Supplemental Effects of Zinc Oxide on the Utilization of Cassava Plant Meal by Growing Pigs in the Humid Tropics

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Abstract: The objective of this study was to evaluate the effects of zinc oxide (ZnO) as an additive on cassava plant meal through the growth, serum metabolites and hematological indices of growing pigs for eight weeks. Four experimental diets were formulated in this study. All the four diets contained 60% cassava plant meal. Diet 1 contained 0 ppm of ZnO, while diets 2, 3 and 4 contained 125, 250 and 300 ppm of ZnO, respectively. The cassava plant meal contained unpeeled tuber plus leaves and tender stems. The unpeeled cassava tuber was mixed with leaves and tender stem at ratio 2.5:1, while the ratio of the leaves and tender stem was 5:1. A total of 16 growing pigs (Large White × Hampshire) with initial mean weight of 24.92 ± 0.37 kg were used in this study. They were randomly distributed into the four experimental diets formulated. There were four animals per diet and each animal served as a replicate. The diets were formulated to contain about 19% crude protein and 2.5 kcal/g metabolizable energy. This experiment was completely randomized designed. The results of this study showed that weight gain, feed intake and feed conversion ratio were not significantly ($P \geq 0.05$) affected by the inclusion of ZnO, although numerically 250 ppm gave the better values. The serum metabolites, such as the total protein, albumin, urea and cholesterol, were not significantly ($P \geq 0.05$) affected by the inclusion of ZnO. However, the serum creatinine and glucose were significantly ($P \leq 0.05$) affected. Moreover, haematological indices, such as the packed cell volume (PCV), haemoglobin (HB) and red blood cell (RBC), were not significantly ($P \geq 0.05$) affected by the inclusion of ZnO; while the white blood cell (WBC) was significantly ($P \leq 0.05$) affected. It can be concluded from this study that ZnO could be used as an additive to improve the utilization of cassava plant meal by growing pigs.

Key words: Cassava plant meal, ZnO, diets, growing pigs.

1. Introduction

The use of cassava (flour, peels and leaves) as feedstuffs for livestock has been a continuous subject of investigation by animal nutritionists in Nigeria. Although there had been many studies by researchers [1-3] on the use of cassava for livestock feeding, which centered on the flour, peels or leaves. In most of these studies, cassava flour was found to be more economical to replace maize, especially in the diets of pig. But according to Akinfala and Matanmi [4], the price of cassava (flour) has been on the increase, because it has been attracting interest as an industrial crop in Nigeria, and various uses in the starch,

pharmaceutical, bread and biscuit industries have been found. This has made the use of cassava flour to replace maize uneconomical, especially in the diets of pigs. Because of the positive effects of the inclusion of the various products of cassava in the diets of livestock, most importantly in pigs, attempt was made by Akinfala et al. [5] to develop a composite cassava plant meal from unpeeled tubers, leaves and tender stems.

This cassava plant meal is composed of unpeeled tuber mixed with tender stems and leaves, which led to reduction in cassava flour content of the diets. This new innovation led to the production of fibrous cassava feedstuffs.

A major concern has been raised in food-animal systems about the use of antimicrobials and its effectiveness in human disease control. The

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emergence of drug resistant microbial populations in humans and animals and the potential for cross-contamination between populations have resulted in public health officials widely requesting for a sharp reduction of promoting antibacterial in food animals [6]. As a result of this, naturally chemotherapeutic agents are being considered by animal nutritionists as feed additives. One of such agent is zinc oxide (ZnO). Zinc is one of the essential trace elements for prokaryotic and eukaryotic cellular functions, acting as a component of a range of enzymes such as alkaline phosphatases [7]. Although, the promoting growth ability of ZnO has not been fully established [8], but the antibacterial properties may explain the promoting growth effect.

The need to increase the efficiency of using cassava plant meal with ZnO as feed additive as a basal diet for pigs led to this study. Hence, the objective of this study was to evaluate the supplemental effects of ZnO on the utilization of cassava plant meal by growing pigs in the tropics.

2. Materials and Methods

The study was carried out at the Swine Unit of the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

Cassava leaves and tender stems (2 cm to the tip of cassava plant) were collected from the cassava plot at

the Obafemi Awolowo University Teaching and Research Farm. They were spread out on a concrete floor open to the air for sun drying. They were turned regularly for even drying, after which they were separately ground. The leaves were confirmed dry when they became crisp, i.e., easy to crumble within the palms; and the tender stems when easily broken without bending. The leaves were sun-dried for about 2 d depending on the intensity of the sunlight, while the tender stems took about 4-6 d. Cassava tubers were also collected, chopped, spread out on a concrete floor for sun drying and were also turned to allow even drying. The drying was done to about 10% moisture content for about 5-7 d depending on the intensity of the sun light. After drying, they were also milled. The leaves and the tender stems were mixed together in the ratio 5:1. To make the cassava plant meal sun-dried, unpeeled cassava tuber was mixed with the leaves and tender stems in the ratio 2.5:1.

The gross composition of the experimental diets is shown in Table 1. The diets contained ZnO in variable proportions.

Four experimental diets were formulated with control diet (without ZnO) as diet 1 and ZnO was added to the diets in three graded levels of 125, 250 and 300 ppm. All other components of the feed were essentially the same.

Sixteen pigs (Large white × Hampshire) were used in

Table 1 Gross composition of experimental diet.

Ingredients (%)	Experimental diets			
	1	2	3	4
Cassava plant meal	40.00	40.00	40.00	40.00
Ground nut cake	18.00	18.00	18.00	18.00
Palm kernel cake	35.00	35.00	35.00	35.00
Fish meal	2.00	2.00	2.00	2.00
Bone meal	1.50	1.50	1.50	1.50
Oyster shell	3.00	3.00	3.00	3.00
*Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
ZnO (ppm)	-	125	250	300
Total	100	100	100	100

*Premix supplied the following per kg diet: 4,000,000 µg VA, 800,000 µg VD3, 2,500 µg VE, 1,000 mg VK, 750 mg VB1, 750 mg VB6, 7,500 mg niacin, 5 mg VB12, 122,500 mg pantothenic acid, 250 mg folic acid, 10 mg biotin, 100 mg chloride, 62.5 mg antioxidant, 40 g manganese, 25 g zinc, 2.5 g copper, 0.6 g iodine, 100 mg selenium, 100 mg cobalt.

the study. They were distributed into four dietary treatments in a completely randomized design. There were four pigs per dietary treatment and each treatment had two replicates with two pigs per replicate. Pigs in each dietary treatment were fed 4% of their body weight throughout the period of the experiment, which lasted for eight weeks. Pigs were fed once daily and water was given *ad libitum*. All routine medication and management practices were carried out accordingly.

The following growth performance parameters were measured and recorded during the experiment: daily feed intake per animal, weight of the animal every day and feed/gain ratio.

At the end of the experiment, blood samples were taken to the laboratory for analysis of various haematological indices, such as white blood cell (WBC), packed cell volume (PCV), red blood cell (RBC) and haemoglobin (HB), using methods outlined by Kelly [9]. The blood samples in the tubes for biochemical assays were allowed to clot before being centrifuged to obtain serum, which was used in the determination of some serum metabolites by standard chemical procedures.

Chemical analysis of the proximate fraction of the feed was carried out as described by Association of Official Analytical Chemists [10]. The data obtained in the experiment were subjected to one way analysis of variance using Statistical Analysis Software [11].

3. Results and Discussion

3.1 The Proximate Composition of the Experimental Diets

The proximate composition of the experimental

diets is shown in Table 2. The dry matter ranged from 92.00% to 92.82%. Diet 1 with 0 ppm of ZnO had the highest value, while diet 4 with 300 ppm of ZnO had the lowest value. The crude protein was the highest (18.10%) in diet 2 with 150 ppm of ZnO and the lowest (17.99%) in diet 3 with 250 ppm of ZnO. The crude fibre was the highest (14.88%) in diet 1 with 0 ppm of ZnO, while the lowest value (9.40%) was found in diet 3 with 250 ppm of ZnO. The ether extract was the lowest (1.57%) in diet 1 with 0 ppm of ZnO, while the higher values occurred with the ZnO based diets. The nitrogen free extract was the lowest (50.91%) in diet 1 with 0 ppm and the highest (54.94%) in diet 3 with 250 ppm of ZnO. The inclusion of ZnO in cassava plant meal based diets in this study appeared to reduce crude fibre and increase ether extract and nitrogen free extract of the diets, most importantly when included at 250 ppm. This may be due to the ability of ZnO to break down fibre component of a feedstuff, and thereby brings about improved utilization of diet. According to Jacela et al. [8], the mechanism by which zinc improves growth rate in pigs is still unclear, however it may not be unconnected with its antibacterial properties. But there appears to be lack of scientific evidence to understand the exact mode of action.

3.2 Growth Performance

Table 3 showed the performance of the animals fed experimental diets. The final body weight, which though was not significantly affected ($P \geq 0.05$), ranged from 41.50 kg in diet 4 which had 300 ppm of ZnO to 44.17 kg in diet 1 which had 0 ppm of ZnO. The average daily weight gain, which ranged from

Table 2 Proximate composition of the experimental diets.

Parameters (%)	Diets			
	1	2	3	4
Dry matter	92.82	92.68	92.78	92.00
Ash	7.39	9.41	8.70	8.16
Crude protein	18.07	18.10	17.99	18.05
Crude fibre	14.88	10.67	9.40	11.28
Ether extract	1.57	1.76	1.75	1.76
Nitrogen free extract	50.91	52.74	54.94	52.75

Table 3 Performance of the animals fed experimental diets.

Parameters	Diets					
	1	2	3	4	Pooled ($\pm$ SEM)	<i>P</i>
Initial body weight (kg)	25.33	24.67	24.00	25.67	0.22	0.008
Final body weight (kg)	44.17	41.70	44.00	41.50	0.58	0.20
Feed intake (kg/day)	1.18 ^a	1.11 ^b	1.13 ^b	1.11 ^b	0.06	0.001
Weight gain (kg/day)	0.34	0.30	0.36	0.28	0.108	0.28
Feed/gain ratio	3.56	3.66	3.26	4.03	0.15	0.38

^{a, b}Means the same row with different superscript differs significantly at $P < 0.05$. SEM: standard error of means.

0.28 kg in diet 4 with 300 ppm of ZnO to 0.36 kg in diet 3 with 250 ppm of ZnO, was not significantly ($P > 0.05$) influenced by the dietary treatment. The daily feed intake, which was though significantly ($P < 0.05$) influenced by dietary treatments, was the lowest in diet 2 (1.11 kg) with 150 ppm of ZnO and the highest in diet 1 (1.18 kg) with 0 ppm of ZnO. The inclusion of ZnO on cassava plant meal based diet appeared to have led to the reduction in feed intake of the animal. This may be due to the ability of ZnO to bring about reduction in the bulkiness of feed. The ZnO appeared to have acted on the fibre component of cassava plant meal and thus bring about reduction in crude fibre. The feed/gain ratio was the lowest in diet 3 (3.26), while diet 4 had the highest value (4.03). The highest weight gain and best feed efficiency in diet 3 may be due to the promoting growth ability of ZnO [6], which appeared to have been noticed when ZnO was used at 250 ppm on cassava plant meal.

3.3 Serum Metabolites

Table 4 showed the serum metabolites of the animals fed experimental diets. The total serum protein ranged from 60.33 g/L to 73.00 g/L. The highest value occurred significantly ($P \geq 0.05$) in diet 3 with 250 ppm ZnO, while the lowest value occurred in diet 2 with 150 ppm ZnO. The urea level was the lowest in diet 4 (4.03 mmol/L), while diet 1 had 6.0 mmol/L ($P > 0.05$). The creatinine of the experimental animal, which was significantly influenced by the experimental diets ($P < 0.05$), was the highest in diet 3

(194.67 mmol/L) and the lowest in diet 1 (129.20 mmol/L). The cholesterol of the experimental animals was not significantly affected ($P > 0.05$) by the experimental diets. The lowest value occurred in diet 2 (2.60 mmol/L) and the highest value occurred in diet 3 (3.20 mmol/L). The serum glucose was significantly affected ($P > 0.05$) by the dietary treatments. The lowest value occurred in diet 4 (3.167 mmol/L), while the highest value occurred in diet 2 (4.73 mmol/L). The non significant ($P > 0.05$) effect of the dietary treatments on the serum metabolites of the experimental animals may as a result of adequacy of dietary protein and energy in the experimental diets [5]. The significantly ($P < 0.05$) higher values of creatinine with the inclusion of ZnO in the diets may be due to increased tissue protein degradation and muscular wastage [12].

3.4 Haematological Indices

Table 5 showed the haematological indices of the experimental animals. The PCV which ranged from 42.67% to 47.05% was not significantly affected ($P > 0.05$) by the dietary treatment. The PCV reduced with increasing levels of ZnO in the diet. This may indicate the possibility that very high level of ZnO causes anaemia in growing pigs. The HB of the experimental animal was not significantly ($P > 0.05$) affected by ZnO supplementation. However, it appeared that the inclusion of ZnO in the diets of the experimental animals led to reduction in HB concentration in the blood. However, all the values obtained were within the range recommended for healthy pigs by Duke [13].

Table 4 Serum metabolites concentration of experimental animals.

Parameters	Diets				Pooled ($\pm$ SEM)	P
	1	2	3	4		
Total protein (g/L)	65.67	60.33	70.33	69.33	2.29	0.26
Albumin (g/L)	42.89	38.67	33.67	35.33	1.56	0.15
Urea (mmol/L)	6.00	4.20	4.20	4.03	0.31	0.05
Creatinine (mmol/L)	129.20 ^c	159.55 ^b	194.67 ^a	177.50 ^a	8.81	0.001
Cholesterol (mmol/L)	3.10	2.60	3.20	2.87	1.51	0.55
Glucose (mmol/L)	4.30 ^{ab}	4.60 ^{ab}	4.73 ^a	3.17 ^b	0.26	0.12

^{a, b, c}Means the same row with different superscript differs significantly at $P < 0.05$. SEM: standard error of means.

Table 5 Haematological indices of the experimental animals.

Parameters	Diets				$\pm$ SEM
	1	2	3	4	
PCV (%)	47.05	46.17	45.60	42.67	0.85
HB (g/100 mL)	13.50	13.30	13.43	12.27	0.25
RBC ($\times 10^6/\mu\text{L}$)	6.70	7.20	6.80	6.40	0.14
WBC ($\times 10^3/\mu\text{L}$)	13.90 ^{ab}	16.17 ^a	8.67 ^c	11.30 ^{bc}	1.04

^{a, b, c}Means the same row with different superscript differs significantly at $P < 0.05$. SEM: standard error of means.

4. Conclusions

It can be concluded from this study that ZnO could be used at 250 ppm as an additive to improve the utilization of cassava plant meal by growing pigs for growth, but for blood parameters, such as haematology and serum metabolites, the inclusion of ZnO at level above 250 ppm did not have any deleterious effect.

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