCP	0	15.00	30.00	15.00	30.00
Corn bran	12.00	12.00	12.00	12.00	12.00
Soya bean meal	25.00	25.00	25.00	27.50	30.00
Wheat bran	10.00	10.00	10.00	7.50	5.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Bone meal	2.50	2.50	2.50	2.50	2.50
Limestone	1.50	1.50	1.50	1.50	1.50
Methionine	0.15	0.15	0.15	0.15	0.15
Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Salt	0.30	0.30	0.30	0.30	0.30
Toxin binder	0.05	0.05	0.05	0.05	0.05
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis					
Crude Protein (%)	19.55	18.65	17.75	19.28	19.00
Metabolizable Energy (Kcal/Kg)	2817.10	2752.00	2686.90	2772.75	2724.40
Crude Fat (%)	4.66	4.45	4.24	4.45	4.24
Crude Fibre (%)	4.91	6.41	7.91	6.36	7.81

T1 = Control diet; T2 = 15% HQCP without soya bean meal; T3 = 30% HQCP without soya bean meal; T4 = 15% HQCP with soya bean meal; T5 = 30% HQCP with soya bean meal.

Data Collection and Performance Measurement

Data on growth performance and feed utilization were collected to evaluate the effects of dietary treatments on the post-weaned pigs. Each pig was weighed at the beginning of the experiment to determine initial body weight and subsequently on a weekly basis using a walkthrough platform digital scale. Feed intake was measured daily. Total weight gain was recorded as the difference between the initial and final body weights. Average daily weight gain was determined by calculating the difference between the final and initial body weights of each pig and dividing the result by the number of experimental days. For feed intake, a known quantity of feed was offered to the pigs without restrictions and refusals were collected and weighed daily. The difference between the amount of feed offered and the quantity refused constituted the daily feed intake. Average daily feed intake was obtained by dividing the total quantity of feed consumed by each pig over the 42-day period. Feed conversion ratio was derived as the ratio of average daily feed intake to average daily weight gain and served as a measure of feed efficiency.

Data Analysis and Means Separation

All data were subjected to one-way analysis of variance (ANOVA) using the General linear model of SAS (1999) and means, where significant, were separated using the Duncan Multiple Range Test at 5% significance level (Duncan, 1955).

Table 2: Proximate Composition of Experimental Diets

	T1	T2	T3	T4	T5
DM	91.75	91.00	91.33	91.57	91.22
ASH	4.58	4.33	5.81	5.22	6.35
NDF	34.78	33.44	36.72	36.85	37.66
ADF	13.50	14.49	12.31	14.71	16.10
EE	3.86	3.06	3.48	2.70	2.72
CF	5.60	6.39	4.19	4.64	5.74
Threonine	0.83	0.78	0.68	0.62	0.64
Methionine	0.36	0.30	0.33	0.27	0.27
lysine	1.09	1.03	0.88	0.83	0.83

DM = Dry Matter, NDF = Neutral Detergent Fibre, ADF = Acid Detergent Fibre, EE = Ether Extract, CF = Crude Fibre , T1 = Control diet; T2 = 15% HQCP without soya bean meal; T3 = 30% HQCP without soya bean meal; T4 = 15% HQCP with soya bean meal; T5 = 30% HQCP with soya bean meal.

RESULTS AND DISCUSSION

Proximate Composition of Experimental Diets

The proximate composition of the experimental diets was carried out according to the methods described by AOAC (2005). Dry matter ranged between 91 and 91.75%, ash content varied between 4.33 and 6.35 (Table 2). Neutral detergent fibre ranged between 33.44 and 37.66% while acid detergent fibre ranged from 12.31 to 16.10. Ether extract ranged from 2.70 to 3.86% and crude fibre ranged from 4.19 to 6.39% (Table 2).

Growth Performance

There were no significant differences in the final body weight (FBW), total weight gain (TWG) and average daily weight gain (ADWG) of pigs on the treatments (Table 3), indicating that inclusion of HQCP up to 30%, whether supplemented with soya bean meal or not, did not adversely affect the pigs' capacity for body weight accretion during the post-weaning period.

Final body weights ranged from 45.50 kg for pigs fed 30% HQCP without soya bean meal supplementation to 51.50 kg for those fed the control diet. Total weight gain and average daily weight gain followed a similar trend, with the highest values recorded from pigs on the control diet (37.83 kg; 0.80 kg/day) while the least values (31.63 kg; 0.67 kg/day) were observed in pigs fed 15% HQCP without soya bean meal supplementation. There was a mild performance depression in diets where maize was replaced with HQCP without adjusting for protein deficit occassioned by the introduction of HQCP. Cassava tuber products such as the peels are rich in fermentable carbohydrates and useful as energy sources but they are relatively low in crude protein and essential amino acids such as lysine and methionine (Amaza, 2021). The observed reduction in weight gain among pigs fed 15% and 30% HQCP without protein supplementation may be attributable to insufficient amino acid availability to support optimal tissue accretion (Kiarie, 2008), particularly in post-weaned pigs whose protein requirements are relatively high (NRC, 2012). Conversely, soya bean meal supplementation in diets with 15% and 30% HQCP with soya bean supplementation appeared to ameliorate this effect, restoring growth to levels closer to the control. These results align with the findings of Adesehinwa *et al.* (2016), who emphasized the importance of correcting for protein dilution in cassava-based diets to support efficient pig growth.

Unlike weight gain, total feed intake (TFI) and average daily feed intake (ADFI) were significantly affected by the dietary treatments. Pigs fed the control diet consumed the most feed (88.50 kg TFI; 1.88 kg ADFI) while those fed 30 % HQCP without soya bean meal supplementation consumed the least amount (74.40 kg TFI; 1.58 kg ADFI). The significant decline in feed intake with increasing HQCP inclusion, especially without protein supplementation may reflect both the fibrous nature of cassava peels and the relatively lower palatability of the diet (Oduguwa *et al.*, 2007). Higher dietary fibre can increase gut fill and reduce gut transit time, thereby suppressing voluntary intake (Sakomura and Rostagno, 2007). The soya bean meal-supplemented HQCP diets partially restored feed intake to levels approaching those of the control group, suggesting that improving dietary protein balance may stimulate appetite and nutrient-driven intake. Studies by Zheng *et al.* (2016) showed that low protein diets significantly inhibited feed intake and body weight of piglets, growing pigs and finishing pigs, indicating that the decrease in feed intake and body weight may be mainly related to limitations in protein and amino acid levels.

Despite the differences in feed intake, feed conversion ratio (FCR) which ranged from 2.35 for pigs fed the control diet to 2.58 for pigs fed 15% HQCP without soya bean meal supplementation remained unaffected by dietary treatment, indicating that the efficiency of converting feed into body weight was broadly maintained across treatments. The ability of pigs on HQCP-based diets to sustain comparable FCRs suggests that once the nutrient requirements are met (even partially), nutrient utilization is not compromised (Kong and Adeola, 2014). This observation is supported by ILRI (2020) which reported that HQCP, when adequately processed and nutritionally balanced, does not impair feed efficiency in swine.

Table 3: Growth Performance of Pigs fed HQCP with or without Soya Bean Meal

	T1`	**T2**	**T3**	**T4**	**T5**	SEM	*p* value
Initial Weight (Kg)	13.67	15.67	13.88	14.75	14.10	0.44	0.73
Final Weight (Kg)	51.50	48.25	45.50	50.88	46.70	1.29	0.58
TWG (Kg)	37.83	32.58	31.63	36.13	32.60	1.04	0.32
ADWG (Kg)	0.80	0.69	0.67	0.77	0.69	0.02	0.32
FI (Kg)	88.50[a]	81.87[ab]	74.40[b]	85.28[ab]	76.30[ab]	1.97	0.11
ADFI (Kg)	1.88[a]	1.74[ab]	1.58[b]	1.81[ab]	1.62[ab]	0.04	0.11
FCR	2.35	2.58	2.36	2.36	2.35	0.04	0.55

[a,b] Means within a row with different superscripts differ significantly at P < 0.05.
T1 = Control diet; T2 = 15% HQCP without soya bean meal; T3 = 30% HQCP without soya bean meal; T4 = 15% HQCP with soya bean meal; T5 = 30% HQCP with soya bean meal. TWG = Total weight gain (kg); ADWG = Average daily weight gain (kg/day); FI = Total feed intake (kg); ADFI = Average daily feed intake (kg/day); FCR = Feed conversion ratio; SEM = Standard error of the mean. Cost variables are expressed in Nigerian Naira (₦).

Fat Deposition of Pigs Fed HQCP Diets with and without Additional Soya bean meal

Fat deposition, as measured by back fat thickness, showed a significant response to diet. Pigs on the control diet recorded the highest back fat thickness (11.33 mm) while pigs in 30% HQCP without soya bean supplementation recorded 8.75 mm which was the leanest in terms of back fat deposition (Figure 1). Intermediate values were observed in the other diets. The decrease in back fat thickness with HQCP inclusion may be due to the higher fibre content and lower digestible energy of the diets which can shift nutrient partitioning away from fat deposition and towards lean tissue accretion (Sakomura and Rostagno, 2007). From a market perspective, such leanness may be advantageous in regions where consumers prefer leaner pork. This result suggests that HQCP can be safely included in post-weaned pig diets at levels up to 30% without compromising growth performance or feed efficiency.

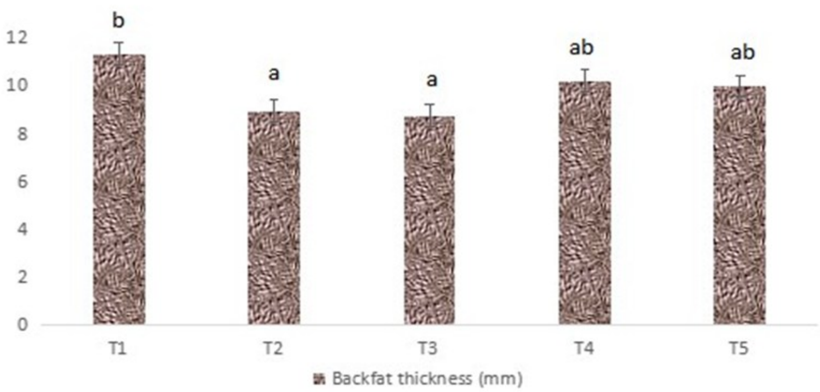

Fig 1: Back fat thickness (mm) of post-weaned pigs fed HQCP supplemented with and without additional soya bean meal in the diet

Haematological Indices of Post-weaned Pigs Fed HQCP Diets with and without Additional Soya bean meal

Except white blood cell (WBC) counts and monocytes, all the parameters measured did not differ significantly across the dietary treatments (Table 4). Values of haemoglobin (Hb), red blood cell (RBC) counts, monocytes and eosinophils were within physiological reference ranges for healthy pigs (Kaneko *et al.*, 2008). Values for packed cell volume (PCV) and lymphocytes were higher than range for healthy post-weaned pigs while values for white blood cells and neutrophils were lower than range (Table 4).

White blood cell (WBC) counts differed significantly in pigs across the different dietary treatments. Only pigs on the control diet had WBC count within the normal range for healthy post-weaned pigs (Table 4). Pigs on the other diets had WBC counts lower than the range for healthy pigs. This could be as a result of weaning stress which could be attributed to a combination of several factors which include separation from the sow, social changes (mixing with new litter), new environment, and dietary changes. These can lead to chronic stress resulting in lower total WBC counts.

Table 4: Haematological Parameters of Post-weaned Pigs Fed Diets Containing High Quality Cassava Peel (HQCP) and Soya bean Meal

Parameter	T1	T2	T3	T4	T5	SEM
PCV (%)	46.17	39.33	40.00	42.33	41.67	1.12
Hb (g/dL)	15.10	12.78	12.87	13.98	13.43	0.38
RBC (x10^{6}uL)	7.56	6.43	6.73	6.90	6.77	0.21
WBC (x10^{3}uL)	4700.00^a	4300.00^{ab}	3950.00^{ab}	3825.00^{ab}	3416.67^c	176.21
PLATELET (uL)	98833.33	84166.67	78500.00	94166.67	80000.00	3906.89
LYM (%)	74.00	68.67	70.17	73.17	71.00	0.93
NEUT (%)	23.00	26.67	26.5	25.83	26.5	0.82
MON (%)	2.00^{ab}	2.67^b	2.00^{ab}	1.33^a	1.17^a	0.17
EO (%)	1.00	2.00	1.33	1.33	1.50	0.18

^{a,b} Means within a row with different superscripts differ significantly ($p < 0.05$).
T1 = Control diet; T2 = 15% HQCP without soya bean meal; T3 = 30% HQCP without soya bean meal; T4 = 15% HQCP with soya bean meal; T5 = 30% HQCP with soya bean meal. PCV = Packed cell volume; Hb = Haemoglobin; RBC = Red blood cell count; WBC = White blood cell count; LYM = Lymphocytes; NEUT = Neutrophils; MON = Monocytes; EO = Eosinophils. SEM = Standard error of the mean

Serum Biochemistry of Post-weaned Pigs Fed HQCP and Soya bean meal

Except for albumin and blood urea nitrogen, none of the other parameters measured differed significantly (Table 5). Blood urea nitrogen (BUN) of pigs fed 30% HQCP without SBM, 15% HQCP with SBM and 30% HQCP with SBM were significantly higher than that of pigs on the control diet and 15% HQCP without SBM. The values were however lower than range for healthy post-weaned pigs. Lower-than-range BUN levels could be caused by nutritional factors especially a diet low in crude protein although the crude protein levels in the diets fed in this study met the crude protein requirements stipulated by NRC (2012). Values for total protein (TP), albumin and alanine aminotransferase (AST) fell within the normal range for healthy post-weaned pigs (Table 5). Total protein concentrations did not differ significantly across treatments. However, serum albumin concentration was significantly lower in pigs fed 15% HQCP with soya bean meal (2.34g/dL), possibly indicating either a dilutional effect due to plasma volume changes or a temporary shift in protein synthesis priorities favouring growth. Albumin levels are often influenced by both dietary protein intake and systemic inflammation (Jain, 1993). Absence of abnormal values indicates that HQCP diets did not induce systemic protein deficiency or hepatic dysfunction. Aspartate aminotransferase (AST) is a key enzyme used to assess liver function and hepatocellular integrity. The values obtained in this study indicates healthy liver function and a successful adaptation of the pigs to the physiological stresses of weaning.

Total antioxidant capacity (TAC) values were not significantly influenced by the diets although the values were higher than normal range for healthy post-weaned pigs (Table 5). A higher than normal TAC is generally considered a positive indicator of good antioxidant status and reduced oxidative stress in post-weaned pigs. It also suggests that the animals' defence systems are effectively managing stress. This suggests that HQCP inclusion, even at 30%, did not induce oxidative stress in post-weaned pigs. ILRI (2020) highlighted that properly processed HQCP, with low cyanide content, can be safely included in pig diets without compromising oxidative status.

Table 5: Serum Biochemical Indices of Post-weaned Pigs Fed Diets Containing HQCP and Soya bean Meal

Parameter	T1	T2	T3	T4	T5	SEM	P-value
GLUC (mg/dL)	69.78	80.35	76.06	57.58	60.41	3.53	0.18
AST (IU/L)	41.16	38.50	39.16	40.83	39.50	0.57	0.56
T.P (g/dL)	6.88	7.18	7.57	7.28	7.33	0.13	0.60
ALB (g/dL)	2.89^{a}	2.87^{a}	2.74^{a}	2.34^{b}	2.70^{a}	0.05	0.01
CHOL (mg/dL)	68.00	63.83	65.00	67.00	68.66	1.16	0.68
HDL (mg/dL)	34.00	31.83	32.33	31.83	34.66	0.74	0.67
BUN (mg/dL)	13.11^{b}	14.45^{ab}	15.25^{a}	14.91^{a}	15.61^{a}	0.27	0.02
TAC (mM Trolox Eq)	14.87	9.56	12.81	10.02	10.89	1.04	0.50

^{a,b} Means within a row with different superscripts differ significantly ($P < 0.05$).
T1 = Control diet; T2 = 15% HQCP without soya bean meal; T3 = 30% HQCP without soya bean meal; T4 = 15% HQCP with soya bean meal; T5 = 30% HQCP with soya bean meal. GLU = Glucose (mg/dL); AST = Aspartate aminotransferase (U/L); TP = Total protein (g/dL); ALB = Albumin (g/dL); CHOL = Cholesterol (mg/dL); HDL = High density lipoprotein cholesterol; BUN = Blood urea nitrogen (mg/dL); TAC = Total antioxidant capacity (mM Trolox Eq). SEM = Standard error of mean

Economic Analysis of Post-weaned Pigs fed HQCP and Soya Bean Meal

Cost of feed per kilogramme was highest for the control diet (₦871.25) and was lowest for diet with 30% HQCP without SBM (724.25) (Table 6). Total feed cost followed the same trend. The control diet cost ₦77,105.63 while the diet with 30% HQCP without SBM cost ₦53,886.01. Cost incurred per kilogramme weight gain was highest for pigs on the control diet (₦2,045.77) while it was lowest for pigs on the diet with 30% HQCP without SBM (₦1,705.68) (Table 6). This trend highlights the cost advantage of HQCP, a by-product whose market price is considerably lower than that of maize, thereby reducing overall ration cost without requiring expensive processing. As reported by ILRI (2020), HQCP can be produced at a significantly reduced cost per unit energy compared to cereals like maize, particularly in cassava-rich regions of West Africa. The cost of HQCP was ₦280/kg (0.177 USD/kg) while maize was ₦770/kg (0.487 USD/kg). Although the additional soya bean meal slightly increased diet cost, the overall economic benefit of HQCP inclusion was still retained. Pigs on diet with 15% HQCP with SBM which had the highest total feed cost (₦69,477.81) among groups fed HQCP had a value still markedly lower than the ₦77,105.63 recorded in the control. This finding aligns with that of Adesehinwa *et al.* (2016) who reported that soya bean supplementation, when used strategically to correct protein dilution in HQCP–based diets, has cost-saving advantages.

Table 6: Economic Analysis of Post-weaned Pigs fed HQCP and Soya Bean Meal

Parameter	T1`	T2	T3	T4	T5
Cost/Kg Feed (₦/Kg)	871.25	797.75	724.25	814.75	758.25
Total feed cost (₦)	77,105.63	65,307.80	53,886.01	69,477.81	55,992.21
FCR	2.35	2.58	2.36	2.36	2.35
Cost/Weight Gain (₦/Kg)	2,045.89	2,060.77	1,705.68	1,923.55	1,780.78

T1 = Control diet; T2 = 15% HQCP without soya bean meal; T3 = 30% HQCP without soya bean meal; T4 = 15% HQCP with soya bean meal; T5 = 30% HQCP with soya bean meal.

CONCLUSION

This study demonstrated that High Quality Cassava Peel (HQCP) can be effectively used to replace maize in the diets of post-weaned pigs at inclusion levels up to 30%.

HQCP is a nutritionally viable energy source when properly processed but there is the importance of protein correction when formulating such diets. Replacement of maize with HQCP considerably reduce feed costs and improve cost efficiency with or without soya bean meal supplementation. HQCP offers a sustainable, locally available and cost-effective alternative to conventional energy sources in swine production. When combined with targeted protein supplementation, it provides an effective strategy to reduce feed costs while supporting acceptable growth performance and carcass quality in post-weaned pigs.

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