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Calcium anacardate in the diet of broiler chickens: the effects on growth and bone quality[1]

Anacardato de cálcio na alimentação de frangos de corte: efeitos no crescimento e qualidade óssea

Carlos Eduardo Braga Cruz[2], Ednardo Rodrigues Freitas[3], Germana Costa Aguiar[3], Nádia de Melo Braz[3] and Maria Tereza Salles Trevisan[3]

ABSTRACT - The aim of this research was to evaluate the effects of adding calcium anacardate (ACa) as a source of anacardic acid to the diet of broiler chickens on the growth, quality and bone composition of the femur and tibia of the birds. A total of 840 male chicks, one day old, were kept in a completely randomised experimental design, with six treatments and seven replications of 20 birds. The following treatments were applied: a diet without the addition of growth promoter (GP), a diet with added GP and other diets with no GP and the addition of ACa at levels of 0.25, 0.50, 0.75 and 1%. The variables under analysis were the weight, length, diameter, Seedor index, and the resistance and deformity of the left femur and tibia of the birds. For bone composition, the dry matter and mineral matter of the right femur and tibia of the chickens were analysed. There were no significant differences between treatments in the growth, quality or composition of the femur or tibia of the birds, showing that the use of calcium anacardate as a source of anacardic acid does not affect bone deposition in broiler chickens up to 42 days of age.

Key words: Organic acid. Bone development. Femur. Tibia.

RESUMO - Com essa pesquisa, objetivou-se avaliar os efeitos da inclusão de anacardato de cálcio (ACa) como fonte de ácido anacárdico na alimentação de frangos de corte sobre o crescimento, qualidade e composição óssea do fêmur e da tíbia das aves. Foram alojados 840 pintos machos de um dia de idade em delineamento experimental inteiramente casualizado com seis tratamentos e sete repetições de 20 aves. Os tratamentos aplicados foram: ração sem adição de promotor de crescimento (PC), ração com PC e, demais, rações sem PC e adição de (ACa) nos níveis de 0,25; 0,50; 0,75 e 1%. As variáveis analisadas foram: peso, comprimento, diâmetro, índice de Seedor, resistência e deformidade do fêmur e da tíbia esquerda das aves. Para composição óssea foram analisadas a matéria seca e a matéria mineral do fêmur e da tíbia direita dos frangos. Não houve diferenças significativas entre os tratamentos no crescimento, qualidade e composição dos ossos do fêmur e da tíbia das aves, indicando que o uso do anacardato de cálcio, como fonte de ácido anacárdico, não afeta a deposição óssea em frangos de corte até 42 dias de idade.

Palavras-chave: Ácido orgânico. Desenvolvimento ósseo. Fêmur. Tíbia.

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[2]Faculdade Terra Nordeste, Ceará/FATENE, Caucaia-CE, Brasil, carlos.zootecnia@gmail.com (ORCID ID 0000-0003-1653-9011)
[3]Departamento de Zootecnia, Universidade Federal do Ceará/UFC, Fortaleza-CE, Brasil, ednardo@ufc.br (ORCID ID 0000-0001-7226-9517), germana_aguiar@hotmail.com (ORCID ID 0000-0002-8140-5119), nadia_zootec@yahoo.com.br (ORCID ID 0000-0002-5502-3512), trevisan@ufc.br (ORCID ID 0000-0003-1274-7497)

INTRODUCTION

Reports of bone problems in broiler chickens are increasingly frequent, with the rise in bone abnormalities being associated with economic loss: they cause discomfort, affect the well-being of the chickens and often lead to the birds being discarded during the breeding cycle, or even to the death of the birds. Among bone problems related to rapid growth in chickens, lameness, weakness in the legs and bone alterations related to metabolic disorders should be mentioned (DIBNER *et al*., 2007; ISLAM *et al*., 2012; JULIAN, 2005). These are problems that directly affect production.

Rath *et al*. (2000) highlighted factors that may interfere in growth and bone development in birds, including the need for a feeding program that would allow adequate animal development, since changes in nutrition can have a direct influence on growth and bone development in birds. On the other hand, when the birds are raised under conditions of heat stress, there may be greater excretion of such minerals as calcium, iron and zinc, with consequent changes in bone quality (POST; REBEL; HUUNRNE, 2003). According to Abioja *et al*. (2012), heat stress had a damaging effect on bone quality in broiler chickens, reducing the length, diameter, amount of ash and resistance of the tibia.

With the ban on the use of antibiotic growth promoters in the diet of birds destined for certain countries, broiler companies have had to adapt, seeking to use alternative products to antibiotics in the feed.

Among alternative additives are the organic acids, which have strong antimicrobial properties, improving the digestibility and absorption of nutrients in the diet, weight gain and feed conversion, and reducing the production of toxic substances by bacteria and desquamation of the intestinal lining; they are used in animal feed to control the growth of fungi and bacteria, benefiting the intestinal pH and consequently the absorption of minerals, especially calcium and phosphorus, which are fundamental for the growth and development of bone tissue (FARIA *et al*., 2009; SALAZAR *et al*., 2008; ŚWIĄTKIEWICZ; ARCZEWSKA-WLOSEK, 2012).

Anacardic acid is a phenolic compound derived from salicylic acid. It is a natural product found in various parts of the cashew tree (*Anacardium occidentale* L.), but mainly in the liquid of the shell of the cashew nut. It can also be found in the peduncle of the cashew (BROINIZI *et al*., 2008; MAZZETO; LOMONACO; MELE, 2009; TREVISAN *et al*., 2006). Anacardic acid acts to inhibit the growth of microorganisms, and displays great antioxidant capacity related to inhibiting the formation of superoxides and the inhibitory action of xanthine oxidase, however, if consumed in excess, it can lead to problems of toxicity (ACHANATH; SRINIVAS; RAMADOSS, 2010; TREVISAN *et al*., 2006). According to Hamad and Mubofu (2015), the antioxidant action of anacardic acid is also due to its ability to form chelates with minerals that are important for the action of enzymes which catalyse lipid oxidation. This property may therefore interfere with intestinal absorption, and consequently reduce the absorption of minerals that are important for bone formation.

The aim of this research was to evaluate the effects of adding calcium anacardate as a source of anacardic acid to the diet of broiler chickens on the growth, quality and bone composition of the femur and tibia.

MATERIAL AND METHODS

To carry out the experiment, 840 one-day-old male Ross 308 chicks were obtained. These were vaccinated while in the incubator to ‘prevent’ Marek’s disease and Gumboro disease. The experiment was conducted in a brick shed, 15 m x 10 m in size, covered in clay tiles, with a cement floor, a ceiling height of 3.5 m, and containing 48 1.5 m X 1.0 m boxes.

The experimental design was completely randomised, with six treatments and seven replications of 20 birds, totalling 140 birds per treatment. The treatments applied were NC = Negative control – a diet with no added growth promoter (GP); PC = positive control - a diet with the addition of GP; PC_1 = a diet with the addition of 0.25% ACa and with no added GP; PC_2 = a diet with the addition of 0.50% ACa and with no added GP; PC_3 = a diet with the addition of 0.75% ACa and with no added GP and PC_4 = a diet with the addition of 1.00% ACa and with no added GP.

The feeding program was divided into three phases: initial (1 to 21 days), growth (22 to 35 days) and final (35 to 42 days). The experimental diets were formulated to be isonutritive and isoenergetic according to the nutritional requirements recommended by the lineage handbook (Tables 1, 2 and 3). In calculating the diets, the chemical composition of the ingredients as presented by Rostagno (2011) were considered.

The anacardic acid was added to the diets in the form of calcium anacardate, an intermediate product in the process of obtaining pure acid from the liquid removed from the cashew nut. This liquid was initially obtained from the cashew nut by heating in an oven at 120 ºC for a maximum of one hour, and was immediately collected and stored while it accumulated in a glass container. The calcium anacardate was extracted in a 4 L beaker by the addition of 550 ml of the liquid from the cashew nut, 150 ml of distilled water and 2850 ml of ethanol, which after mixing, were heated to 50 °C and stirred for 4 hours, with the temperature constantly monitored. Throughout the procedure, 250 g of calcium hydroxide were added to the mixture. After 4 h of stirring and heating, the mixture was allowed to stand for 1 h when the supernatant was removed. An additional 800 mL of ethanol was then added, and the mixture was again stirred for 1 h whilst being heated. At the end of this stage, the calcium anacardate was oven-dried for 72 h and then triturated (TREVISAN *et al*., 2006).

Table 1 - Calculated percentage and nutritional composition of the experimental diets for broiler chickens of 1 to 21 days of age

Ingredient	NC	PC	% Calcium anacardate			
			0.25	0.50	0.75	1.00
Maize	55.83	55.83	55.83	55.83	55.83	55.83
Soybean meal	36.05	36.05	36.05	36.05	36.05	36.05
Soybean oil	3.10	3.10	3.10	3.10	3.10	3.10
Dicalcium phosphate	1.90	1.90	1.90	1.90	1.90	1.90
Limestone	0.83	0.83	0.83	0.83	0.83	0.83
Inert	1.00	0.91	0.75	0.50	0.25	-
DL-Methionine	0.30	0.30	0.30	0.30	0.30	0.30
L-Lysine HCl	0.29	0.29	0.29	0.29	0.29	0.29
Vitamin + mineral sup.[1]	0.20	0.20	0.20	0.20	0.20	0.20
Choline	0.05	0.05	0.05	0.05	0.05	0.05
Common salt	0.45	0.45	0.45	0.45	0.45	0.45
Calcium anacardate	-	-	0.25	0.50	0.75	1.00
Nicarbazin	-	0.004	-	-	-	-
Monteban	-	0.040	-	-	-	-
BMD11%[2]	-	0.046	-	-	-	-
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated energetic and nutritional composition						
Metab. Energy (kcal/kg)	3.000	3.000	3.000	3.000	3.000	3.000
Crude protein (%)	21.16	21.16	21.16	21.16	21.16	21.16
Dry matter (%)	88.80	88.80	88.80	88.80	88.80	88.80
NDF (%)	11.63	11.63	11.63	11.63	11.63	11.63
ADF (%)	4.80	4.80	4.80	4.80	4.80	4.80
Calcium (%)	0.89	0.89	0.89	0.89	0.89	0.89
Avail. phosphorous (%)	0.46	0.46	0.46	0.46	0.46	0.46
Sodium (%)	0.20	0.20	0.20	0.20	0.20	0.20
Chlorine (%)	0.32	0.32	0.32	0.32	0.32	0.32
Total lysine (%)	1.36	1.36	1.36	1.36	1.36	1.36
Total methionine (%)	0.60	0.60	0.60	0.60	0.60	0.60
Total meth.+cystine (%)	0.94	0.94	0.94	0.94	0.94	0.94
Total threonine (%)	0.82	0.82	0.82	0.82	0.82	0.82
Total tryptophan (%)	0.26	0.26	0.26	0.26	0.26	0.26

[1]Vitamin/mineral supplement (composition per kg of product): vit. A – 5,500,000 IU; vit. B1 – 500 mg; vit. B12 – 7,500 mcg; vit. B2 – 2,02 mg; vit. B6 – 750 mg; vit D3 – 1,000,000 IU; vit. E – 6,500 IU; vit. K3 – 1,250 mg; biotin - 25 mg; niacine -17.5 g; folic acid – 251 mg; pantothenic acid – 6,030 mg; cobalt – 50 mg; Copper – 3,000 mg; Iron - 25 g; Iodine – 500 mg; Manganese – 32.5 g; Selenium – 100.50 mg; Zinc – 22.49 g; [2]Bacitracin methylene disalicylate 11%

Table 2 - Calculated percentage and nutritional composition of the experimental diets for broiler chickens of 22 to 35 days of age

Ingredient	NC	PC	% Calcium anacardate			
			0.25	0.50	0.75	1.00
Maize	60.90	60.90	60.90	60.90	60.90	60.90
Soybean meal	30.93	30.93	30.93	30.93	30.93	30.93
Soybean oil	3.67	3.67	3.67	3.67	3.67	3.67
Dicalcium phosphate	1.66	1.66	1.66	1.66	1.66	1.66
Limestone	0.76	0.76	0.76	0.76	0.76	0.76
Inert	1.00	0.90	0.75	0.50	0.25	-
DL-Methionine	0.24	0.24	0.24	0.24	0.24	0.24
L-Lysine HCl	0.23	0.23	0.23	0.23	0.23	0.23
Vitamin + mineral sup.[1]	0.15	0.15	0.15	0.15	0.15	0.15
Choline	0.05	0.05	0.05	0.05	0.05	0.05
Common salt	0.41	0.41	0.41	0.41	0.41	0.41
Calcium anacardate	-	-	0.25	0.50	0.75	1.00
Salinomycin	-	0.05	-	-	-	-
BMD11%[2]	-	0.05	-	-	-	-
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated energetic and nutritional composition						
Metab. Energy (kcal/kg)	3.100	3.100	3.100	3.100	3.100	3.100
Crude protein (%)	19.15	19.15	19.15	19.15	19.15	19.15
Dry matter (%)	88.75	88.75	88.75	88.75	88.75	88.75
NDF (%)	11.53	11.53	11.53	11.53	11.53	11.53
ADF (%)	4.55	4.55	4.55	4.55	4.55	4.55
Calcium (%)	0.80	0.80	0.80	0.80	0.80	0.80
Avail. phosphorous (%)	0.41	0.41	0.41	0.41	0.41	0.41
Sodium (%)	0.18	0.18	0.18	0.18	0.18	0.18
Chlorine (%)	0.30	0.30	0.30	0.30	0.30	0.30
Total lysine (%)	1.18	1.18	1.18	1.18	1.18	1.18
Total methionine (%)	0.52	0.52	0.52	0.52	0.52	0.52
Total meth.+cystine (%)	0.83	0.83	0.83	0.83	0.83	0.83
Total threonine (%)	0.75	0.75	0.75	0.75	0.75	0.75
Total tryptophan (%)	0.23	0.23	0.23	0.23	0.23	0.23

[1]Vitamin/mineral supplement (composition per kg of product): vit. A – 5,500,000 IU; vit. B1 – 500 mg; vit. B12 – 7,500 mcg; vit. B2 – 2,02 mg; vit. B6 – 750 mg; vit D3 – 1,000,000 IU; vit. E – 6,500 IU; vit. K3 – 1,250 mg; biotin - 25 mg; niacine -17.5 g; folic acid – 251 mg; pantothenic acid – 6,030 mg; cobalt – 50 mg; Copper – 3,000 mg; Iron - 25 g; Iodine – 500 mg; Manganese – 32.5 g; Selenium – 100.50 mg; Zinc – 22.49 g; [2]Bacitracin methylene disalicylate 11%

During the experimental period, data of maximum and minimum temperature and relative humidity were collected in the early morning and late afternoon, using a maximum and minimum thermometer and a psychrometer respectively. The mean minimum and maximum ambient temperature in the shed during the experiment was 26.0 and 28.9 °C respectively, and the relative humidity was 69%.

Throughout the experimental phase (from 1 to 42 days of age), the birds and the diets were weighed. At 42 days, after weighing the birds and diets, two birds were selected per plot, with a weight close to the average weight of each plot. Once identified, the birds were euthanised by cervical dislocation and weighed on a digital balance to obtain the body weight; the thighs and upper thighs were then removed, duly labelled, weighed on a 0.01 g precision

Table 3 - Calculated percentage and nutritional composition of the experimental diets for broiler chickens of 35 to 42 days of age

Ingredient	NC	PC	% Calcium anacardate			
			0.25	0.50	0.75	1.00
Maize	62.75	62.75	62.75	62.75	62.75	62.75
Soybean meal	28.03	28.03	28.03	28.03	28.03	28.03
Soybean oil	4.80	4.80	4.80	4.80	4.80	4.80
Dicalcium phosphate	1.57	1.57	1.57	1.57	1.57	1.57
Limestone	0.74	0.74	0.74	0.74	0.74	0.74
Inert	1.00	1.00	0.75	0.50	0.25	-
DL-Methionine	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine HCl	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin + mineral sup.[1]	0.10	0.10	0.10	0.10	0.10	0.10
Choline	0.05	0.05	0.05	0.05	0.05	0.05
Common salt	0.41	0.41	0.41	0.41	0.41	0.41
Calcium anacardate	-	-	0.25	0.50	0.75	1.00
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated energetic and nutritional composition						
Metab. Energy (kcal/kg)	3.200	3.200	3.200	3.200	3.200	3.200
Crude protein (%)	18.32	18.32	18.32	18.32	18.32	18.32
Dry matter (%)	88.55	88.55	88.55	88.55	88.55	88.55
NDF (%)	11.26	11.26	11.26	11.26	11.26	11.26
ADF (%)	4.51	4.51	4.51	4.51	4.51	4.51
Calcium (%)	0.78	0.78	0.78	0.78	0.78	0.78
Avail. phosphorous (%)	0.39	0.39	0.39	0.39	0.39	0.39
Sodium (%)	0.20	0.20	0.20	0.20	0.20	0.20
Chlorine (%)	0.28	0.28	0.28	0.28	0.28	0.28
Total lysine (%)	1.16	1.16	1.16	1.16	1.16	1.16
Total methionine (%)	0.53	0.53	0.53	0.53	0.53	0.53
Total meth.+cystine (%)	0.83	0.83	0.83	0.83	0.83	0.83
Total threonine (%)	0.70	0.70	0.70	0.70	0.70	0.70
Total tryptophan (%)	0.22	0.22	0.22	0.22	0.22	0.22

[1]Vitamin/mineral supplement (composition per kg of product): vit. A – 5,500,000 IU; vit. B1 – 500 mg; vit. B12 – 7,500 mcg; vit. B2 – 2,02 mg; vit. B6 – 750 mg; vit D3 – 1,000,000 IU; vit. E – 6,500 IU; vit. K3 – 1,250 mg; biotin - 25 mg; niacine -17.5 g; folic acid – 251 mg; pantothenic acid – 6,030 mg; cobalt – 50 mg; Copper – 3,000 mg; Iron - 25 g; Iodine – 500 mg; Manganese – 32.5 g; Selenium – 100.50 mg; Zinc – 22.49 g

digital balance and kept in a freezer at -20 °C, where they remained until boning.

For boning, the pieces were thawed in a domestic refrigerator (at 4 °C) for 12 hours and then placed on benches for the material to reach room temperature. The thighs and upper thighs were then weighed, duly labelled and immersed in boiling water for 10 minutes, after which they were boned using a scalpel, as per the methodology described by Bruno (2002).

The lengths of the left femur and tibia were measured by digital calliper, and the weight was obtained by precision balance (0.01 g). Bone density was calculated using the Seedor Index, and the bone weight (mg) to length (mm) ratio was evaluated (SEEDOR, 1991).

Bone strength and deformity were determined in the bone *in natura* (tibia and femur) with the aid of a mechanical press. The bones were placed horizontally on a wooden support and a force applied to the centre of each bone. The maximum amount of force applied to the bone before breaking was considered the breaking resistance (kgf/cm^2) and the amount of force at the time the bone broke was considered the deformity (mm).

The chemical composition of the bones was determined at the Animal Nutrition Laboratory (LANA) of the Department of Animal Science of the Federal University of Ceará. After thawing, the right tibia and femur were placed in suitable containers, weighed and dried in a forced ventilation oven at 55 °C for 72 h. The samples were then removed from the oven and reweighed to obtain the pre-dried matter. After weighing, the bones were crushed in a ball mill, and the samples ground and placed in duly labelled plastic bags for the dry matter (DM) and mineral matter (MM) to be later determined as per a methodology described by Silva and Queiroz (2002).

Statistical analysis was carried out using the Statistical Analysis System software (SAS INSTITUTE, 2009). The data were analysed using the ANOVA procedure and when significant, were compared by the SNK test (5%). To determine the optimum inclusion level, increasing levels of calcium anacardate were subjected to regression analysis.

RESULTS AND DISCUSSION

The results for bone weight, length, diameter, Seedor index, resistance and deformity (Table 4) did not present a significant difference between treatments. In evaluating bone composition (Table 5), there was also no significant difference between treatments in the dry matter or mineral matter of the femur and tibia.

The results demonstrate that the use of calcium anacardate in the diets did not alter the bone parameters under evaluation.

Bird growth depends on the availability of nutrients for metabolic processes, for which nutrients must be ingested at a sufficient rate to meet the nutritional requirements of the animals after being digested and absorbed in the digestive tract. Thus, if there is a reduction in the intake or digestibility of minerals in the diet, especially calcium and phosphorus, there may be problems with the growth and quality of the bone tissue (RATH *et al*., 2000). In this context, since the diets were formulated to be isonutritive and isocaloric, there were no significant differences in diet intake: NC = 5168.72, PC = 5176.49, PC_1 = 5162.41, PC_2 = 5157.83, PC_3 = 5154.90 and PC_4 = 5111.72 g/bird (CRUZ, 2015); it can be inferred that the availability of such nutrients as Ca and P was also not affected by the addition of the acid, and consequently there was no negative effect from the ACa on the growth or quality of the femur or tibia.

Considering that organic acids can reduce the pH of the gastrointestinal tract, thereby reducing the load of pathogenic microorganisms and improving mineral absorption (FARIA *et al*., 2009; SALAZAR *et al*., 2008; ŚWIĄTKIEWICZ; ARCZEWSKA-WLOSEK, 2012), it was expected that the use of calcium anacardate would promote improvements in the growth and bone quality of the chickens, which did not occur.

The magnitude of the response to the use of an organic acid in animal feed depends on the chemical properties of the acid or its salt. Organic acids used as growth promoters in poultry feed are generally short-chain acids (C1 - C7), and are more effective than those that have a greater capacity for dissociation and for reducing the pH of the digestive tract (DIBNER; BUTTIN, 2002).

In this context, it is worth pointing out that calcium anacardate is a salt comprising a nucleus of salicylic-acid and a side chain with 15 carbons, and that the intestinal pH of the chickens remained within normal parameters (5.6 to 6.5) (CRUZ, 2015). Therefore, the absence of any significant effects from the ACa on the bone parameters can be attributed to the chemical properties of the calcium anacardate product and of the anacardic acid.

Among other factors, chemical characteristics have been related to variability in the effects between the different organic acids and their mixtures, and even to inconsistency in the results for any one acid. Boling-Frankenbach *et al*. (2001) found that the addition of citric acid promoted a linear increase in mineral deposition in the tibia of broiler chickens submitted to diets deficient in available phosphorus. For Islam *et al*. (2012), the addition of 0.75% citric acid to the diet of broiler chickens improved resistance, density and the levels of bone ash. Chowdhury *et al*. (2009) reported a significant increase in the percentage of ash in the tibia of broiler chickens fed with citric acid. According to Martinez-Amezcua, Parsons and Baker (2006), the addition of phytase mixed with citric acid increased the levels of ash in the tibia of broiler chickens. Liem, Pesti and Edwards Junior (2008) evaluated the addition of citric acid, malic acid or fumaric acid in diets deficient in phosphorus, and found an increase in the levels of bone ash in the tibia with the addition of citric acid only. Świątkiewicz and Arczewska-Wlosek (2012), studying the effect of formic, propionic, acetic, caproic and capric acids, reported that diets for broiler chickens supplemented with these organic acids increased the resistance and rigidity of the femur, but had no influence on the bone quality of the tibia. According to Hafeez *et al*. (2014), the organic acids (formic and propionic) did not affect bone quality in the tibia of broiler chickens, and their use does not have any negative effect on bone quality in these animals.

Adding antioxidant compounds to the diet has been suggested as a way of avoiding the loss of bone quality that can occur in broiler chickens subjected to heat stress. Considering that anacardic acid is a phenolic compound derived from salicylic acid, whose antioxidant action has been the most reported among its biological actions (TREVISAN *et al*., 2006), an improvement in bone quality was expected in the chickens, which was not confirmed in this study.

The benefits of using antioxidants, especially natural antioxidants, on bone performance and quality in broiler chickens, are inconsistent and require further clarification. Lohakare *et al*. (2005) showed that the addition of ascorbic acid to chicken diets improved the amount of mineral matter and the resistance of the tibia. However, Konca *et al*. (2009) reported that adding ascorbic acid to the diet had no significant influence on the parameters of bone weight, length, ash or resistance in broiler chickens. Hosseini-Vashan *et al*. (2012) reported that the addition of powdered saffron as an antioxidant in the diet of broiler chickens had no influence on performance, but improved oxidative status and liver function, reduced stress, and increased calcium concentration in the tibia.

Table 4 - Mean values for weight, length, diameter, Seedor index, resistance and deformity of the left femur and tibia in broiler chickens at 42 days of age fed on different levels of calcium anacardate in the diet

Treatment	Femur					
	Weight (g)	Length (mm)	Diameter (mm)	SI (mg/mm)	BR (kgf/cm^2)	Def (mm)
NC	9.25	73.88	9.89	124.76	15.21	0.57
PC	9.12	75.57	9.80	120.58	16.32	0.58
0.25% ACa	9.00	74.51	9.80	120.69	13.63	0.53
0.50% ACa	9.69	75.78	9.91	127.81	17.94	0.50
0.75% ACa	9.38	75.59	9.98	124.53	14.64	0.51
1.00% ACa	9.51	75.94	9.75	125.13	14.28	0.50
ANOVA	p-value					
Treatments	0.2987	0.2864	0.8760	0.2643	0.1627	0.0758
Regression	p-value					
Linear	0.2626	0.0852	0.9816	0.4233	0.9245	0.4934
Quadratic	0.2399	0.3607	0.2989	0.2571	0.0989	0.8062
CV(%)	6.30	2.49	3.67	5.10	20.45	12.18
	Tibia					
NC	11.92	97.83	7.67	121.49	14.06	0.61
PC	12.04	100.21	7.69	119.99	14.40	0.65
0.25% ACa	11.59	98.74	7.70	117.31	15.98	0.62
0.50% ACa	12.63	100.38	7.87	125.45	15.28	0.60
0.75% ACa	12.20	100.20	7.93	122.07	15.16	0.62
1.00% ACa	12.42	99.68	7.96	124.62	16.16	0.64
ANOVA	p-valor					
Treatments	0.3233	0.3232	0.7132	0.2912	0.8405	0.8198
Regression	p-valor					
Linear	0.2015	0.3520	0.2897	0.1898	0.9913	0.5616
Quadratic	0.2393	0.1322	0.6851	0.3468	0.5475	0.3349
CV(%)	7.15	2.45	5.53	5.58	21.89	10.03

Mean values followed by different letters in a column differ by the SNK test (5%); SI=Seedor index, BR=boné resistance, Def=deformity, NC=Negative Control, PC= Positive Control

Table 5 - Mean values for dry matter and mineral matter of the right femur and tibia in broiler chickens at 42 days of age fed on different levels of calcium anacardate in the diet

Treatment	Femur		Tibia	
	DM (%)	MM (%)	DM (%)	MM (%)
NC	53.77	38.42	54.61	40.00
PC	54.05	38.12	55.46	40.15
0.25% ACa	54.91	39.50	55.62	41.44
0.50% ACa	56.38	38.42	55.59	39.88
0.75% ACa	54.13	39.39	54.38	41.09
1.00% ACa	54.18	39.42	54.75	41.41
ANOVA	p-value			
Treatments	0.1574	0.1839	0.4256	0.0953
Regression	p-value			
Linear	0.2409	0.8119	0.1210	0.7437
Quadratic	0.3377	0.2890	0.7630	0.0690
CV(%)	3.54	3.28	2.59	3.20

Mean values followed by different letters in a column differ by the SNK test (5%); DM=dry matter, MM= mineral matter, NC=Negative Control, PC= Positive Control

CONCLUSION

Calcium anacardate as a source of anacardic acid at levels of up to 1.00% in the diet does not affect the growth, quality or bone composition of the femur or tibia in broiler chickens.

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