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Influence of dietary supplementation with kaolin on growth performance and haematological indices of broiler chickens

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ABSTRACT
A feeding trial was conducted to assess the impact of dietary kaolin (clay) as a feed additive on the growth performance and haematological characteristics of broiler chickens. A total of 180 day-old Arbour Acres broilers, with an average initial body weight of 50 g, were used for the 56-day experiment, which was arranged in a Completely Randomised Design (CRD). The birds were randomly allotted to five dietary treatments; each was replicated three times with 12 birds per replicate. The treatments consisted of: (1) a control group fed the basal diet only; (2) basal diet supplemented with 10 g kaolin/kg feed; (3) basal diet + 20 g kaolin/kg; (4) basal diet + 30 g kaolin/kg; and (5) basal diet + 40 g kaolin/kg. Results indicated that dietary inclusion of kaolin significantly ($p < 0.05$) improved growth performance, particularly in feed intake and feed efficiency. Results also showed that birds fed kaolin-supplemented diets had significantly ($p <0.05$) higher RBC, Hb, and MCV concentrations compared with the control, which supported normal or enhanced haemopoiesis and maintained adequate oxygen transport without causing anaemia. It was therefore concluded that kaolin inclusion in broiler diets has beneficial effects on growth performance without compromising blood cellular constituents.

Keywords: Feed Additive, Broiler, Performance, Haematology, Clay Supplementation

INTRODUCTION

Feed represents the most expensive component in any livestock enterprise, particularly in poultry production (Duncan *et al.,* 2023). Consequently, any significant reduction in feed cost will lower overall production expenses and thereby increase farm profitability. Due to escalating prices of conventional feed ingredients such as groundnut cake and soybean meal, Vlaicu *et al*. (2024) suggested that research efforts should be geared toward innovative feeding strategies to improve resource efficiency without negatively affecting productivity. One promising alternative is kaolin, commonly referred to as china clay—a fine, white clay mineral formed by the breakdown of aluminium-bearing rocks, including feldspar. Kaolin has notable adsorption properties and lacks inherent toxicity (Aremu *et al*., 2023). Because of these characteristics, kaolin is considered a simple yet effective agent for countering the adverse effects of harmful elements existing in both the organism and its external habitat (Mustapha *et al*., 2019; Chen *et al*., 2024).

Owen *et al*. (2012) investigated the incorporation of dietary kaolin (clay) as a dietary additive aimed at enhancing animal growth performance without impairing essential nutrient balance. Additionally, studies by Islam *et al. (*2025) showed that kaolin consumption, particularly through geophagic behaviour in livestock, can serve as a source of essential minerals and in the management of gut parasites/pathogens and gastrointestinal disorders.

Despite the reported benefits of kaolin in both nutrition and medicine, some clinical studies have brought attention to potential issues. For instance, Bonglaisin *et al*. (2022) associated geophagy (kaolin ingestion) with mineral deficiencies, particularly iron deficiency, potentially leading to anaemia. However, contrasting evidence from Attarha *et al.* (2021) indicated that combining kaolin intake with iron supplementation led to haemoglobin levels within the normal range, haematocrit, and erythrocyte counts in humans. Furthermore, Islam *et al.* (2025) have highlighted the effectiveness of kaolin when utilised as a dietary source of essential minerals, including iron, contributing positively to haemoglobin and ferritin concentrations in serum

This study aims to evaluate the impact of offering broiler chickens' diets containing varying levels of kaolin on performance and haematology in Kwara State, Nigeria.

MATERIALS AND METHODS

The poultry section of the Teaching and Research Farm, Kwara State University, Malete, Nigeria, served as the experimental site for the feeding trial. Kaolin clay investigated in this study was purchased at the commercial laboratory, Central Research and Diagnostic Laboratory, Tanke, Ilorin, Nigeria.

Dietary Kaolin was added to the dietary mixture at 0g kaolin/kg for Treatment 1 and designated as the control. Treatments 2, 3, 4 and 5 had 10g kaolin/kg, 20g kaolin/kg, 30g kaolin/kg and 40g kaolin/kg, respectively. Nutrient levels of the produced kaolin-based diets (Table 1) were based on the NRC (1994) recommendations. Ingredient composition and the calculated nutrient content of the experimental diets are presented on an as-fed basis, as indicated in Table 1.

Test animals and feeding trial

A total of 180 Arbour Acres broiler chicks were utilised for this trial. The experiment was arranged in a one-way classification design comprising five dietary treatments. Each treatment group contained three replicates, with twelve (12) chicks per replicate. Before the start of the feeding trial, all the experimental birds were given a conventional starter diet for one week. Following this period, the birds were fed their respective experimental diets *ad libitum* for 56 days (Table 1).

Table 1: Composition of the Experimental Diets (%)

	Kaolin supplementation levels (g/kg)				
Ingredients	**0**	**10**	**20**	**30**	**40**
Maize	58.25	58.25	58.25	58.25	58.25
SBM	38.40	38.40	38.40	38.40	38.40
Bone meal	1.50	1.50	1.50	1.50	1.50
Oyster shell	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50
Lysine	0.10	0.10	0.10	0.10	0.10
DL-methionine	0.25	0.25	0.25	0.25	0.25
*Vit/Min premix	0 .50	0.50	0.50	0.50	0.50
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis					
ME (Kcal/kg)	2954	2959	2943	2958	2946
Crude protein (%)	23	23	23	23	23
Crude fibre (%)	4.20	4.11	4.13	4.28	4.23
Crude fat (%)	4.65	4.73	4.55	4.53	4.67
Methionine (%)	0.49	0.48	0.45	0.48	0.45
Lysine (%)	1.25	1.20	1.10	1.25	1.10

SBM= soybean meal, 0.50 premix supplied, per kilogram of diet: vitamin A, 12,000 IU; vitamin D3, 2,000 IU; vitamin E, 50 IU; vitamin B1, 1 mg; vitamin B2, 3 mg; vitamin B6, 1 mg; vitamin B12, 10 µg; vitamin K, 2 mg; copper (cupric sulphate), 75 mg; nicotinic acid, 12 mg; pantothenic acid, 10 mg; iron, 200 mg; cobalt, 0.5 mg; manganese, 40mg; zinc, 90 mg, iodine, 1 mg; selenium, 0.2 mg; calcium, 31.25 g; sodium,10g

Data Collection

Before the commencement of the experiment, all birds were individually weighed using a digital electronic weighing balance with an accuracy of 0.01 kg to obtain their initial body weights. Thereafter, body weights were recorded weekly at the same time of the day, preferably before the morning feeding, to minimise variation due to gut fill.

The quantity of feed offered to each replicate was weighed and recorded daily. At the end of each day, the leftover feed was collected and weighed. Daily feed intake for each replicate was calculated as the difference between the quantity of feed offered and the quantity of feed refused. Weekly feed intake was obtained by summing the daily feed intake values, while total feed intake was determined by summing the weekly values over the experimental period.

Body weight gain was determined by subtracting the initial body weight from the final body weight for each bird or replicate. Weekly body weight gain was calculated as the difference between the current week's body weight and the previous week's body weight. Average daily weight gain was obtained by

dividing the total body weight gain by the number of experimental days. The feed conversion ratio (FCR) was calculated as the ratio of total feed consumed to total body weight gain for each replicate, with lower FCR values indicating better feed utilisation efficiency. Feed conversion ratio was computed using the equation:

FCR = Total Feed Intake (g) ÷ Total Body Weight Gain (g)

At the conclusion of the experiment, a blood sample was collected from one broiler chicken randomly selected from each replicate within all treatment groups for haematological analysis. Blood samples were collected into EDTA-treated tubes to prevent coagulation. The haematological parameters measured included White Blood Cell (WBC) count, Red Blood Cell (RBC) count, Packed Cell Volume (PCV), and Haemoglobin concentration (Hb). Derived erythrocyte indices — Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH), and Mean Corpuscular Haemoglobin Concentration (MCHC) were calculated from the RBC, PCV, and Hb values following the method outlined by Jain (1986).

Data Analysis

Data generated from the study were subjected to one-way Analysis of Variance (ANOVA) using the General Linear Model procedure of the Statistical Analysis System (SAS, 2003). Differences between treatment means were compared using Duncan's Multiple Range Test, as described by Steel and Torrie (1980).

RESULTS

Results contained in Table 2 revealed that broilers fed the control diet containing 0g kaolin exhibited significantly ($p < 0.05$) higher weight gain compared to those fed kaolin-based diets.

The data for daily feed intake indicated that the birds in treatment I (control), showed a significant difference ($p < 0.05$) among the experimental diets. The daily feed consumption was highest in treatment 1 (94.07g) and ranged between 83.93 g and 87.50 g in the treated group of birds. The data showed that birds on control group, 10g, 20g, 30g and 40g dietary levels of kaolin had 22.13g, 19.46g, 20.67g, 21.19 and 21.15g of mean daily weight gain respectively.

There was a significant difference ($p<0.5$) in feed conversion ratio among the birds in the different dietary treatments. Birds fed 10, 30, and 40g kaolin recorded the best feed: gain ratio of 2.23, 2.21, 2.25, respectively, which were significantly better than the control (0g) and those fed 20g kaolin ($p<0.05$).

Table 2: Effect of dietary supplementation with kaolin on growth performance of broiler chickens

	Supplementation levels of Kaolin (g/kg)					
Parameters	**0**	**10**	**20**	**30**	**40**	**SEM**
Daily weight gain (g/bird/day)	22.13^{a}	19.46^{c}	20.67^{bc}	21.19^{ab}	21.15^{ab}	1.12
Feed intake (g/bird/day)	94.07^{a}	83.93^{c}	87.50^{b}	85.71^{c}	85.21^{c}	0.08
Feed conversion ratio	2.32^{b}	2.23^{a}	2.40^{b}	2.21^{a}	2.25^{a}	0.18

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a

SEM= Standard error of mean. Means with different superscripts along the same rows are significantly different ($p<0.05$).

On haematology of broilers (Table 3), birds fed kaolin-based diets had significantly ($p <0.05$) higher RBC, Hb, and MCV concentrations compared with the control. Whereas the concentrations of PCV, WBC, MCH and MCHC were not significantly ($p > 0.05$) different between treatments except for the birds on 10g/kg group that had a significant ($p < 0.05$) difference in PCV and WBC from the control and other treatments

Table 3: Haematological Indices of Broiler Chickens Fed Kaolin-supplemented Diets

Parameters	Kaolin supplementation level g/kg 0	10	20	30	40	SEM
RBC (x 10^{12}/l)	2.36^{ab}	2.52^{a}	2.30^{b}	2.18^{b}	2.24^{b}	0.106
Haemoglobin (g/d)	8.75^{b}	9.30^{a}	9.00^{a}	8.50^{b}	8.70^{b}	0.415
PCV (%)	31.20^{a}	25.60^{b}	31.30^{a}	29.85^{a}	30.60^{a}	1.405
Mean Cell Volume (fl)	132.25^{ab}	129.60^{b}	136.10^{a}	137.00^{a}	136.55^{a}	3.372
MCH (pg)	37.15	37.95	39.15	39.00	38.80	1.216
MCHC (g/dl)	28.05^{a}	28.55^{a}	28.75^{a}	28.50^{a}	28.45^{a}	0.402
WBC (x 10^{9}/l)	231.00^{a}	213.85^{b}	229.65^{a}	226.10^{a}	231.25^{a}	4.706

RBC= Red Blood Cell, PCV=Packed Cell Volume, Mean Cell Haemoglobin (MCH) and Mean Cell Haemoglobin Concentration (MCHC), WBC= White Blood Cell, Raw= untreated, SEM= Standard error of mean, $p < 0.05$; Means with different superscripts along the same rows are significantly ($P<0.05$)

DISCUSSION

The findings of this study indicated that birds fed the control diet had the highest feed intake and weight gain. Incorporating kaolin into broiler diets significantly ($p < 0.05$) improved feed conversion ratio. Birds fed diets containing 10–30 g/kg kaolin consumed less feed (83.93-87.50)g/b/day compared with the control group (94)g/b/day, which was reflected in an improved feed conversion ratio of (2.21-2.40) compared with the control group with a feed conversion ratio of (2.32). Previous studies have reported that clay minerals, such as kaolin, enhance weight gain and feed efficiency, reduce gut bacterial contamination, and mitigate the negative effects of mycotoxin-contaminated diets (Islam *et al.,* 2025; Tauqir and Nawaz, 2001). Kaolin may also protect the intestinal mucosa by adhering to pathogens and promoting their selective excretion (Ejiofor *et al.,* 2021; Owen, 2012), which could explain the observed reduced feed intake and improved feed conversion in treated birds. However, reports on the effects of clays on animal performance have been inconsistent, likely due to variations in clay type, source, grade, and physicochemical properties (Damato *et al.,* 2022; Oko *et al*., 2011; Ouhida *et al*., 2000). The present results align with previous studies indicating that supplementation of broiler diets with 10–30 g/kg clay enhances growth performance (Xia *et al*., 2001; Tauqir and Nawaz, 2001; Xia *et al*., 2004; Owen *et al*., 2012; Du *et al.,* 2023; Sholikin *et al.,* 2023).

Haematological parameters are key indicators of livestock health (Jain, 1986) and can be influenced by diet (Talebi *et al*., 2005). In this study, red blood cell (RBC) counts ranged from 2.24–2.52 × 10^{12}/L, near the standard range of 3–6 × 10^{6}/dL reported for chickens (Madubuike and Ekenyem, 2006). RBC counts increased with kaolin inclusion up to 30 g/kg, possibly due to the high iron content in diets, which may have promoted erythropoiesis. Similarly, haemoglobin (Hb) levels increased significantly ($p < 0.05$) with kaolin supplementation, ranging from 8.50–9.30%, consistent with previously reported values of 6–13% (Iheukwumere *et al*., 2002).

Packed Cell Volume (PCV) values ranged from 25.6–31.3%, within the 28–30.7% range reported by Ogbuewu *et al*. (2010), though lower than 28.18–38.16% reported by Oko *et al*. (2011). Mean Corpuscular Volume (MCV) values of 129.6–137.0 fl exceeded the normal range of 115–127 fl (Swenson, 1993) but were higher than 16.67–21.08 fl reported by Oko *et al*. (2011). The significant ($p < 0.05$) increase in MCV suggests an increase in red blood cell size with kaolin inclusion. Mean Corpuscular Haemoglobin (MCH) values showed no significant differences ($p > 0.05$), ranging from 37.15–39.15 pg, higher than 25.4–33.4 pg reported by Mitruka *et al*. (1977), indicating that kaolin did not affect the average haemoglobin content per cell. Mean Corpuscular Haemoglobin Concentration (MCHC) values of 28.05–28.75 g/dL were within established ranges of 25.3–32.5 g/dL (Mitruka and Rawsley, 1977), suggesting no signs of anaemia in the birds.

White blood cell (WBC) counts mirrored RBC trends, indicating that dietary kaolin did not compromise the birds' disease resistance. Lower PCV, WBC, and RBC values may reflect potential stress or anaemic conditions (Schalm *et al*., 1975). Overall haematological parameters remained within ranges reported in the literature (Nwonu *et al*., 1996).

CONCLUSION AND RECOMMENDATION

From this study, it can be concluded that kaolin can be included in the diets of broiler chickens up to 30% for improved feed efficiency without compromising the performance and haematological parameters of the chicks.

CONFLICT OF INTEREST

The authors declare no conflict of interest

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