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Activated Charcoal Affects the Bioavailability of Cyanide in Weaned Pigs: Growth Performance, Nutrient Retention and Cyanide Degradability in Various Segments of the Gastro-Intestinal Tract

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Abstract— ***Sixty-four weaned pigs (Large White-Landrace, age = 8 weeks) were assigned to eight groups with eight pigs per group, and each pig was a replicate. A set of four diets formulated, contained cassava root meal (CRM) at 0%, 25%, 50% and 75% replacing maize such that they were without activated charcoal while the next set of four diets had activated charcoal (AC) at 40g/kg diet as a supplement. Thus, making eight diets. The experiment was a 2 x 4 factorial arrangement in a completely randomised design. The result indicated that the interaction effect differs significantly (p< 0.05) for Live Weight (LW), Daily Weight Gain (DWG), Daily Feed Intake (DFI), Feed-Gain ratio (F:G) and Hydrogen Cyanide (HCN) intake. Diets with activated charcoal supplementation (ACS) differed significantly (p<0.05) for LW such that the control group had a higher value (29.06kg) which is similar to that of groups 2 (28.25kg) and 3(28.63kg). Diets with ACS (0% and 50% CRM) for DWG recorded the highest value (0.35kg/day) (p<0.05). The least F:G was observed in diet with 50% CRM with ACS. Cyanide intake increased with increasing CRM with or without AC supplementation. Apparent digestibility of CP, EE, CF, NFE and HCN were significantly affected (p<0.05) (i.e by both varying levels of CRM and activated charcoal supplementation) except for nitrogen-free-extract at 25% CRM level where charcoal supplementation had no effect. Digestibility of HCN improved significantly (<0.05) across the CRM levels. The interaction effects of CRM and ACS differ (p<0.05) for cyanide degradability in the stomach, caecum and large intestine. It can be concluded that weaned pigs fed 50% CRM with ACS had higher DWG and F:G. Diets without ACS had significantly better nutrient digestibility at 0% level (control) except for CP and ash at 50% CRM. ACS significantly (p<0.05) influenced HCN degradability but more in the stomach and caecum at 25% CRM level. For improved weight and feed conversion, 50% CRM replacement for maize with ACS is recommended.***

Keywords— ***Activated charcoal, Cyanide, Cassava root, Pig, Performance***

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I. INTRODUCTION

Cassava tubers are excellent calorie source because of their highly digestible starch (70 – 80 percent) (Morgan and Choct, 2016) which Gomes et al. (2005) and Promthong et al. (2005) linked to high amylopectin. Despite all the crucial agricultural and nutritional worth of cassava, its food and feed importance is greatly breached by the existence of inherent cyanogenic glycosides, especially linamarin and lotaustralin (Ngiki et al., 2014) which are hydrolysed to give hydrogen cyanide (Esonu, 2006, Udedibie et al., 2008). They are culturally subjected to diverse methods which lower the degree of antinutrients, increase feeding value, and transform the shortlived root into a stable commodity. The cassava root could be peeled, chopped, grated, soaked, dried, boiled, or fermented as a way of processing singly or in combinations. (Odukwe, 1994; (Chandrasekara and Kumar, 2016). These processes have been reported to lower cyanide levels differently (Okoli et al., 2012) due to the method applied, duration or the combination.

About 86% free HCN can be lost to sun drying because it can vaporize at about 28^{o}C, however, bound cyanide is more stable and contributes more to cyanide toxicity (Gomez et al., 1984). Olayeni et al., (2023) demonstrated that the addition of activated charcoal, a non-nutritive adsorptive materials to diets decreased the sorption of HCN from the GIT. This would add to a variety of physical and chemical techniques that had been employed to detoxify cassava.

Activated charcoal, a carbon conjugate with an uptick surface area (Olayeni et al., 2023) is very minuscule, odourless, insipid black powder and absorptive for many toxins, and drugs (Kutlu et al. 2002). It is an insolvable, non-specific carrier that adsorb molecules and prevents absorption of some (Olayeni et al., 2023). Ayanwale et al. (2006) added varying quantities of activated shear butter tree charcoal to layers diets and reported significant improvement in egg weight. Also, Choi et al. (2009) observed that wood vinegar enhanced growth, nutrient absorption and inhibition of coliforms when added to weaner pig's diet.

Therefore, this study evaluated the effect of activated charcoal on the bioavailability of cyanide in weaned pigs on growth performance, cyanide intake, nutrient retention and cyanide degradability in various segments of the GIT.

II. MATERIALS AND METHODS

Location

The Research Piggery unit is in the derived savannah area, located between 8^{o}069'N and 8^{o} 118'N and 4^{o}039'E and 4^{o}147'E with mean yearly precipitation and temperature of 1248mm and 26.3^{o}C and a comparative humidity of around 85% at about 501m altitude (Ojediran et al. 2020).

Cassava root meal and Activated charcoal (test materials)

Fresh cassava sweet variant (TMS 3052) and activated charcoal were procured locally. The cassava roots were washed, chopped, and sun-dried until constant weight was attained. The chips were hammer-milled to derive cassava root meal (CRM) (Olayeni et al., 2023).

Preparation of experimental diets

A set of four diets formulated, contained cassava root meal (CRM) at 0, 25, 50 and 75% replacing maize such that they were without activated charcoal while the next set of four diets had activated charcoal (AC) at 40g/kg diet as a supplement. Thus, making eight diets. The experiment was a 2 x 4 factorial arrangement in a completely-randomised-design (Table1)

Table 1: Gross composition of experimental diets

Ingredients (%)	1(0%)	2(25%)	3(50%)	4(75%)	1(0%)	2(25%)	3(50%)	4(75%)
Maize	55.00	41.25	27.50	13.75	55.00	41.25	27.50	13.75
Cassava RM	0.00	13.75	27.50	41.25	0.00	13.75	27.50	41.25
Soybean meal	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
Fish meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Blood meal	3.25	4.25	5.25	6.25	3.25	4.25	5.25	6.25
Wheat offal	10.00	9.00	8.00	7.00	10.00	9.00	8.00	7.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Oyster shell	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50

Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
*Premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
A. Charcoal	-	-	-	-	+	+	+	+
Calculated Nutrients								
Crude protein	18.04	18.22	17.79	17.34	18.04	18.22	17.79	17.34
ME(kcal/kg)	2747.0	2719.0	2690.0	2661.0	2747.0	2719.0	2690.0	2661.0
Crude fibre	3.94	4.09	4.12	4.24	3.94	4.09	4.12	4.24

RM – Root Meal, A. - Activated

* Each kg feed contained: Vit. A, 1500IU A, 1500IU; Vit. 2,500IU, Bit. E1101U, Vit B3 40mg; Vit. B6, 20mg; Chlorine chloride, 400mg; Mn 120mg, Fe 70mg; Cu 100m; I l;2.2m Se 0.2mg,; Zn 45m;Co; 0.02m.

Experimental animals and management

Sixty-four weaned pigs (Large White-Landrace, age = 8 weeks) were assigned to eight groups with eight pigs per group, and each pig was a replicate. A set of four diets formulated, contained cassava root meal (CRM) at 0, 25, 50 and 75% replacing maize such that they were without activated charcoal while the next set of four diets had activated charcoal (AC) at 40g/kg diet as a supplement. Thus, making eight diets. Each pig was housed in a pen measuring 0.46m x 0.9m with a concrete floor. They were acclimatised for a week. Feed and water were supplied *ad libitum*.

Experimental design

The experiment was a 2 x 4 factorial arrangement in a completely randomised design.

Data Collection

Feed intake: From the weighed quantity of feed supplied, left-over were collected on a daily basis to determine the feed intake.

Actual feed intake (kg) = offered (kg) – left over (kg)

Weight gain: The weekly weight gains were estimated by deducting the previous week's weight from the present week's weight.

Weight gain = present week weight (kg) – present week weight (kg).

Daily weight gain: This was determined by dividing the total weight gain by the number of days the animals were placed on the experiment.

Daily weight gain (kg) = (Total weight gain (kg))/(Total number of days)

Feed to gain Ratio: This is a measure of the efficiency of feed utilization by the pigs obtained by dividing the total feed intake by the total weight gained.

Feed gain Ratio = (Total feed intake (kg))/(Total weight gain (kg))

Cyanide Intake: This was determined using the analysed cyanide in the feed to multiply the total feed intake.

Cyanide intake = Total cyanide in feed (mg/kg) x total feed consumed (kg)

Sample collection and handling

Nutrient Digestibility

At the end of the 8th week of the experiment, four animals per group were housed individually in metabolic cages. Each pig also had access to an individual feeder and drinker. The animals were fed *ad libitum* for three days for acclimatization. Faecal samples were collected from the animals for 5 days. The fresh samples for each day were weighed and oven-dried at 1050C for 24 hours. Faecal samples collected from animals on each treatment were bulked and milled, and sub-samples for each group were stored for proximate analysis.

Hydrogen cyanide degradability in various segments of GIT/digesta collection

The whole lengths of the digestive tracts of slaughtered animals were removed for GIT sampling. Samples of digesta were collected from the stomach, caecum, and the middle part of the large intestine for analysis.

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Proximate analysis

Sample of the cassava root meal (CRM), experimental diets, faecal samples as well as digesta from different segments of the gastro-intestinal tract (GIT) were analysed to determine the proximate composition by the standard methods of AOAC (1990). The cyanide levels of the experimental diets, CRM and the digesta were determined using the procedure described by Bradbury et al. (1999) and Egan et al. (1998).

Statistical analysis

All data generated were subjected to statistical analysis of variance (ANOVA) using 2 x 4 factorial in a completely randomized design of SAS (2000) and where significant differences were observed in the means they were compared using Duncan's Multiple Range Test of the same statistical software (Duncan, 1955).

III. RESULTs

Growth performance of weaner pigs

Table 2 shows the treatment effect of varying levels of dietary cassava root meal on the performance of weaner pigs. No significant ($p>0.05$) effect was observed concerning final live weight, weight gain and feed gain ratio while significant differences ($p<0.05$) were observed in feed intake and hydrocyanide intake (HCN). Pigs fed the control diet had a significantly higher ($p<0.05$) feed intake than those fed diets containing CRM. The HCN intake increased from 0.00mg/kg (control) to 19.71mg/kg (75% CRM) ($p<0.05$).

`The main effect of activated charcoal supplementation on the performance of weaner pigs is presented in Table 3. Final live weight, weight gain, feed intake and HCN intake were significantly ($p<0.05$) affected by activated charcoal supplementation while the feed gain ratio was not affected ($p>0.05$). Pigs fed diets with activated charcoal had increased final live weight, weight gain, feed intake and HCN intake.

Table 4 shows the interaction effect of cassava root meal (CRM) and activated charcoal supplementation on the performance of weaner pigs. The interaction effect was significant ($p< 0.05$) on final live weight, weight gain, feed intake, feed gain ratio and HCN intake. Differences between weaner pigs fed varying levels of CRM with activated charcoal supplementation were significant ($p<0.05$) for final live weight with the control group having the highest value (29.06kg) which is similar to that of groups 2 and 3 but significantly decreased ($p<0.05$) in group 4 (27.38kg). Variations in cassava root meal levels without activated charcoal supplementation had no effect ($p>0.05$) on the final live weight. A similar trend was observed for daily weight gain. Weaner pigs on diets 1 and 2 with AC supplementation had similar values for feed intake which were significantly ($p<0.05$) higher than those of diets 3 and 4. Weaner pigs fed CRM (0% and 75%) without AC supplementation showed similar values which were significantly higher than those fed 25 and 50% ($p<0.05$). The feed gain ratio for weaner pigs fed varying levels of CRM without AC supplementation was similar ($p>0.05$) while those with AC supplementation differed significantly ($p<0.05$). Pigs on control, diets 2 and 4 were not significantly ($p>0.05$) different while the lowest value of 2.95% was obtained for pigs on diet 3.

Table 2: Treatment effect of dietary cassava root meal on the performance of weaner pigs

	% CRM				
Parameters	0	25	50	75	SEM
Initial weight (kg)	9.54	9.45	9.49	9.51	0.30
Final weight (kg)	27.78	27.00	27.81	26.69	0.80
Daily weight gain (kg/day)	0.33	0.32	0.33	0.31	0.10
Feed intake (kg/day)	0.99^{a}	0.94^{b}	0.93^{b}	0.94^{b}	0.01
Feed/ gain ratio	3.03	3.00	2.86	3.12	0.12
HCN intake (mg/kg)	0.00^{d}	6.49^{c}	12.79^{b}	19.71^{a}	0.14

^{abcd}: Means in the same row with different superscripts differ significantly ($p<0.05$)

Table 3: Supplementation effect of activated charcoal on the performance of weaner pigs fed CRM diets

	Activated charcoal		
Parameters	-	+	SEM
Initial weight (kg)	9.45	9.55	0.02
Final weight (kg)	26.31^{b}	28.33^{a}	0.47

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Daily weight gain (kg/day)	0.30[b]	0.34[a]	0.01
Feed intake (kg/day)	0.86[b]	1.03[a]	0.01
Feed /gain ratio	2.92	3.09	0.08
HCN intake(mg/kg)	8.91[b]	10.59[a]	0.13

abcd: Means in the same row with different superscripts differ significantly (p<0.05)

Table 4: Interaction effects of cassava root meal and activated charcoal on the growth performance of weaner pigs

		% CRM				
Parameter	Charcoal supplementation	0	25	50	75	SEM
Initial weight (kg)	-	9.48	9.40	9.45	9.48	0.28
	+	9.61	9.50	9.53	9.55	0.02
	SEM	0.29	0.29	0.31	0.29	
Final liveweight (kg)	-	26.50[y]	25.75	27.00	26.00	0.72
	+	29.06[ax]	28.25[ab]	28.63[a]	27.38[b]	0.22
	SEM	0.58	0.93	1.11	0.68	
Daily weight gain(kg/day)	-	0.30[y]	0.33	0.32	0.30	0.01
	+	0.35[ax]	0.30[c]	0.35[a]	0.32[b]	0.00
	SEM	0.01	0.34[ab]	0.20	0.01	
Feed intake(kg/day)	-	0.91[ay]	1.05 [ay]	0.85[by]	0.88[ay]	0.01
	+	1.06[ax]	0.83[bx]	1.02[bx]	1.01[bx]	0.01
	SEM	0.03	0.01	0.03	0.03	
Feed /gain ratio	-	3.00	2.85	2.80	3.05	0.11
	+	3.05[ab]	3.16[a]	2.95[b]	3.19[a]	0.04
	SEM	0.04	0.04	0.13	0.14	
HCN intake(mg/kg)	-	0.00[d]	5.75[cy]	11.62[by]	18.28[ay]	0.20
	+	0.00[d]	7.24[cx]	13.96[bx]	21.14[ax]	0.08
	SEM	0.00	0.12	0.11	0.34	

abcd: Means in the same row with different superscripts differ significantly (P<0.05)
x,y: Means along the same column with different superscripts differ significantly (P<0.05)

- : Non – charcoal supplementation
+ : Charcoal supplementation

Nutrient digestibility of weaner pigs

The effect of cassava root meal on nutrient digestibility in weaner pigs is presented in Table 5. Crude protein, ether extract, crude fibre, ash, nitrogen-free extract and hydrogen cyanide (HCN) digestibilities were significantly (p<0.05) affected by cassava root meal levels. Crude protein digestibility was significantly (p<0.05) higher at 0% CRM level than other treatments while pigs fed diets containing 25 and 75% CRM levels showed similarity (p>0.05) in the digestibility. The same trend was observed with crude fibre and nitrogen-free extract in diet 1. A significant (p<0.05) increase was observed in the digestibility of HCN as the CRM level increased.

The supplementation effect of activated charcoal on the nutrient digestibility of weaner pigs is presented in Table 6. Significantly (p<0.05) higher values of digestibility coefficients for ether extract, HCN and ash were observed with activated charcoal supplementation; while crude protein, crude fibre and nitrogen-free extract showed significantly (p<0.05) higher digestibility values in non-supplemented diets. Table 7 shows the interaction effect of CRM and activated charcoal supplementation on the apparent digestibility of nutrients in weaner pigs. Apparent digestibility of crude protein, ether extract, crude fibre, ash, nitrogen-free extract and

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HCN were significantly affected (p<0.05) by the interaction (i.e by both varying levels of CRM and activated charcoal supplementation) except for nitrogen-free extract at 25% CRM level where charcoal supplementation had no effect. The same trend was also recorded for HCN digestibility while non-supplementation significantly (p<0.05) affected crude protein and crude fibre digestibility except at 75% CRM level. While nitrogen-free extract was equally affected except at 25% CRM level where similarity (p>0.05) was observed for both the supplemented and non-supplemented groups. Crude protein digestibility for the non-supplemented group was depressed (p<0.05) across the CRM levels except at the 50% level. The similarity was noticed (p>0.05) for ether extract at 0 and 75% levels. For ash, a significant increase (p<0.05) was observed up to 50% CRM level while nitrogen free extract also showed a similar trend. Digestibility of HCN improved significantly (<0.05) across the CRM levels.

Table 5: Treatment effects of dietary CRM on the nutrient digestibility of weaner pigs.

	% CRM				
Nutrient (%)	0	25	50	75	SEM
Crude protein	43.58^{a}	30.72^{c}	38.70^{b}	30.43^{c}	0.31
Ether extract	65.67^{b}	62.36^{c}	55.50^{d}	66.82^{a}	0.16
Crude fibre	51.20^{a}	31.17^{c}	28.01^{c}	45.61^{b}	1.27
Ash	54.53^{b}	37.62^{c}	58.90^{a}	55.11^{b}	0.33
Nitrogen free extract	67.37^{a}	61.57^{b}	43.28^{d}	54.70^{c}	1.21
HCN	0.00^{d}	80.48^{c}	86.16^{b}	96.30^{a}	0.46

[abcd]: Means in the same row with different superscripts differ significantly (P<0.05)

Table 6: Supplementation effects of activated charcoal on the nutrient digestibility of weaner pigs.

	Activated charcoal		
Nutrient (%)	-	+	SEM
Crude protein	41.50^{a}	30.20^{b}	0.26
Ether extract	41.25^{b}	83.93^{a}	1.24
Crude fibre	42.19^{a}	35.80^{b}	3.18
Ash	37.35^{b}	65.74^{a}	2.65
Nitrogen free extract	61.14^{a}	52.32^{b}	2.52
HCN	60.24^{b}	71.22^{a}	9.98

[a,b] Means in the same row with different superscripts differ significantly (P<0.05)
+ : Charcoal supplementation
- : Non – charcoal supplementation

Table 7: Interaction effects of CRM and activated charcoal supplementation on the nutrient digestibility of weaner pigs.

		% CRM				
Nutrient (%)	Charcoal Supplementation	0	25	50	75	SEM
Crude protein	-	44.35^{bx}	39.58^{cx}	53.71^{ax}	28.36^{dy}	0.23
	+	42.82^{ay}	21.86^{dy}	23.68^{cy}	32.49^{bc}	0.40
	SEM	0.04	0.39	0.07	0.75	
Ether extract	-	48.53^{ay}	40.77^{by}	27.43^{cy}	48.26^{ay}	0.06
	+	82.82^{cx}	83.96^{bx}	83.57^{bcx}	85.39^{ax}	0.23
	SEM	0.17	0.13	0.03	0.26	
Crude fibre	-	64.77^{ax}	33.38^{cx}	31.23^{dx}	39.39^{by}	0.04
	+	37.63^{by}	28.96^{cy}	24.80^{cy}	51.84^{ax}	0.49
	SEM	0.06	0.39	0.07	2.53	
Ash	-	29.78^{dy}	34.60^{cy}	43.42^{ay}	41.59^{by}	0.19
	+	79.28^{ax}	40.65^{dx}	74.39^{bx}	68.64^{cx}	0.37
	SEM	0.02	0.05	0.05	0.73	

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Nitrogen free extract	-	72.82^{ax}	61.29^{b}	48.78^{cx}	61.67^{bx}	0.01
	+	61.93^{ay}	61.84^{a}	37.78^{cy}	47.74^{by}	1.33
	SEM	0.07	0.15	0.22	2.42	
HCN	-	0.00^{d}	67.73^{cy}	78.54^{by}	94.70^{a}	0.54
	+	0.00^{d}	93.20^{cx}	93.79^{bx}	97.89^{a}	0.03
	SEM	0.00	0.10	0.11	0.93	

^{abcd}: Means in the same row with different superscripts differ significantly (P<0.05)
^{x,y}: Means along the same column with different superscripts differ significantly (P<0.05)

Cyanide digestibility at various segments of GIT of weaner pigs

Table 8 shows the treatment effects of dietary cassava root meal diets on the digestibility of cyanide at various segments of the gastro-intestinal tract (GIT) of weaner pigs. Cyanide digestibility significantly (p<0.05) increased as CRM increased in the stomach and large intestine. The values of 65.91 and 65.83 at 25% and 75% CRM levels were similar in the large intestine while a value of 62.59 was obtained at 25% CRM level in the caecum which was significantly (p<0.05) higher than other CRM levels.

The supplementation effect of activated charcoal on the cyanide digestibility at various segments of GIT is shown in Table 9. Activated charcoal supplementation significantly (p<0.05) increased cyanide digestibility in the stomach, caecum and large intestine.

The interaction effect of CRM and activated charcoal supplementation on the cyanide digestibility at various segments of GIT of weaner pigs is presented in Table 3.10. The interaction effect of CRM and activated charcoal was significant (p<0.05) for cyanide digestibility in the stomach, caecum and large intestine. Variations among the weaner pigs fed 0, 25, 50 and 75% CRM without activated charcoal supplementation were significant (p<0.05) for cyanide digestibility in the stomach, caecum and large intestine with animals fed 25% CRM diet having the highest values in the caecum and large intestine (31.33 and 40.24% respectively). However, weaner pigs fed 75% CRM diet had significantly (p<0.05) higher values in the stomach. Variations among groups with activated charcoal supplementation were also significant (p<0.05). weaner pigs fed 25% CRM diet had significantly (p<0.05) higher values in the stomach and caecum (97.8 and 93.85 respectively), while in the large intestine, 75% CRM level had the highest value of 97.37%. The similarity is shown in the caecum between pigs fed diets containing 25 and 50% CRM levels. At 25, 50 and 75% CRM levels, activated charcoal supplementation significantly increased (p<.0.05) cyanide digestibility in GIT segments.

Table 8: Treatment effect of CRM diets on the cyanide digestibility at various segments of GIT of weaner pigs.

	% CRM				
Parameters (%)	0	25	50	75	SEM
Stomach	0.00^{d}	50.82^{c}	55.84^{b}	78.73^{a}	5.39
Caecum	0.00^{d}	62.59^{a}	60.87^{b}	57.18^{c}	5.01
Large intestine	0.00^{c}	65.91^{a}	61.07^{b}	65.83^{a}	4.84

^{abcd}: Means in the same row with different superscripts differ significantly (P<0.05)

Table 9: Supplementation effect of activated charcoal on the cyanide digestibility at various segments of GIT of weaner pigs.

	Activated charcoal		
Parameters (%)		**+**	**SEM**
Stomach	20.49^{b}	72.20^{a}	4.80
Caecum	21.15^{b}	69.17^{a}	3.82
Large intestine	25.00^{b}	71.40^{a}	4.13

^{a,b} Means in the same row with different superscripts differ significantly (P<0.05)
+ : Charcoal supplementation
- : Non – charcoal supplementation

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Table 10: Interaction effect of CRM and activated charcoal on the cyanide digestibility at various segments of GIT of weaner pigs.

Parameters (%)	Charcoal Supplementation	% CRM 0%	25%	50%	75%	SEM
Stomach	-	0.00^{d}	4.17^{cy}	17.08^{by}	60.72^{ay}	0.08
	+	0.00^{d}	97.48^{ax}	94.60^{cx}	96.74^{bx}	0.06
	SEM	0.00	0.03	0.14	0.12	
Caecum	-	0.00^{d}	31.33^{ay}	28.06^{by}	25.21^{cy}	0.08
	+	0.00^{c}	93.85^{ax}	93.68^{ax}	89.16^{bx}	0.04
	SEM	0.00	0.03	0.16	0.06	
Large Intestine	-	0.00^{d}	40.24^{ay}	25.48^{cy}	34.29^{b}	0.06
	+	0.00^{d}	91.58^{cx}	96.66^{bx}	97.37^{a}	0.04
	SEM	0.00	0.13	0.04	0.04	

^{abcd}: Means in the same row with different superscripts differ significantly (P<0.05)
^{x,y}: Means along the same column with different superscripts differ significantly (P<0.05)

IV. DISCUSSION

Growth Performance

It was observed that the varying levels of dietary cassava root meal did not significantly affect the performance of weaner pigs as indicated by the final live weight, daily weight gain and feed-to-gain ratio. This implies that the diets contained enough nutrients and that the protein quality supported the growth of the animals. Agunbiade et al. (2001) and Tuleum et al. (2005) made similar observations and reported that the quality of protein in cassava root meal was not inferior to that of maize. Omokhije et al.(2008) observed similarity in feed to feed-to-gain ratio and protein efficiency ratio of rabbits fed 30% cassava root meal based diets and maize-based diet, whereas a slight difference in feed intake was observed in this study between the weaner pigs fed the control diet and those fed cassava root meal based diets. Miller et al. (1974) observed that cassava root is low in palatability; thus increasing its level in the diets subsequently reduces the palatability of such diets. Israel (1992) however, observed that cassava root meal did not significantly reduce feed intake. The difference in this study could be attributed to the presence of cyanide in the cassava root-based diets in which the intake by the pigs significantly increased as the level of CRM increased.

The observation that activated charcoal supplementation significantly increased the final live weight, daily weight gain, feed intake and hydrogen cyanide intake of the weaner pigs fed cassava root meal-based diets is an indication that despite the increasing level of CRM in diets activated charcoal supplementation was able to arrest any depressive effect of hydrogen cyanide. This aligns with the observation that the addition of activated charcoal improved the body weight gain and feed utilization (Hesham et al., 2004). Wang et al., (2006) also reported that activated charcoal supplementation at 2% affected average weight gain not through feed intake but possibly by dilution of nutrient concentration.

Nutrient Digestibility

The decreases observed for crude protein, nitrogen-free extract and crude fibre as well as the increased apparent digestibilities recorded from this study agree with the report of Bui et al. (1996) who worked with dried cassava root meal diets and observed a decrease in digestibility of crude protein from 88 to 66%. The value obtained in this study was below what was reported by these authors. The general presentation in this study negated the results of Sonaiya and Omole (1982) who reported that feeding cassava-based diets resulted in a higher digestibility of DM and energy than sorghum diets. Gomez and Valdivieso (1983) suggested that the higher digestibility of cassava-based diets could be caused by the physico-chemical characteristics of cassava starch granules. This assertion could be noticed in ether extract digestibility. HCN digestibility is relative to the amount in the diets and intake as well as the ability of the weaner pigs to handle the HCN toxicity at that level. A similar observation was made by Egena (2002) when fermented cassava was used for broilers.

In this study activated charcoal supplementation significantly increased the digestibility of ether extract, ash and HCN. The ability of the activated charcoal to bind with fat-soluble substances and toxins might have justified the better digestibility of ether extract and HCN. Kutlu et al. (2002) observed a similar trend in ash digestibility when broiler chickens were fed activated coconut shell charcoal and attributed it to the mineral content of the charcoal which usually aids digestion in monogastric animals.

Hydrogen Cyanide Digestibility at Various Segments of GIT

The increased cyanide digestibility in the stomach as the level of intake increases may not be totally ascribed to HCN intake, but also to the acidic nature of the stomach (i.e low pH). The ability of the large intestine to handle HCN digestibility could be attributed to fermentation of fibre to acids by micro-organisms which presents a condition slightly similar to the stomach. Cunningham et al. (1963) detected that volatile fatty acids and lactic acid in the stomach favoured the acidic condition of the stomach.

Activated charcoal supplementation significantly favoured HCN digestibility in the stomach, caecum and large intestine. Previous studies by Levis et al. (1975) and Olkkola and Neovonen (1984) showed that the presence of food in the stomach before the administration of activated charcoal may reduce or enhance the efficacy of activated charcoal. In this study, however, activated charcoal was mixed with the diets and fed concurrently, as such, it enhanced the digestibility.

The interaction effect of CRM and activated charcoal also favoured the digestibility of HCN at various segments of gastro-intestinal tract of weaner pigs. Generally, activated charcoal supplementation favoured HCN digestibility in the stomach and large intestine. The efforts of the activated charcoal would have reduced the growth of non-beneficial micro-organisms known to be involved in digestive disorders. The addition of organic acids like citric, fumaric, formic, and propionic acids to the diet of pigs have been reported to improve their performance (Kirchgessner et al., 1997; Partanen and Mroz, 1999). This was possible in this study probably because of the contribution of an acidic environment by the CRM especially at the highest inclusion level of 75% where better digestibility of HCN was observed.

V. CONCLUSIONS

Weaner pigs fed 50% CRM with activated charcoal supplementation had higher weight gain and feed-to-gain ratio. Diets without activated charcoal supplementation had significantly better nutrient digestibility at 0% level (control) except for crude protein and ash at 50% CRM. Activated charcoal supplementation significantly ($p<0.05$) influenced HCN degradability but more in the stomach and caecum at 25% CRM level. For better weight and feed conversion, 50% CRM with AC supplementation is recommended.

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