INFLUENCE OF CASSAVA PEEL AND PALM KERNEL CAKE SUPPLEMENTATION ON GROWTH PERFORMANCE AND SERUM BIOCHEMICAL INDICIES OF GROWING PIGS

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ABSTRACT

This study was designed to evaluate the growth performance and serum biochemical indices of grower pigs fed cassava peel and palm kernel cake-based diets. Twelve pigs (17.5-32.16kg) were divided into four treatments with three replicates each. Four diets were formulated with different inclusion of Cassava Peel and Palm Kernel Cake (CPX) mixture. T1 (control), T2 (50% 2:3CPX), T3 (50% 3:2CPX), and T4 (50% 4:1CPX). Data collected included feed intake, weight gain, feed conversion ratio, and serum parameters. Results showed significant differences in total serum protein among treatments. Treatments 1 (Control) and 3 (50% 3:2CPX) had similar protein levels, differing from treatments 2 and 4. Aspartate aminotransferase levels were similar in treatments 1, 2, and 4 but differed significantly (p<0.05) from treatment 3. Globulin and aspartate aminotransferase were significantly different across all serum parameters. Albumin levels differed significantly (P<0.05) among treatments 1, 2, 3, and 4. Aspartate aminotransferase, alkaline phosphatase, and plasma protein significantly differed across all serum biochemical indices. Treatments 2 and 4 were similar but differed from treatment 3. The study's outcomes reveal the impacts of non-conventional dietary regimens on the growth performance and physiological well-being of grower pigs, thereby providing important data for the optimization of sustainable swine production systems. Adding 50% level of cassava peel and palm kernel cake mixture (at 2:3 ratios of their mixture) to the diet of young pigs boosted their growth and improved their blood health.

Keywords: Cassava peel, palm kernel cake, serum, grower pigs, alternative feed sources

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INTRODUCTION

Cassava (*Manihot esculenta*), commonly grown in the tropics, is estimated to be mostly (60%) used for human consumption. The remaining (40%) is used for animal feed, starch and industrial uses (Oboh *et al*., 2004). Since the early 1930s, cassava has been known and used as a livestock substitute instead of grains for monogastric animals. The popularity of cassava as a substitute resource in livestock feeds became acceptable because it is relatively cheap compared to grains (especially corn). Also, because of the increased demand for corn for human and industrial uses such as in textiles, breweries and bakeries (Moseri, 2010). Cassava peel is a by-product obtained by mechanically removing the peels of cassava roots in food processing factories, where products such as gari, fufu and elubo (cassava flour) are being produced for human' consumption. It is an agro-industrial by-product that has no dietary value to man but is usable in animal feed to reduce the production cost of animal products. It has proven to be a potential replacement for maize in the diet of growing pigs (Irekhore *et al*., 2015; Akinola *et al*., 2013) due to its relatively high energy content. Limit to its use as feedstuff in the diet of non-ruminant is due to high fibre, low protein content and the presence of hydrogen cyanide (Balogun and Bawa, 1997). Its low crude protein content of 5.35% (Aderemi and Nworgu, 2007), can, however, be overcome by combining it with cassava leaf, a crop residue from the cassava plant.

Cassava peel and bagasse are fibrous, starch-rich agro-industrial wastes, which cause severe environmental impacts upon their disposal. However, these can be raw materials for biodegradable food packaging. The cassava starch industry is one of the well-established and widely scattered agro-industries, especially across the tropical and sub-tropical regions of the world. The production of cassava root has been estimated to exceed 250 million tons per annum (Martín *et al*., 2017). These roots are processed to produce cassava starch, an essential staple food ingredient that provides nutrition and promotes food security in many nations worldwide (Uchechukwu-Agua *et al*., 2015).

To optimize the use of cassava peels and leaves in pig feed, physical treatment is necessary to break down the fibre and release the encapsulated nutrients, making them easier to digest by monogastric animals. Research has consistently shown that enzyme supplementation in diets enhances nutrient digestibility (Kiarie *et al*., 2013; Irekhore *et al*., 2015). Therefore, enzyme use may improve the utilization of cassava peels and leaves in pig rations.

Palm kernel meal (PKM) is an abundant agro-industrial by-product from the red oil processing mill with potential nutritive value for livestock feeding. It is a common feed ingredient used in practical pig feeding (Fatufe *et al*., 2007). Research has shown that PKM can be incorporated at low levels (10 to 30%) in pigs' diets (Agunbiade *et al*., 1999; Akintunde *et al*., 2011).

The chemical composition of PKM showed that it has a crude protein (CP) concentration of 14–18% and a moderate energy value10.6 MJ/kg DM (Kim *et al*., 2016; Sathitkowitchai *et al*., 2018). These values depend on processing techniques that affect the ether extract and crude fibre content (Ojediran *et al*., 2020). However, PKM has high levels of non-starch polysaccharides (NSP) such as mannan, xylan which limits its utilisation as feed for non-ruminant animals (Adeola and Cowieson, 2011; Sharmila *et al*., 2014). The cell wall components of PKM consist of 58% mannan, 12% cellulose and 4% xylan (Sathitkowitchai *et al*., 2018). Furthermore, PKM is coarse-textured and gritty in appearance with high viscosity which tends to decrease nutrient absorption (Ojediran *et al*.,2020) having anti-nutritional properties that hinder the full utilization of nutrients in pigs (O'Shea *et al*., 2014; Oladokun *et al*., 2016). Although PKM has limitations, research indicates its potential as a partial replacement for maize and soybean in pig and poultry diets, supporting maintenance and moderate growth. (Alshelmani *et al*., 2017). Previous research indicates that solid-state fermentation and enzyme supplementation significantly improved PKM's feeding value for monogastric. (Alshelmani *et al*., 2017; Mirnawati *et al*., 2011; Kononenko and Gorkovenko, 2011; Ravindran and Son 2011) among others.

The use of agro-industrial byproducts for livestock feeding especially in developing countries is seen as a measure for sustainable livestock development. However, Oluwafemi and Akpodiete (2010) concluded that the inclusion of 40 and 60% palm kernel cake with or without enzyme supplementation as a replacement for maize in weaning pigs ration had no negative effect on nutrient utilisation as well as the overall performance characteristics of the animals. Therefore, Palm Kernel Cake (PKC) can be used as energy feed ingredients in formulating weaners ration up to 60% inclusion level. The addition of proteolytic, fibrolytic or carbohydrate-degrading enzymes to PKC-based diets has great potential to release unavailable nutrients and energy. Palm kernel meal (PKM) has been extensively studied on various monogastric species including poultry, pigs and rabbits (Perez *et al*., 2000). Nutrition has a direct impact on the physiology of the animal, for example, blood composition, which in turn influences the overall health and well-being of an animal, ultimately affecting its responses. This study was carried to investigate the influence of cassava peel and palm kernel meal supplementation on growth performance serum biochemical indices of growing pigs.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Teaching and Research Farm, Rocky Fella Section. University of Ibadan, Ibadan and Department of Animal Science, University of Ibadan, Oyo state, Nigeria. The geographical location is longitude 7^0 $27^1.05^{11}$ N and latitude 3^0 $53^1.74^{11}$E of the Greenwich Meridian East at an altitude of 200m above sea level.

Experimental animal and management

A total of 12 Large White male weaners with an average weight ranging from 17.5kg – 32.16kg were purchased from the Piggery unit of the Teaching and Research Farm, University of Ibadan, Ibadan, Oyo State. Before the arrival of the pigs, proper biosecurity measures were observed by cleaning, proper disposal of the dirty and disinfecting the pens, drinking and feeding troughs to prevent infection. The pigs were acclimated for 2 weeks. During the period of acclimatization, they were fed with concentrate with adequate cool clean water.

Experimental diet

The pigs were fed grower mash with the inclusion of cassava peel and Palm kernel cake at different inclusion levels. The Cassava peels and PKC (CPX) were properly mixed at ratios 2:3, 3:2 and 4:1 for treatments 2, 3 and 4 respectively. The mixtures were bagged and fermented under airtight conditions for 3 days after which the temperature began to drop. Furthermore, the mixtures were later dried for 3 days at varying temperature and humidity as follows; 28ºC and 66%, 33ºC and 55%, and 31ºC and 66% for days 1,2 and 3 respectively. Four diets were formulated where maize was partially replaced and corn bran and wheat offal were replaced with CPX at varying ratios as shown in Table 1 below.

Experimental Design and Data Collection

A total of 12 animals were allotted into 4 treatments with each treatment having 3 replicates and 1 animal per replicate in a completely randomized design. Data collected include feed intake, weight gain, feed conversion ratio, creatinine, Alanine Transaminase (ALT), Alkaline Phosphatase (ALP) and Aspartate Transaminase (AST). For Creatinine, ALT, ALP and AST, the pigs were bled using a sterile 5mL syringe and 21-gauge needle. 5mL of whole blood was collected and dispensed into test tubes without anticoagulant and left for 10 minutes to coagulate. The supernatant serum was later decanted into sterile bottles for the determination of the analysis. Creatinine, alanine and aspartate aminotransferases were determined based on the colorimetric measurement of hydrazone formed with 2, 4 dinitrophenyl hydrazine according and ALP by phenolphthalein monophosphate method. The feeding trial lasted for 4 weeks.

Table 1: Gross composition of experimental diets fed to growing pigs

Treatments	**T1**	**T2**	**T3**	**T4**
CPX Ratio	**0**	**2:3**	**3:2**	**4:1**
Ingredients:				
Maize	30.00	20.00	20.00	20.00
Soyabean meal	12.00	12.00	12.00	12.00
Groundnut cake	10.00	10.00	10.00	10.00
Corn bran	20.00	0.00	0.00	0.00
Wheat bran	20.00	0.00	0.00	0.00
CPX	**0.00**	**50.00**	**50.00**	**50.00**
Palm oil	3.00	3.00	3.00	3.00
Dicalcium Phosphate	2.50	2.50	2.50	2.50
Oyster shell	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50
Grower premix	0.50	0.50	0.50	0.50
Lysine	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20
Total	100	100	100	100

CPX = Cassava peel and Palm kernel cake mixture; T1 = Control diet; T2 = 50% of 2:3CPX; T3 = 50% of 3:2 CPX and T4 = 50% of 4:1 CPX

Chemical Analysis

The proximate chemical compositions of the four experimental diets were determined by the method of AOAC (1995). Cyanide acid concentration in the mixtures was determined by knowing the acidic level using the pH meter.

Statistical Design and Analysis

Data obtained were analyzed using one-way analysis of variance (ANOVA) procedure of SAS (2011) software and means were compared using Duncan's multiple range test of the same software.

RESULTS

The growth performance of growing pigs fed cassava and palm kernel cake diets at varying levels is as shown in Table 2 below. All the growth parameters were not significantly different. However, treatment 4 had the highest weight gain while the lowest weight gain was observed in treatment 2. For feed conversion ratio, the least feed conversion ratio of 1.93 was observed in treatment 2 while treatment 4 had the highest weight gain.

Table 2: Growth performance of growing pigs fed Cassava peel and Palm kernel cake

Treatments	**T1**	**T2**	**T3**	**T4**	**SEM**
CPX Ratio	**0**	**2:3**	**3:2**	**4:1**	
Parameters:					
Average initial weight	31.88	29.99	29.62	33.06	1.62
Average final weight	36.24	34.05	34.72	38.27	1.67
Average Feed intake	2.10	2.10	2.10	2.10	2.10
Average weight gain	4.35	4.05	5.09	5.20	0.08
Feed Conversion Efficiency	2.07	1.93	2.42	2.47	0.11

CPX = Cassava peel and Palm kernel cake mixture; T1 = Control diet; T2 = 50% of 2:3 CPX; T3 = 50% of 3:2 CPX and T4 = 50% of 4:1 CPX.

The serum biochemical indices of growing pig-fed cassava peel and palm kernel cake at week 1 are shown in Table 3. Total protein and aspartate aminotransferase were significantly (P<0.05) different from all the serum parameters determined in this study. For total protein, treatments 1 and 3 were similar but were significantly different from treatments 2 and 4. Also, treatment 2 is significantly different from treatment 4. Results obtained for Aspartate aminotransferase showed that treatments 1, 2 and 4 were similar but were significantly (P<0.05) different from treatment 3.

Table 3: Serum biochemical indices of growing Pigs fed Cassava peel and Palm kernel cake at week 1

Treatments	T1	T2	T3	T4	SEM	Normal Range
CPX Ratio	0	2:3	3:2	4:1		
Parameters:						
Glucose conc. (mg/dl)	57.89	61.87	54.15	60.17	2.75	60-125
Creatinine (g/dl)	1.79	2.00	1.90	1.83	0.15	0.6-2.2
Total protein (g/dl)	6.95^{ab}	7.89^{a}	7.52^{ab}	6.59^{b}	0.22	5.8-8.45
Albumin (g/dl)	3.42	3.36	3.05	3.20	0.07	2.41-3.93
Globulin (g/dl)	3.53	4.53	4.46	3.39	0.21	2.0-3.9
AB:GB	0.97	0.75	0.70	0.95	0.04	0.45-1.08
AST (I.U/L)	36.72^{a}	39.82^{a}	27.85^{b}	43.95^{a}	2.06	15.3-56.3
ALT (I.U/L)	21.77	21.77	21.94	20.93	0.53	21.7-46.5
ALP (I.U/L)	51.05	41.73	45.74	38.82	2.27	41-176.1
Plasma protein	9.66	8.56	9.50	9.70	0.28	-

^{a,b}Mean in the same row having different superscripts are significantly (P<0.05) different from each other. CPX = Cassava peel and Palm kernel cake mixture; T1 = Control diet; T2 = 50% of 2:3CPX; T3 = 50% of 3:2 CPX and T4 = 50% of 4:1 CPX. AST = Aspartate transferase; ALT = Alanine transferase; ALP = Alkaline phosphatase.

Table 4 shows the serum biochemical indices of growing pig-fed cassava peel and palm kernel cake at week 2. Globulin and Aspartate aminotransferase were significantly (P<0.05) different out of all serum parameters determined. Treatments 2 and 4 were similar but differed significantly from treatments 1 and 3, and treatments 1 and 3 were different significantly (P<0.05) from each other for Albumin. For aspartate amino transferee, treatment 1 is significantly (P<0.05) different from treatments 2 and 3, and treatment 4 is similar to treatments 1 and 2 but different (P<0.05) significantly from treatment 3.

The serum biochemical indices of growing pig-fed cassava peel and palm kernel cake at week 3 are shown in Table 5. Glucose concentration (107.33-136.9 mg/dl), creatinine (0.65-1.16g/dl), total protein (7.94-8.15g/dl), albumin (3.03-3.10g/dl), globulin (4.48-5.87g/dl), albumin: globulin ratio (0.51-0.65), aspartate aminotransferase (26.25-71.32 IU/L), Alanine aminotransferase (19.50-23.00 IU/L), and alkaline phosphatase (37.50-73.96 IU/L), were not significantly (P>0.05) different.

The result of serum biochemical indices of growing pig-fed cassava peel and palm kernel cake at week 3 is shown in Table 6. Aspartate aminotransferase (28.53-42.49 IU/L), alkaline phosphatase (33.47-9.83 IU/L) and plasma protein (7.35-9.10) were significantly (P<0.05) different from all the serum biochemical indices determined.

Table 5: Serum biochemical indices of growing Pigs fed Cassava peel and Palm kernel cake at week 3

Treatments	T1	T2	T3	T4	SEM	Normal Range
CPX Ratio	**0**	**2:3**	**3:2**	**4:1**		
Parameters:						
Glucose conc.(mg/dl)	121.21	107.33	121.07	136.90	14.56	60-125
Creatinine (g/dl)	1.16	0.65	0.76	0.99	0.14	0.6-2.2
Total protein (g/dl)	8.92	8.15	8.54	7.94	0.23	5.8-8.45
Albumin (g/dl)	3.04	3.03	3.09	3.10	0.06	2.41-3.93
Globulin (g/dl)	5.87	5.12	5.45	4.48	0.22	2.0-3.9
AB:GB	0.51	0.60	0.57	0.65	0.03	0.45-1.08
AST (I.U/L)	37.34	71.32	26.25	61.08	9.00	15.3-56.3
ALT (I.U/L)	21.16	20.60	19.50	23.00	0.77	21.7-46.5
ALP (I.U/L)	73.96	59.38	56.25	37.50	7.63	41-176.1
Plasma protein	9.13	8.90	9.63	9.26	0.21	-

$^{a-c}$Mean in the same row having different superscripts are significantly (P<0.05) different from each other. CPX = Cassava peel and Palm kernel cake mixture; T1 = Control diet; T2 = 50% of 2:3CPX; T3 = 50% of 3:2 CPX and T4 = 50% of 4:1 CPX; AST = Aspartate transferase; ALT = Alanine transferase; ALP = Alkaline phosphatase.

Treatments 2 and 4 are similar but differed (P<0.05) significantly from treatment 3 for the same parameter. Treatment 1 is similar to treatments 2 and 3 for aspartate aminotransferase. Alkaline phosphatase showed a significant (P<0.05) difference between treatments 4 and 1, 2 and 3 and treatments 1, 2 and 3. Treatments 2 and 3 are similar. Significant (P<0.05) differences were observed for plasma protein between treatments 3 and 4. Treatments 1 and 2 were similar and also have something in common with treatments 3 and 4.

Table 6: Serum Biochemical Indices of growing pigs fed Cassava peel and Palm kernel cake at week 4

Treatments	T1	T2	T3	T4	SEM	Normal Range
CPX Ratio	**0**	**2:3**	**3:2**	**4:1**		
Parameters;						
Glucose conc.(mg/dl)	94.92	102.05	101.30	105.84	4.34	60-125
Creatinine (g/dl)	0.65	0.64	0.58	0.68	0.04	0.60-2.2
Total protein (g/dl)	6.59	6.40	6.23	6.10	0.17	5.8-8.45
Albumin (g/dl)	4.91	5.01	5.13	5.37	0.18	2.41-3.93
Globulin (g/dl)	1.67	1.39	1.10	0.73	0.23	2.0-3.9
AB:GB	3.12	4.51	14.14	13.33	2.64	0.45-1.08
AST (I.U/L)	32.31^{ab}	42.49^{a}	28.53^{b}	42.19^{a}	2.41	15.3-56.3
ALT (I.U/L)	22.27	17.27	21.22	20.76	0.97	21.7-46.5
ALP (I.U/L)	75.78^{b}	33.47^{c}	40.23^{c}	91.83^{a}	7.45	41-176.1
Plasma protein	7.80^{ab}	8.56^{ab}	9.10^{a}	7.35^{b}	0.28	-

$^{a-c}$Means in the same row having different superscripts are significantly (P<0.05) different from each other. CPX = Cassava peel and Palm kernel cake mixture; T1 = Control diet; T2 = 50% of 2:3CPX; T3 = 50% of 3:2 CPX and T4 = 50% of 4:1 CPX. AST = Aspartate transferase; ALT = Alanine transferase; ALP = Alkaline phosphatase.

DISCUSSION

The performance characteristics are very key to swine production. The effect of offering cassava peels and palm kernel cake on the performance characteristics of pigs in terms of weight gain, feed intake and feed conversion ratio had no significant effect in the levels of cassava peels mixed with palm kernel cake meal. The present study's outcome diverges from Igene's (2006) findings, which suggested that cassava inclusion above 50% in pig diets negatively impacts live weight and feed conversion ratio. Conversely, our results align with Moseri *et al*., (2020) conclusion that cassava peel can be safely incorporated up to 30-50% in grower-finisher pig diets without compromising growth rate. Notably, our study supports the recommended threshold of 40% cassava peel inclusion for grower pigs, indicating no adverse effects on growth performance.

The animal's health status is greatly influenced by the kind of feed that has been fed to the animals which has always been a priority in animal nutrition (Janez *et al*., 2012). Hence, serum biochemistry is among those factors that generally influence the quality of feed consumed by an animal. Also, serum parameters are reliable indicators of health status and reflect any physiological, nutritional, or even pathological changes that occur in the organism (Simaraks *et al*., 2004; Koronowicz *et al*., 2016). The level of glucose concentration reported in this study varies within treatments and across the week. It was observed that the glucose level increases as the week increases except in treatment 1 which reduced during the second week of the feeding trial. The values observed in this study were within the normal range except for those in treatment 1 and 3 for weeks 1 and 2 respectively. The increase in the glucose level as the weeks increase could be because the experimental diet fed has begun to effect changes in the body of the animal. The highest increase was observed in week 3 with treatment 4 having the highest value followed by treatment 2, 3 and 1 and later decline in week 4. This could be as a result of the ratio of cassava peel present in those diets and it could be linked to the presence of high fermentable carbohydrates in the diet fed due to different levels of cassava peel inclusion. The observation was corroborated by the report of Okah and Ibeawuchi, (2011) who attributed an increase in serum glucose levels due to high fermentable carbohydrates in the diet.

Serum creatinine reduces across the week with treatment 4 having the least value in weeks 1 and 2 but increases a bit in week 3 and later declines in week 4. Although all the values reported except for treatment 3 in week 4 are all within normal range. Andres *et al*., (2008); Brosnan *et al*., (2011); Moret *et al*., (2011) and Shao and Hathcock, (2006) observed that creatine is synthesized in the body from amino acids glycerin, arginine and methionine. This implies that the test ingredients are poor sources of the amino acid stated above since creatinine is derived from the diet or produced endogenously. The reduction in creatinine may expose the animal to the risk of cardiovascular disease because Brosnan *et al*., (2007) and Moret *et al*., 2011) concluded additional creatinine can prevent the formation of many chronic diseases including diseases of the cardiovascular system. Creatinine reduction across the treatment can also bring about a slow growth rate. Young *et al*, 2007 observed that creatinine supplements may also contribute to the improvement of weight growth in pigs.

The total protein among treatments showed a significant difference in 1 week with treatments 1 and 2 having similar values but significantly different from treatment 3. Treatment 1 has something in common with treatments 2,3 and 4. All the values reported were within the recommended range

(Ahamefule *et al*., 2006). The total protein also reduces across the week.

For Albumin, the value observed showed a significant difference in week 2 with treatment 1 significantly different from treatments 2 and 3 but had something in common with treatment 4. All the values recorded for weeks 1 and 2 were within the reported range for healthy pigs. All the values observed in week 3 were higher compared to weeks 1 and 2 and were not within the normal range reported for healthy pigs. This could be a result of the increase in the age of the experimental animals. Also, the increase in the concentration of albumin could be a result of loss of water. Values observed for globulins reduce as the week increases. Only all the values observed for Globulin in week 4 were within the normal range for healthy pigs.

Aspartate aminotransferase was significantly different across the last week with treatment 3 having the least statistical value. Out of the 3 weeks, only the value observed in week 2 for treatments 1, 2 and 4 and treatments 2 and 4 in week 3 were above the recommended range. Rochling, (2001) reported that the amount of AST found in the blood is directly related to the extent of tissue damage.

Also, the measurement of ALT and AST helps in the diagnosis of liver or heart damage and the level of both increases when disease processes affect the liver. Alanine aminotransferase is a more liver-specific enzyme (Johnston, 1999). Therefore, an increase in the ALT level in this study signifies the high toxic level of the experimental diet presented concerning the treatment affected. Furthermore, ALT and AST levels are severely decreased under nutritional deficiencies (e.g., Vit. B6 deficiency (Johnston, 1999). Alanine aminotransferase and AST values measure liver enzyme synthetic activities. The very low values of these liver enzymes compared to the reported normal values indicate impaired liver function probably because the experimental animals were not in optimal health condition which could be attributed to nutrient deficiencies (Buzzard *et al*., 2013).

Alkaline phosphate test is used to detect liver or bone disorders (Tolman and Rej, 1999; Mohamadnia *et al,* 2010). The ALP in treatment 4 in weeks 1 and 2, and treatment 2 and 3 in week 3 were not within the normal reported range. The values in week 3 were significantly different with treatment 4 having the highest value followed by treatment 1. Treatments 1, 2 and 3 were not significantly different from each other but treatment 4 in weeks 1 and 2, treatment 4 in week 3 and treatment 2 and 3 in week 4 were below the normal range.

CONCLUSION

Adding 50% level of cassava peel and palm kernel cake mixture (at 2:3 ratios of their mixture) to the diet of young pigs boosted their growth and improved their blood health. This mix helped counteract the negative effects of high fiber and other unwanted compounds. However, changes in certain blood enzymes suggest possible organ damage, which needs attention.

RECOMMENDATION

From this study it was discovered that changes in blood enzymes may signal organ damage especially with 50% inclusion level in other diets besides the control, therefore more research is needed to assess the damage level and find the ideal dietary mix of cassava peel and palm kernel cake for growing pigs.

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