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HIGH-QUALITY CASSAVA PEEL MEAL FOR GROWING PIGS: IMPLICATIONS ON CARCASS, MEAT QUALITY, ORGAN WEIGHTS, HEPATIC AND JEJUNUM HISTOLOGY

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ABSTRACT

The global increase in the production and processing of cassava tubers generates a lot of peel as waste. However, the effect of processing methods to increase the quality of the peel as an animal feed resource must look at the quality of the resultant food products. These effects are insufficiently studied. The study aimed to assess the impact of the processed peel on carcass quality, meat quality, organ weight and organ histology of growing pigs. Thirty (30) male growing pigs (Landrace × Large white) were randomly distributed to five groups with six (6) animals per group in a completely randomized design. Maize was substituted with high quality cassava peel meal (HQCPM) at 0%, 25%, 50%, 75%, and 100% for the experimental diets ranging from diets V to Z. The pigs fed HQCPM diets had higher carcass weights, resulting in an improved carcass yield. The colour, flavour, tenderness, juiciness, texture, and overall acceptability were statistically superior in the pigs fed diet Z. High feed fibre influenced organ weights: the HQCPM diets reduced ($P<0.05$) the organ weights. More so, the HQCPM diets affected ($P<0.05$) the histology of the liver and intestine with varying degrees of inflammation, shortened villi length, and reduced surface area. HQCPM diets enhanced the carcass weight and meat quality of growing pigs up to 100% replacement for maize. Nevertheless, the diets reduced organ weights and villi lengths, leading to reduced absorptive function.

Keywords: Histomorphometric, cassava peel, Organ, Pig, Pork quality, Primal cut

INTRODUCTION

In recent years, there have been concerted efforts by the key players in the livestock industry to contribute to doubling food production to meet the growing population demand by providing nutrients from animal products. Besides poultry, the swine industry is one of the most rapidly expanding livestock subsectors due to the various benefits attached to pig production. Pigs are known to be prolific, with short generational intervals and high fecundity (**Nkwengulila, 2014**). Additionally, the ability of pigs to ingest diverse feeds and efficiently convert by-products, wastes, and nutrients to high-quality animal protein (**Adesehinwa, 2008**) makes them more economically beneficial to farmers (**Ahaotu, 2017**) than other livestock.

Feed is considered the single greatest production cost in the pig industry (**Woyengo *et al*., 2014**), accounting for 55-85% of the overall production cost depending on the intensification of the production system (**Osondu, 2014**). Feed cost influences the profit margin and sustainability of pig production (**Ojediran *et al*., 2020a**), leading livestock nutritionists to the development of least-cost rations from low-cost feed ingredients (**Ahaotu *et al*., 2018**), especially from finished-food processing wastes and agro-industrial by-products (**Akintunde *et al*., 2011**).

Cassava (*Manihot esculenta*), a very cheap source of carbohydrates, serves as a portion of supplementary staple food for over 200 million Africans besides being used as livestock feed (**Banjoko *et al*., 2008**). Globally, Nigeria is ranked first on the cassava production scale with about 60 million tonnes (**FAOSTAT, 2019**). In Nigeria, cassava processing produces around fourteen (14) million metric tonnes of peels, woody tubers, undersized tubers, and stumps as by-products (**Okike *et al*., 2015**), which endangers human health due to environmental pollution. To mitigate the hazards associated with cassava by-products, livestock producers have identified cassava peels as a potential feed ingredient and incorporated them into livestock feed formulation. The potency of cassava peels for feeding animals has been demonstrated by several researchers, especially as an energy source and replacement for maize in pigs ration (**Akinfala and Tewe, 2001; Fatufe *et al*., 2007; Adesehinwa *et al*., 2008; Akinola *et al*., 2013**).

Despite the potency of cassava peel as a livestock feed resource, its use is limited due to its low crude protein content, poor amino acid (AA) profile, high fibre, high level of hydrogen cyanide (HCN) (**Salami and Odunsi, 2003**) and drying constraints during the wetter period of the year (**Ojediran *et al*., 2020b**). Appropriate supplementation of cassava peel diets with protein-rich sources and amino acids can effectively address the poor protein and AA profile. While HCN reduces nutrient bioavailability by hindering nutrient utilization, low-quality peels with aflatoxin contamination risk are generated when cassava peels are not properly dried. Also, the high fibre content of cassava peels negatively influences its use in monogastric (**Adesehinwa, 2011**) as it reduces digestibility. Hence, to utilize cassava peel judiciously in livestock ration formulation, especially monogastric, the peels must undergo some forms of treatment (**Salami, 2000; Chauynarong *et al*., 2009**).

Researchers have experimented several methods, including sun-drying (**Olafadehan *et al*., 2011**), ensiling (**Olafadehan *et al*., 2011**), boiling, soaking, enzymatic treatment (**Adesehinwa *et al*., 2011**), biodegradation (**Arowora *et al*., 2005**), and fermentation (**Ojediran *et al*., 2022**), to improve the nutritional value of cassava peels. In 2015, the Consultative Group on International Agricultural Research (CGIAR) scientists developed an innovative method for transforming wet cassava peels into high-quality cassava peel (HQCP) meal, which is safe and hygienic for livestock feeding (**ILRI, 2015**).

The use of HQCP meal has been tested on different classes of pigs (**Adesehinwa *et al*., 2016, 2017, 2018; Fatufe *et al*., 2017**). **Adesehinwa *et al*. (2016)** conducted a feeding trial of partial substitution of maize with varying levels of HQCP in growing pigs' diets. In the same study, the effect of HQCP was assessed on growth, cost-benefit, and blood biochemical responses of growing pigs. **Fatufe *et al*. (2017)** verified the nutrient availability of HQCP by conducting a nutrient digestibility trial to determine the effect of replacing corn partially with varied degrees of HQCPM on the nutrient and fibre fraction digestibility of growing pigs. Furthermore, **Adesehinwa *et al*. (2018)** fed HQCP supplemented with or without multi-strain direct-fed microbial (DFM) as partial substitutes for maize to growing pigs. Also, **Ojediran *et al*. (2022)** assessed the effects of fermented HQCP meal as a maize replacement on growth, production economics, and organoleptic of weaned pigs. However, the assessment of carcass, meat quality, organ weight, and histology of growing pigs fed HQCP is scarce in the literature. Therefore, this study focused on examining the effect of substituting maize with HQCP on the carcass, meat quality, organ weight, and histology of growing pigs.

MATERIAL AND METHODS

Research location

The swine facility of the Teaching and Research Farm at Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria was used for this study.

Procurement and preparation of test ingredients

Fresh cassava peels were procured from a cassava processing centre within Ogbomoso. At the same processing plant, the peels were further processed by sorting, washing, grating, pressing, sieving, and drying to generate a high-quality cassava peel meal (HQCPM) (**ILRI, 2015**). The production of HQCPM involved a multistage process (**Ojediran *et al*., 2023**) with the aim of reducing the HCN content. The procedure reduced HCN drastically (**Ojediran *et al*., 2023**) than just sun drying or gratting or ensiling employed by **Olurotimi *et al*. (2011).**

Experimental pig management

Thirty (30) male growing pigs (large-white × landrace) weighing averagely 23.85 ± 0.25 kg were allocated at random to five (5) treatments with six (6) replicates in a seven-week trial. The experiment commenced with the weighing of pigs after the pigs had been acclimatized for a duration of one week. Subsequent weighing occurred at weekly intervals. The pigs had unrestricted access to meticulously weighed feed and fresh water for the whole duration of the feeding trial.

Experimental diets

High-quality cassava peel meal (HQCPM) was used to formulate the diets by replacing maize in a maize-palm kernel cake-based diet. Five diets were compounded for the experiment (Table 1). Diet V served as the control diet with maize-palm kernel meal-based and no HQCPM. In diets W, X, Y, and Z, HQCPM substituted maize at 25%, 50%, 75%, and 100%, respectively.

Table 1 Gross composition of experimental diets

Ingredients (%)	V (0%)	W (25%)	X (50%)	Y (75%)	Z (100%)
Maize	40.00	30.00	20.00	10.00	0.00
HQCPM	0.00	10.00	20.00	30.00	40.00
Palm kernel cake	24.00	24.00	22.00	20.00	19.00
Wheat offal	7.00	7.00	7.00	7.00	5.00
Soybean meal	4.00	14.00	15.00	16.50	17.50
Full-fat soybean	4.00	4.00	6.00	8.00	11.00
#Fixed ingredients	21.00	21.00	21.00	21.00	21.00
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Nutrient composition					
Crude protein	17.15	16.78	16.78	16.79	17.02
M.E. (kcal/kg)	2838.80	2791.37	2755.94	2720.50	2701.07
Ether extract	4.49	4.23	4.47	4.38	4.46
Crude fibre	6.00	6.24	6.35	6.46	6.58

HQCPM = High-quality cassava peel meal; #Fixed ingredients = Groundnut cake-8.00%, Corn bran-10.00%, Bone meal-2.00%, Lysine-0.25%, Methionine-0.25%, Premix-0.25%, Salt-0.25% M.E. =Metabolizable energy; V= 0% maize replacement (control); W=10% maize replacement with HQCPM; X=20% maize replacement with HQCPM; Y=30% maize replacement with HQCPM; Z= 40% maize replacement with HQCPM.

Data Collection

Carcass evaluation: On terminating the experiment, two (2) pigs from each treatment group were randomly selected and transferred to the slaughterhouse where their gut was emptied through starvation for 12 hours before they were weighed, stunned, and slaughtered using traditional procedures (**Ojediran *et al*., 2021**). The bled weights were recorded after bleeding, and the hairs were singed before washing the carcass. The eviscerated weight was recorded after the visceral contents were removed, while the carcass weight was recorded after removing the head and trotters. The weights of the primal cuts, including the head, jowl, loin, ham, picnic shoulder, buston butt, spareribs, belly, and trotters were also weighed and expressed as a percentage of the live weight of the respective animal at slaughter.

Meat quality: The ham samples from the slaughtered animals from each treatment were cut into pieces of similar sizes in a raw state for sensory evaluation of the meat quality. The meat sub-samples were cooked in boiled water for five (5) minutes. Ten regular meat consumers served as panelists to evaluate the sub-samples based on the following sensory parameters; colour, flavour, tenderness, juiciness, texture, and overall acceptability as described by **Akinwumi *et al*. (2013):** the pre-labbeled meat samples were cooked at 100℃ for 15 minutes, allowed to cool and were served to the panelist as coded samples. The meat sensory parameters were evaluated using a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely) as the descriptor (**Ojediran *et al*., 2019**).

Organ weights: The weight of the following organs: whole stomach (WS), empty stomach (ES), gastrointestinal tract (GIT), liver, kidney, lungs, pancreas, and heart were estimated by weighing and expressed in relation to each slaughtered animal's live weight.

***Histology*:** The histological examination was done on the liver and jejunum by meticulously following the procedure described by **Ojediran *et al*. (2020a).** Labeled triplicate portions of the organs fixed in 10% neutral buffered formalin were further processed in an automatic tissue processor, embedded in paraffin wax and sectioned at 5 microns on a rotary microtome mounted on glass slides. Photomicrographs of the tissues were captured with a computerized digital camera (**Amscope MU900**).

Statistical Analysis

The collated data were analyzed using a one-way Analysis of Variance (ANOVA) of **SAS (2000)**, and Duncan's Multiple Range Test was used to separate the significant means.

RESULTS AND DISCUSSION

Carcass evaluation

Table 2 depicts the carcass characteristics of growing pigs fed high-quality cassava peel meal. The HQCPM diets had significant effects (P<0.05) on the carcass parameters. The variations in all the parameters did not follow a particular trend, but the pigs fed diet X had the highest values for final live weight, carcass weight, buston butt, belly, and ham. The pigs fed diet X had the highest final live weight, while the least final live weight was recorded in animals fed diet Z. The eviscerated weight was highest in the animals fed diet V and least in the pigs fed diet Y. The trotters of animals fed diet W are comparable to those fed diet X, but differ (P<0.05) from those fed other diets. However, pigs fed diet X had similar trotters value with pigs fed diets V and Z. The head values of all the treatments were found to be significantly different (P<0.05) from one another except for treatments W and Y, which par to each other. The jowl value was highest in animals fed diet Y and significantly different (P<0.05) from the values of pigs fed other diets (P>0.05). The picnic shoulder value ranged from 10.29% to 12.62% as observed in pigs fed diets Y and V, respectively. The buston butt values of animals fed diet V were not significantly different (P>0.05) from the values of animals fed diet W and X, however, differences (P<0.05) exist in the buston butt of animals fed diet W and X as well as those fed diets X and Y. The loin value is highest in animals fed the control diet and least in the pigs fed diet Z, which is similar to pigs fed diet X. The spare rib value ranged from 7.16% to 10.81% in pigs fed diets Y and Z, respectively. None of the diets had a similar effect on the belly of the animals. Pigs fed diets V, W, X, and Y had related (P>0.05) ham values and differs (P<0.05) from pigs fed diet Z.

Table 2 Carcass characteristics of growing pigs fed high-quality cassava peel meal

Parameters (%)	Treatments						
	V	W	X	Y	Z	SEM (±)	P-value
Final live weight (kg)	50.70^{b}	50.40^{c}	55.50^{a}	45.90^{d}	44.40^{e}	1.05	<0.001
Eviscerated weight	89.74^{a}	84.9^{d}	88.11^{b}	79.74^{e}	85.81^{c}	0.91	<0.001
Carcass weight	65.09^{d}	69.05^{b}	72.25^{a}	63.40^{e}	68.02^{c}	0.44	<0.001
Trotters	1.58^{b}	1.69^{a}	1.62^{ab}	1.44^{c}	1.58^{b}	0.02	<0.001
Head	6.61^{d}	6.85^{c}	7.57^{b}	6.86^{c}	7.88^{a}	0.13	<0.001
Jowl	2.76^{b}	3.17^{b}	3.06^{b}	3.68^{a}	3.60^{b}	0.92	0.040
Picnic shoulder	12.62^{a}	11.51^{c}	12.07^{b}	10.29^{d}	11.82^{b}	0.21	<0.001
Buston butt	8.54^{ab}	8.23^{b}	9.01^{a}	6.28^{d}	7.09^{c}	0.27	<0.001
Loin	15.29^{a}	12.40^{c}	11.89^{d}	14.37^{b}	11.60^{d}	0.39	<0.001
Spare rib	10.26^{b}	7.54^{d}	9.73^{c}	7.16^{e}	10.81^{a}	0.39	<0.001
Belly	6.51^{e}	7.44^{b}	7.57^{a}	7.12^{c}	6.76^{d}	0.11	<0.001
Ham	19.04^{a}	19.25^{a}	19.94^{a}	18.69^{a}	16.43^{b}	0.33	0.010

SEM= standard error of means; a,b,c,d,e =means with different superscripts along a row are significantly different (P<0.05)

In the study of growing pigs fed cassava peel-based diet supplemented with or without Farmazyme® 3000 proenix, **Adesehinwa *et al*. (2011)** reported comparable dressing percentage of pigs across the dietary groups and maize replacement with cassava peels supplemented with or without the exogenous enzyme did not affect the carcass weights of the pigs. While studying the effects of fermented and enzyme-supplemented cassava peels meal (CPM) on sows, **Unigwe *et al*. (2017)** reported that pigs fed a conventional maize-based diet had higher live weight, carcass weight, and dressing percentage than pigs fed cassava-based diets. However, no significant difference (P>0.05) was observed when the cassava-based diet was supplemented with an enzyme. In this study, it is evident that the maize replacement with high-quality cassava peel meal (HQCPM) influenced the carcass characteristics of grower pigs without following a particular trend. While the HQCPM diets depressed the final live weight (except diet X) and eviscerated weight, the carcass weight was increased (excluding diet Y). The findings of this study corroborate **Fanimo *et al*. (2005)** report that high levels of dietary fibre resulted in a reduction in weight gain and fat deposition in the carcass. The final live weight recorded in this study agrees with that of **Olayeni (2016)**, where the author studied the nutritive value of cassava root meal supplemented with or without activated charcoal in weaning-growing pig diets. Nevertheless, the weights of the picnic shoulder, ham, loin, and buston butt obtained in this study were superior, while the belly weight was inferior to that reported by the same author. The yields in pigs increase by 1% for every 10kg live weight (**Walter, 2000**). However, the depression of the pigs' final live weight by the HQCPM diets does not correspond to a reduced carcass weight in this study. The improved carcass yield in animals fed HQCPM diets might be due to the multi-processing technique of generating HQCP.

Meat quality

The meat quality of growing pigs fed high-quality cassava peel meal is illustrated in Table 3. The colour, flavour, tenderness, juice, texture, and overall acceptability were all significantly affected (P<0.05) by the HQCPM diets. The pigs fed diet Z were superior to the animals fed the other diets for all the meat quality and sensory evaluation parameters. For the meat colour, the animals fed diet X had similar values to those fed diet Z, while the pigs fed diet Y had comparable flavour values to the animals fed diets X and Z. While the meat tenderness was parred between the animals fed diets V and X, the pigs fed diets W and Y also had similar values. There was parity in the juiciness values of animals fed diets W and Y, which is comparable to diets X and Z. Diets V, W, and X had similar effects on the meat texture, and the values are comparable to the values of pigs fed diets Y and Z. The pigs fed diet Z had the highest acceptability followed by the pigs fed diet W. While similarities occur between the animals fed diets V, X, and Y.

Table 3 Meat quality of growing pigs fed high-quality cassava peel meal

Parameters	Treatments						
	V	W	X	Y	Z	SEM (±)	P-value
Colour	4.00^{b}	4.20^{b}	6.90^{a}	4.90^{b}	7.20^{a}	0.27	<0.001
Flavour	4.40^{c}	3.70^{c}	6.20^{b}	5.10^{ab}	8.40^{a}	0.32	<0.001
Tenderness	5.90^{b}	4.30^{c}	6.30^{b}	4.20^{c}	8.00^{a}	0.29	<0.001
Juice	4.70^{c}	5.50^{ab}	6.10^{b}	5.90^{ab}	7.80^{a}	0.23	<0.001
Texture	5.40^{ab}	5.90^{ab}	5.70^{ab}	4.60^{b}	7.00^{a}	0.25	0.040
Overall acceptability	6.50^{b}	7.20^{ab}	6.90^{b}	6.40^{b}	8.20^{a}	0.19	0.010

SEM= standard error of means; a,b,c =means with different superscripts along a row are significantly different (P<0.05)

Meat colour affects consumers' preferences and is the first judging criterion for meat quality and acceptability (**Akinwumi *et al*., 2013; Ojediran *et al*., 2022**). Consumers reject meat products whose colour deviates from the norm (**Qiao *et al*., 2001**). Meat colour depends on several factors, including myoglobin content, meat structure, and muscle composition (**Akinwumi *et al*., 2013; Karthika *et al*., 2016; Ojediran *et al*., 2019**). Meat flavor tends to develop with age, while juiciness depends largely on the carcass fat content (**Lawrie, 1998**). **Ikeme (1990)** reported that intramuscular or subcutaneous fat improves the flavor, juiciness, and tenderness of fat. Several studies have reported that cassava peels cause no harmful effect on birds (**Abu *et al*., 2015**) and pigs (**Adomeh *et al*., 2018; Ojediran *et al*., 2022**). In this study, a total replacement of maize by HQCPM in the pigs' diet had the greatest positive influence on the panelists' judgment of the meat quality as the highest scores for all the sensory parameters as well as the overall acceptability were recorded in the diet Z.

Table 4 Organ weights of growing pigs fed high-quality cassava peel meal

Parameters	Treatments						
(% LW)	V	W	X	Y	Z	SEM(±)	P-value
Whole stomach	2.37^{ab}	2.85^{ab}	2.30^{ab}	3.99^{a}	1.53^{b}	0.34	0.020
Empty stomach	0.96^{a}	0.92^{ab}	0.82^{b}	0.99^{a}	0.94^{a}	0.02	0.040
GIT	17.46	19.44	17.66	19.94	18.92	0.44	0.070
Liver	2.84^{a}	2.68^{b}	2.18^{e}	2.28^{d}	2.54^{c}	0.07	<0.001
Kidney	0.36^{a}	0.37^{a}	0.32^{c}	0.35^{b}	0.35^{b}	0.01	<0.001
Lungs	1.45^{a}	0.85^{c}	0.85^{c}	0.83^{c}	1.09^{b}	0.04	<0.001
Pancreas	0.18^{a}	0.17^{a}	0.15^{b}	0.13^{c}	0.13^{c}	0.01	<0.001
Heart	0.39^{c}	0.41^{ab}	0.40^{b}	0.42^{a}	0.39^{c}	0.04	<0.001

%LW= percentage of live weight, GIT = Gastro-Intestinal Tract; SEM= standard error of means; a,b,c,d,e =means with different superscripts along a row are significantly different (P<0.05)

Organ weight

As shown in Table 04, the HQCPM diets influences (P<0.05) the pigs' organ weights except for the gastrointestinal tract (GIT) (P>0.05). The control diet had the highest influence on the liver, lungs, and pancreas. The whole stomach values for diets V, W, and X are comparable with diets Y and Z. There was similarity in the empty stomach for pigs fed diets V, Y, and Z, while diet W which is also similar to the three diets is comparable with diet X. The liver weight for diets W and Y are similar and differ (P<0.05) from diets X and Z which are also comparable. Diets V and W had similar effects on kidney weight and show distinction (P<0.05) from the other diets. Diet Y which had the least value for lungs was not statistically different (P>0.05) from diets W and X, but differs (P<0.05) from diets V and Z. The pancreas weight decreased linearly with increasing HQCPM inclusion, but similar values were recorded for diets Y and Z. The heart weight ranged from 0.39% in pigs fed diets V and Z to 0.42% in pigs fed diet Y.

Not only are high-fibre diets implicated in the enlargement of pigs' relative organ weight (**Unigwe *et al*., 2017**), but high fibre feed ingredients can also have consequential effects on the functionality of pigs' gastrointestinal tract because of gut weight and gut fill, and cause variations in body weight and carcass weight (**Njoku *et al*., 2015**). To digest fibre-rich diets, the gut secretes more digestive fluids (**Wenk, 2001**), and the digestive organs are enlarged (**Ojediran *et al*., 2021**). In this present study, the HQCPM diets influenced the organ weights except for the gastrointestinal tract (GIT) but did not follow a particular pattern. In fact, the findings of this study indicated that the HQCPM diets do not necessarily increase organ weights, thereby contradicting the aforementioned studies of **Wenk, 2001 and Ojediran *et al*., 2021**. The mechanism behind this result might not be clearly understood but might be associated with the HQCPM processing method.

Histology

The villi morphology of growing pigs fed high-quality cassava peel meal (HQCPM) is presented in Table 5. The cryptal depth was not significant (P>0.05) among the treatments, while the other parameters (villi length, villi width, and cryptal width) were statistically different (P<0.05) across the treatments. Animals fed diet Z had the least values for all the significant parameters, while the pigs offered the control diet had the highest values for villi length and cryptal width. The villi width was greater for pigs fed diets W and X than those fed diet V, while animals fed diets Y and Z had considerably lower values than those fed diet V.

Table 5 Villi histology of growing pigs fed high-quality cassava peel meal

Parameters (µm)	Treatments						
	V	W	X	Y	Z	SEM (±)	P- value
Villi length	4985.10[a]	4841.70[ab]	4077.30[ab]	4617.30[ab]	3853.10[b]	164.51	0.010
Villi width	1065.40[a]	1079.50[a]	1091.70[a]	618.96[ab]	512.07[b]	102.33	0.040
Cryptal width	814.71[a]	688.75[ab]	671.77[ab]	557.67[bc]	466.45[c]	37.69	0.010
Cryptal depth	2236.70	2801.30	2633.90	2364.20	2235.30	98.27	0.060

SEM= standard error of means; a,b,c =means with different superscripts along a row are significantly different (P<0.05)

Plate 1-5 shows the micrographs of the liver and intestine (jejunum) morphology of the growing pigs. No lesion was seen in the liver and intestine of the pigs fed the control diet (diet V) as depicted by plates 1a and 1b, respectively. There was centrilobular degeneration of hepatocytes on the liver (plate 2a) and loss of surface enterocytes in the intestine (plate 2b) of pigs fed diet W. The animals fed the diet with 50% HQCPM as a replacement for maize (diet X) had foci hepatocellular coagulation necrosis and inflammation on the liver (plate 3a), and there was a loss of surface enterocytes and cryptal hyperplasia in the intestine (plate 3b). Plate 4a illustrates that there was centrilobular hepatocellular atrophy on the liver, and plate 04b depicts the loss of surface enterocytes and blunting of villi in the intestine of pigs fed diet Y. Pigs fed diet Z had multifocal coagulation necrosis of hepatocellular necrosis on the liver (plate 5a) with villi atrophy and hyperplasia of crypts in the intestine (plate 5b).

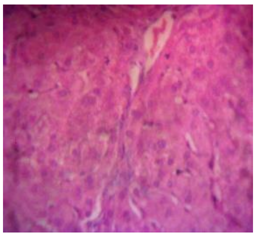

Plate 1a (Liver, Diet V)

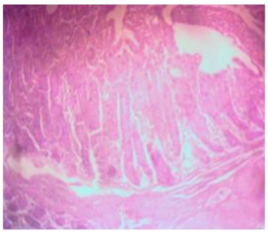

Plate 1b (Jejunum, Diet V)

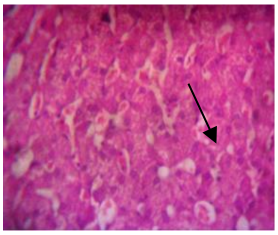

Plate 2a (Liver, Diet W)

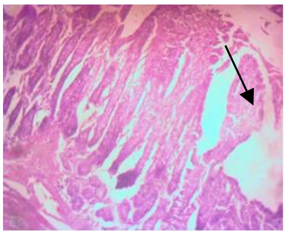

Plate 2 (Jejunum, Diet W)

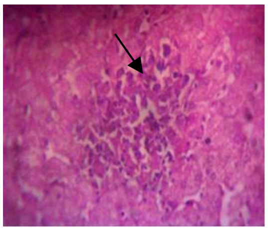

Plate 3a (Liver, Diet X)

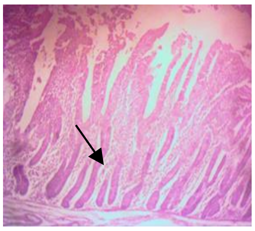

Plate 3b (Jejunum, Diet X)

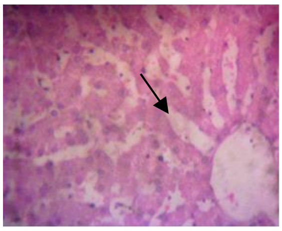

Plate 4a (Liver, Diet Y)

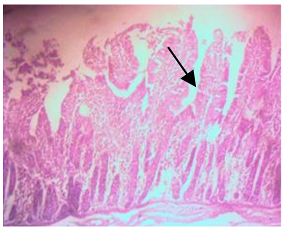

Plate 4b (Intestine, Diet Y)

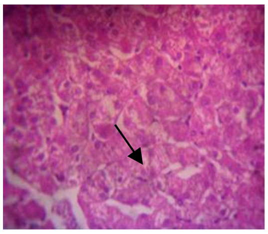

Plate 5a (Liver diet Z)

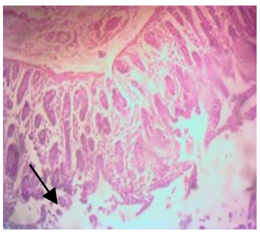

Plate 5b (Jejunum, Diet Z)

Intestine: The intestinal integrities of the pigs were maintained by the control diets as no lesion was observed in the jejunum. Furthermore, the growing pigs fed the control diet had longer villi lengths which could be linked to greater nutrient absorption due to increased surface area (**Caspary, 1992**). Also, **Yassar and Forbed (1999)** reported that the presence of a plethora of cell mitosis and higher villus heights in the intestine indicates the activation of intestinal functions. The perquisites of the control diet on the intestine could be justified by the lack of HCN in the diet. The HCN in the HQCPM diets had inferred residual effects which are observable in the pigs' intestinal morphology. The effect manifestation is depicted by the shorter villi length and reduced villi width in pigs fed 100% HQCPM replacement of maize. Furthermore, there is a loss of surface enterocytes, and the shorter villi heights causes a reduction in intestinal function (atrophy). The findings of this present study support the study of **Olayeni and Farinu (2020)** in the sense that villi erosion and short villi are associated with reduced villus surface area and reduced absorptive functions. However, in the same study, the HCN residual effects were mildly reversed by the inclusion of activated charcoal. Several studies have recognized that anti-nutritional factors alter nutrient digestion, absorption, and utilization (**Jiang *et al*., 2000; Fasina *et al*., 2004**). Hydrogen cyanide, being an anti-nutritional factor is capable of interfering with some enzymes to cause loss of intestinal integrity (**Olayeni and Farinu, 2020**).

Liver: The control diet had no visible lesion in the liver, and this could be attributed to the absence of the anti-nutritional factor, HCN, in the diet. In contrast, the HQCPM diets had anomalous effects on the liver. These effects include the degeneration of the centrilobular hepatocytes, liver inflammation, localized death cells (necrosis), and a general reduction in the functionality of the liver. Even though it is present in a reduced concentration, the HCN in the HQCPM diets could be responsible for these consequential effects as the HQCP processing techniques could not completely eradicate the HCN contents of the peels. However, the severity of the lesions could have been reduced by including inert substances like activated charcoal and kaolin (**Olayeni and Farinu, 2020**). Activated charcoals can bind to chemicals and aflatoxins to reduce their absorption from the gastrointestinal tract, and distribution of toxins like HCN to the blood and organs (**Olayeni and Farinu, 2020**).

CONCLUSION

Conclusively, HQCPM diets enhanced the carcass weight at 50% HQCPM replacement for maize and meat quality of growing pigs at 100% HQCPM replacement for maize. Nevertheless, the diets reduced organ weights in pigs fed diets 50-100% HQCPM replacement for maize, shortened villi width and cryptal width at 75-100%HQCPM replacement for maize and reduced villi height at 100% HQCPM replacement for maize. Further studies should focus on reversing the negative consequences of HQCPM on the histology of growing pigs.

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