Ciência Rural, Santa Maria, v.45, n.10, p.1835-1840, out, 2015 http://dx.doi.org/10.1590/0103-8478cr20141193
ISSN 0103-8478 ANIMAL PRODUCTION

Kaolin in the diet and its effects on performance, litter moisture and intestinal morphology of broiler chickens

O caulim na ração e seus efeitos sobre desempenho, umidade da cama e morfologia intestinal de frangos de corte

Marina Jorge de Lemos[I*] Lígia Fátima Lima Calixto[I] Osvanira dos Santos Alves[I] Daniele Santos de Souza[I] Bárbara Brandt Moura[I] Túlio Leite Reis[I]

ABSTRACT

The objective of this study was to evaluate the effect of the addition of kaolin in the diet on performance, litter moisture and intestinal morphology of broiler chickens. Four hundred ninety-two broiler chickens distributed in a completely randomized design with three treatments and four replicates of 41 birds each, divided into three periods (15-21; 22-34; 35-52 days) were used. The following treatments were: Control - reference diet without added kaolin; treatment 1 - reference diet + 0.75% kaolin; Treatment 2 - reference diet + 1.5% kaolin. The variables analyzed were: feed intake, average weight, average weight gain, feed conversion, litter moisture, villus height and crypt depth. The inclusion of kaolin in the diet significantly reduced feed intake, increased weight and average weight gain and improved feed conversion of broilers. The litter moisture decreased significantly after the inclusion of kaolin in the diet. The height of the duodenal villi of broilers increased significantly after inclusion of kaolin, while crypt depth was not influenced. The inclusion 0.75% of kaolin in the diet improved the performance, decreased litter moisture and benefited the intestinal integrity of broilers.

Key words: *clay, feed conversion, intestinal villi.*

RESUMO

Objetivou-se com este trabalho avaliar o efeito da adição de caulim na ração sobre o desempenho, a umidade da cama e a morfologia intestinal de frangos de corte. Foram utilizados 492 frangos de corte, distribuídos em um delineamento inteiramente casualizado com três tratamentos e quatro repetições de 41 aves cada, dividido em 3 períodos (15-21 dias; 22-34 dias; 35-52 dias). Os tratamentos adotados foram os seguintes: Controle - ração referência sem adição de caulim; tratamento 1- ração referência + 0,75% de caulim; tratamento 2 - ração referência + 1,5% de caulim. As variáveis analisadas foram: consumo de ração, peso médio, ganho médio de peso, conversão alimentar, umidade da cama, altura das vilosidades e profundidade de cripta. A inclusão de caulim na ração reduziu significativamente o consumo, aumentou o peso e o ganho médio de peso e melhorou a conversão alimentar dos frangos. A umidade da cama diminuiu significativamente após inclusão de caulim na ração. A altura das vilosidades duodenais dos frangos aumentou significativamente após inclusão do caulim, enquanto que a profundidade das criptas não foi influenciada. A inclusão de 0,75% de caulim na dieta melhorou o desempenho, diminuiu a umidade da cama e beneficiou a integridade intestinal de frangos de corte.

Palavras-chave: *argila, conversão alimentar, vilosidades intestinais.*

INTRODUCTION

The use of clays like the kaolin, acting as an inert ingredient in feed, has been very common in broiler and laying hen's aviculture (SAFAEIKATOULI et al., 2011). In systematic mineralogy, kaolin, which is a thin clay, usually white in color, formed by the weathering of aluminous minerals, is classified as a phyllosilicate, due to its absorption capacity and absence of primary toxicity (OWEN et al., 2012).

Studies using kaolin in the feed of poultry with higher concentration than its use in inert form, aimed to improve digestion and nutrients absorption, which showied improvementt, given the purposes of this substance is to promote the reduction of toxins that cause injuries to the intestinal epithelium, by the absorption and excretion of the pathogen thereby protecting the intestinal mucosa, hence improving the performance of the poultry (OLVER, 1997; FERREIRA et al., 2005; TRCKOVA et al., 2009; OWEN et al., 2012). Other purposes have been

[I]Departamento de Produção Animal, Instituto de Zootecnia, Universidade Federal Rural do Rio de Janeiro (UFRRJ), BR 465, Km 07, 23890-000, Seropédica, RJ, Brasil. E-mail: marijorgelemos@hotmail.com. *Corresponding author.

Received 08.13.14 Approved 02.19.15 Returned by the author 05.17.15
CR-2014-1193.R2

reported, such as improvement in nutrients digestibility by reducing the digest transit in laying hens and broiler chickens (CASTAING, 1989) and reduction of the free moisture of feces due to its antidiarrheal action (OLVER, 1997). In this context, the aim of this study was to assess the effectiveness of adding kaolin in the feed on performance, litter moisture and intestinal morphology of broiler chickens.

MATERIAL AND METHODS

The study was conducted in an experimental shed for broiler chickens in the aviculture section of the Universidade Federal Rural do Rio de Janeiro (UFRRJ), from September to November of 2013. Four hundred and ninety two mixed broiler chickens from the Cobb commercial strain were used, distributed in a completely randomized design with three treatments and four repetitions of 41 chickens each. The experiment began at 8 days of age and went on until the chickens completed 52 days, ending with the slaughter.

The adopted treatments were as follows: Control - reference feed without addition of kaolin; treatment 1 - reference feed + 0.75% of kaolin; treatment 2 - reference feed + 1.5% of kaolin. The experimental diets were isoproteic and isoenergetic and were made with a base of corn and soybean meal (Table 1), in order to meet the minimum nutritional requirements of the broiler chicken in the different periods according to ROSTAGNO et al. (2011). The poultry was weighted on the first day of experiment and placed in boxes in a completely randomized design. The poultry adaptation period to the experimental feed was of 7 days and when they completed 15 days of age the data collection began.

The experimental shed is made of masonry with dimensions of 12m x 45m, covered with French tiles, subdivided into 18 experimental boxes, of which 12

Table 1 - Percentage composition of the reference feed used in each experimental period.

Ingredients (%)	Periods		
	15 to 21 days	22 to 34 days	35 to 52 days
Corn (% 7.52 CP)	55.108	59.546	63.462
Soybean meal (% 47.53 CP)	39.222	34.41	30.819
Soybean oil	2.354	3.018	3.003
Dicalcium phosphate	1.472	1.238	1.011
Limestone	0.812	0.774	0.696
Salt	0.419	0.399	0.39
DL-Methionine	0.232	0.213	0.189
L-Lysine HCl	0.090	0.112	0.131
Vitamin[1]	0.100	0.100	0.100
Mineral[2]	0.100	0.100	0.100
Choline chloride	0.050	0.050	0.050
BHT	0.040	0.040	0.040
Kaolin	0.00	0.00	0.00
	Nutritional composition values		
Calcium (%)	0.819	0.732	0.638
Metabolizable energy (Mcal kg^{-1})	3.00	3.10	3.15
Phosphorus available (%)	0.391	0.342	0.298
Lysine digestible (%)	1.174	1.078	1.010
Lysine total (%)	1.299	1.193	1.118
Met + cist digestible (%)	0.846	0.787	0.737
Met + cist total (%)	0.932	0.868	0.814
Methionine digestible (%)	0.548	0.507	0.468
Methionine total (%)	0.579	0.536	0.496
Potassium (%)	0.887	0.812	0.758
Crude protein (%)	22.8	21.0	19.7
Sodium (%)	0.210	0.20	0.195
Threonine digestible (%)	0.767	0.703	0.658
Threonine total (%)	0.880	0.801	0.758
Tryptophan digestible (%)	0.260	0.234	0.215
Tryptophan Total (%)	0.288	0.259	0.238

[1]Vitamin A (min) 7.500.000UI kg^{-1}; vitamin D3 (min) 2.500.000UI kg^{-1}; vitamin E (min) 1.200mg kg^{-1}; vitamin K3 (min) 1.200mg kg^{-1}; thiamine (min) 1.500mg kg^{-1}; riboflavin (min) 5.500mg kg^{-1}; pyridoxine (min) 2000mg kg^{-1}; vitamin B12 (min) 12.000mcg kg^{-1}; niancina 35g kg^{-1}; panteonato de cálico (min) 10g kg^{-1}; biotin (min) 67mg kg^{-1};
[2]Iron (min) 60g kg^{-1}; coper (min) 13g kg^{-1}; manganese (min) 120g kg^{-1}; zinc (min) 100g kg^{-1}; iodine (min) 2.500mg kg^{-1}; selenium (min) 500mg kg^{-1}.

were used with a dimension of 6m² of area. The density inside each box was of 7 birds for m². Not only water but also feed was given ad libitum during all the experimental period. The management and equipment used were conventional for the creation of broiler chickens.

The experiment was divided into 3 periods (15-21 days), (22-34 days) and (35-52 days), wherein at the end of each period the broiler of each experimental unit was weighted to obtain an average weight and determine the weight gain calculated by the difference between the initial and final weight within the period. Feed intake from each period was obtained from the difference of the feed provided minus the leftover feed. In case of death, the feed from the feeder was immediately weighted to calculate the corrected intake. The feed conversion was obtained from the ratio of feed intake/weight gain in the period.

In order to analyse the intestinal morphology, the broilers were slaughtered at 52 days of age. Five broilers per unit were separated, summing twenty broilers per treatment and sent for slaughter. After the slaughter procedures, the small intestine of 60 broilers (20 per treatment) was collected for evaluation of morphometric parameters, according to the method described by PELICANO et al. (2005). The intestinal morphology analysis considered the following variables: villi height and crypt depth.

The litter moisture was assessed through litter samples (20g) collected from three spots of each box a day before the broilers were sent for slaughter, areas near the feeders and drinkers were avoided and each litter collection spot corresponded to a circle of about 20cm radius and 7cm high as described by NIKOLAKAKIS et al. (2013). After being placed in plastic bags, identified, weighted and frozen for three weeks the samples were sent to the Bromatology laboratory in the Animal Science Institute of the UFRRJ, for procedures for the moisture analysis according to the method recommended by the Ministry of Agriculture Livestock and Supply – MAPA (1991). The results were submitted to analysis of variance. Subsequently, the averages were compared by the Tukey test at a 5% significance level.

RESULTS AND DISCUSSION

The results of performance of the broiler chickens fed with different levels of kaolin at different stages are presented in table 2.

The feed intake was significantly reduced ($P<0.05$) after adding kaolin in the feed in the period of 15 to 21 days of age and 22 to 34 days of age. The lowest feed intake was observed after adding 1.5% of kaolin in the period of 15 to 21 days of age. In the period of 22 to 34 days of age both levels of kaolin tested diminished feed intake compared to the control, treatments which didn't differ from one another ($P>0.05$). In the period of 35 to 52 days of age however, effects of adding kaolin ($P>0.05$) were not observed in the broilers' feed intake. The incorporation of clays in the feed reduces the digest transit rate improving the digestibility which causes the poultry

Table 2 - Feed intake, average weight, average weight gain and feed conversion of broiler chickens fed with different levels of kaolin in different periods.

Treatment	Feed Intake (g)	Average weight (g)	Average weight Gain (g)	Feed Intake
	(15 to 21 days)			
Control	632.0 c	600 b	400 b	1.58 a
0.75 kaolin	575.4 b	632 a	420 a	1.37 b
1.5 kaolin	564.3 a	631 a	418 a	1.35 b
CV %	2.68	4,25	3,05	2.49
	(22 to 34 days)			
Control	1591.20 b	1536 c	936 b	1.70 a
0.75 kaolin	1596.00 a	1582 b	950 a	1.68 a
1.5 kaolin	1597.31 a	1593 a	962 a	1.66 a
CV %	3.05	3.69	3.14	2.68
	(35 to 52 days)			
Control	3215.11 a	3067 c	1531 b	2.1 a
0.75 kaolin	3201.90 a	3224 b	1642 a	1.95 b
1.5 kaolin	3214.40 a	3233 a	1640 a	1.96 b
CV %	3.65	4.84	3.15	2.98

Averages followed by the same letter in the column don't differ from one another at a 5% probability by the Tukey test ($P>0.05$).

to require a lower feed intake to meet their nutritional needs (CASTAING, 1989; ANGULO et al., 1995). Similar to that seen in the present study, a lower feed intake was observed by HU et al. (2013) after adding clay (montmorillonite) into the broiler chickens' diet.

The average weight increased significantly (P<0.05) after adding kaolin in all periods analysed. In the period of 15 to 21 days of age both levels of kaolin tested increased the average weight compared to the control, treatments which didn't differ from one another (P>0.05). In the other periods (22 to 34 and 35 to 52 days of age) the inclusion of 1.5% of kaolin resulted in the highest average weight. The average weight gain also increased significantly (P<0.05) after inclusion of both levels of kaolin tested, in all periods analysed compared to the control, treatments which didn't differ from one another (P>0.05). According to CASTAING (1989) and ANGULO et al. (1995) the incorporation of clay in the feed reduces the digest transit rate, increasing the time of exposure to digestive enzymes, therefore improving the feed's nutrients digestibility resulting in improved animal performance. XIA et al. (2004) and PARIZADIAN et al. (2013) also observed improvements in broiler chickens' weight gain after the inclusion of clay (montmorillonite) in the diet.

Feed conversion improved significantly (P<0.05) after adding kaolin in the feed in the periods of 15 to 21 days of age and of 34 to 52 days of age compared to the control, treatments which didn't differ from one another (P>0.05). In the period of 22 to 34 days of age no effects of adding kaolin (P>0.05) were observed. The best feed conversion results follow the behavior observed in the present study for feed intake and weight gain. Similar to that seen in the present study, PARIZADIAN et al. (2013) when evaluating the inclusion of clay (clinoptilolite) into the broiler chickens' diet (levels of 0, 1.5 and 3%) also observed significant improvement in feed conversion when compared to the control (without inclusion of clay in the diet). These authors state that the addition of clay to the feed improves enzymatic activity of gastrointestinal secretions and nutrient digestibility. According to MARTIN-KLEINER et al. (2001) ion exchange property of clays can alter the pH and ionic composition of gastrointestinal fluids, thereby altering the enzymatic activity of gastrointestinal secretions and increasing the digestibility of nutrients promoting improved animal performance.

The height of the duodenal villi of broiler chickens (Table 3) was influenced (P<0.05) by the inclusion of kaolin. The highest averages of villus height were observed in chickens that were fed with kaolin compared to the control treatment (without kaolin). According to MACARI et al. (2002), the absorptive capacity of the intestine will be directly proportional to the size of the villi and poultry with higher villi may have a better absorption of nutrients. The intake of clays can improve the intestinal integrity through its role in absorption and excretion of pathogenic microorganisms in poultry gastrointestinal tract (XU et al., 2003). HU et al. (2013) observed improvements in intestinal integrity measured by the villi height by providing clay (montmorillonite) to broiler chickens. These authors also state that maintaining the intestinal integrity is essential for the proper functioning of epithelial cells and the use of clays when feeding the poultry is a great alternative to maintain intestinal health and consequently animal performance.

Table 3 - Height of intestinal villi and depth of intestinal crypts in the duodenum of broiler chickens fed with different levels of kaolin.

Treatment	Villus height (μm)	Crypt depth (μm)
Control	948.95b	205.84a
0.75 kaolin	1073.21a	206.40a
1.5 kaolin	1098.32a	208.25a
CV %	9.14	10.47

Averages followed by the same letter in the column don't differ from one another at a 5% probability by the Tukey test (P>0.05).

The depth of intestinal crypts wasn't affected (P>0.05) by the inclusion of kaolin (Table 3). Some authors report that the increase of crypt depth may indicate high cellular proliferative activity which typically occurs as an epithelial response to some injury to the mucosa and seeks to renew losses in the villi height (FURLAN et al., 2004). This renewal, according to MARKOVIC et al. (2009) requires energy and protein, which may decrease the growth and development of other tissues. In the present study, such was not observed.

The results of improvement of the intestinal integrity observed in the present study were reflected in the performance results, since according to XU et al. (2003) clay possess the capacity to absorb and excrete pathogenic microorganisms present in the poultry's gastrointestinal tract which promotes improvements in the environment and in the epithelium and, consequently, greater use of nutrients.

The litter moisture of broiler chickens was affected (P<0.05) by the inclusion of kaolin in the feed (Table 4). Both levels of kaolin tested diminished the litter moisture percentage, compared to the control

Table 4 - Litter moisture of broiler chickens fed with different levels of kaolin.

Treatment	Litter Moisture (%)
Control	33.9836a
0.75 kaolin	28.2948b
1.5 kaolin	24.7895c
CV %	5.68

Averages followed by the same letter in the column don't differ from one another at a 5% probability by the Tukey test (P>0.05).

and lower moisture percentages were observed in the litter samples of broilers that were fed with a higher content of kaolin (1.5%) compared to the control treatment (without kaolin). Similar results to the present study were found by NIKOLAKAKIS et al. (2013) that after inclusion of different levels of clay (Zeolite) in the diet, observed lower moisture of the broiler chicken's litter. PARIZADIAN et al. (2013) also observed a significant reduction in moisture content of excreta and improved quality of litter after inclusion of clay (clinoptilolite) in the broiler chickens' diet. These authors state that the broiler's litter when moist is a propitious environment for the growth of bacteria and fungi; and also the main cause of ammonia emissions, one of the most serious environmental factors that affect the production of broiler chickens. CASTAING (1989) and OLVER (1997) state that the use of clay may cause the reduction of moisture in broilers and laying hens' litter due the capacity of this substance to absorb and retain ammonia (CASTAING, 1989; OLVER, 1997), being a great tool for prevention of diarrhea and problems with an excess of ammonia in the environment.

CONCLUSION

The inclusion of 0.75% of kaolin in the diet improved performance, diminished litter moisture and benefited the intestinal integrity of broiler chickens.

ACKNOWLEDGEMENTS

To Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for granting the scholarship.

ETHICS COMMITTEE

Protocol N. 352/2013.

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