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Requerimento de sódio para codornas japonesas em postura

Sodium requirement of japanese laying quail

Requisito de sodio para codornices japonesas en postura

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Heder José D'Avila Lima
ORCID: https://orcid.org/0000-0002-8360-8227
Federal University of Mato Grosso, Brasil
E-mail: hederdavila@yahoo.com.br
Marcos Vinícius Martins Morais
ORCID: https://orcid.org/0000-0001-8335-4127
Federal University of the Jequitinhonha and Mucuri, Brasil
E-mail: viniciusmartins_zootecnia@hotmail.com
Sergio Luiz de Toledo Barreto
ORCID: https://orcid.org/0000-0002-3888-277X
Federal University of Viçosa, Brasil
E-mail: sbarreto@ufv.br

Resumo

O experimento foi realizado para estimar a exigência nutricional de sódio (Na) para codornas japonesas em postura. (*Coturnix coturnix japonica*). Neste estudo, foram utilizadas 280 codornas japonesas aos 128 dias de idade, com peso médio de 9 ± 5,2 g e taxa de produção de ovos de 82,3 ± 0,94%. As aves foram distribuídas em um delineamento experimental inteiramente casualizado, contendo cinco tratamentos e sete repetições, com oito codornas por repetição, totalizando trinta e cinco unidades experimentais. As dietas experimentais foram baseadas em farelo de milho e soja e continham cinco níveis diferentes de sódio (0,08%, 0,12%, 0,16%, 0,20% e 0,24%). As dietas eram isocalóricas e continham concentrações iguais de aminoácidos, com balanço eletrolítico de 250 mEq/kg. Os parâmetros avaliados foram: consumo de ração (g/codorna/dia); produção de ovos por codorna por dia (%); peso do ovo (g); massa de ovos (g/codorna/dia); e conversão alimentar por massa de ovo (kg/kg) e por dúzia de ovos (kg/dz). Além disso, foram avaliados a composição dos ovos em termos da massa absoluta (g) e relativa (%) da gema, albumina e casca de ovo e a variação do peso corporal (g) e viabilidade (%) das codornas. Não houve efeito significativo ($p>0,05$) nos parâmetros descritos. Não ocorreram distúrbios nutricionais relacionados ao nível de inclusão de sódio nas dietas.

A inclusão de 0,08% de sódio na dieta de codornas japonesas em postura foi satisfatória para manter a produção e a qualidade dos ovos sem perdas no consumo ou conversão alimentar.

Palavras-chave: *Coturnix coturnix japônica*; Deficiência; Sal; Produção de ovos; Qualidade de ovos.

Abstract

A study was conducted in order to estimate the sodium requirements of Japanese laying quail (*Coturnix coturnix japonica*). In this study, we used 280 Japanese quails at 128 days of age, with an average weight of 9 ± 5.2 g, and an egg production rate of 82.3 ± 0.94%. An experimental design methodology was employed, completely randomized with five treatments and seven replications. Each replicate consisted of eight quails, with a total of thirty-five experimental units. The experimental diets were based on corn and soybean meal, and contained five different levels of sodium (0.08%, 0.12%, 0.16%, 0.20% and 0.24%). The diets were isocaloric and contained equal concentrations of amino acids, with an electrolyte balance of 250 mEq/kg. The parameters we evaluated were feed intake (g/quail/day); egg production per quail per day (%); egg weight (g); egg mass (g/quail/day); and feed conversion by egg mass (kg/kg) and per dozen eggs (kg/dz). In addition, we evaluated the composition of the eggs in terms of the absolute (g) and relative (%) mass of the yolk, albumen and eggshell. We also measured the body weight variation (g) and viability (%) of the quails. There were no significant effects ($p>0.05$) on the described parameters. No nutritional disorders occurred related to the level of inclusion of sodium in the diets. The inclusion of 0.08% sodium in the diet of laying Japanese quails was satisfactory to maintain egg production and quality without losses in feed intake or feed conversion.

Keywords: *Coturnix coturnix japonica*; Deficiency; Salt; Egg production; Egg quality.

Resumen

El experimento se realizó para estimar el requerimiento nutricional de sodio (Na) para codornices japonesas en postura (*Coturnix coturnix japonica*). En este estudio, se utilizaron 280 codornices japonesas a los 128 días de edad, con un peso promedio de 9 ± 5.2 g, y una tasa de producción de huevos de 82.3 ± 0.94%. Las aves se distribuyeron en un diseño experimental completamente al azar, con cinco tratamientos y siete repeticiones, con ocho codornices por repetición, totalizando treinta y cinco unidades experimentales. Las dietas experimentales se basaron en harina de maíz y soya y contenían cinco niveles diferentes de sodio (0.08%, 0.12%, 0.16%, 0.20% y 0.24%). Las dietas eran isocalóricas y contenían concentraciones de aminoácidos iguales con un equilibrio electrolítico de 250 mEq / kg. Los parámetros evaluados fueron: ingesta de alimento (g / codorniz / día); producción de huevos por codorniz por día (%); peso del huevo (g); masa de huevo (g / codorniz / día); y conversión de alimento por masa de huevo (kg / kg) y por docena de huevos (kg / dz). Además, la composición del huevo se evaluó en términos de masa absoluta (g) y relativa (%) de yema, albúmina y cáscara de

huevo y la variación del peso corporal de la codorniz (g) y la viabilidad (%). No hubo efecto significativo (p> 0.05) en los parámetros descritos. No hubo trastornos nutricionales relacionados con el nivel de inclusión de sodio en las dietas. La inclusión de sodio al 0.08% en la dieta de las codornices japonesas fue satisfactoria para mantener la producción y calidad del huevo sin pérdida en la ingesta de alimento o la conversión de alimento.

Palabras clave: *Coturnix coturnix japonica*; Discapacidad; Sal; Producción de huevo; Calidad del huevo.

1. Introduction

Coturniculture is recognized as an activity with remarkable economic potential, since advances made in the genetic improvement of quails have allowed increased production rates over and above the naturally rapid reproduction cycle. In addition, only a small investment is required to initiate quail culture. Increased production rates have increased the nutritional requirement of quails and it is thus necessary to continually perform analysis in order to adjust nutrient levels in quail diets, according to the needs of the animals (Barreto et al., 2007).

A balanced diet must primarily provide the animal with necessary nutrients for maintenance, as well as those needed for egg laying. The diet must also be sufficient to assure egg quality, good pigmentation and eggshell resistance (Ito et al., 2009).

Minerals in general, perform extremely important functions and guarantee the survival and production of birds. Sodium is a fundamental macromineral that contributes to the perfect functioning of the metabolism, in addition, it regulates the osmotic pressure and the electrolytic balance of cells; also acts in the absorption and transport of glucose and amino acids (Murakami & Furlan, 2002; Costa et al., 2008). Sodium deficiency can cause reduced feed consumption, fertility, and egg production and can increase mortality (Oliveira & Almeida., 2004).

On the other hand, excessive amounts of sodium can increase water consumption and moisture content of the excreta, as well as causing metabolic alkalosis and problems in animal management (Costa et al., 2008; Lima et al., 2011). Furthermore, excessive sodium can result in increased osmolarity of the extracellular fluid, which might lead to dehydration (Guyton & Hall, 1997; Mencalha et al., 2013).

Due to the low cost of sodium supplementation sources for animals — regular salt is commonly used — the sodium requirements of quails have been hardly studied. Petrucci et al.

(2017) studying the effect of different levels of sodium (0.05%; 0.10%; 0.15%; 0.20%, 0.25% and 0.30%) in the laying quail diet, found that 0.208% sodium in the feed, represents the level ideal for bird performance. In contrast, researchers have usually adopted levels varying from 0.25% to 0.30% salt in the diets of laying Japanese quails (Barros et al, 2001; Murakami et al., 2006).

Therefore, this work aimed to estimate the sodium nutritional requirements of laying Japanese quails, and to evaluate their egg quality and production.

2. Methodology

The experiment was performed in the poultry sector of the Universidade Federal de Viçosa - MG, Brazil over a period of 84 days, divided in four 21-day phases. We used 280 Japanese quails at 128 days of age, with an average weight of 174.9 ± 5.2 g, and an average egg production of 82.3 + 0.94%. The quails were distributed in a completely randomized design that consisted of five treatments and seven replicates, with eight quails per experimental unit.

The quails were housed in galvanized steel cages at a density of 121.4 cm²/bird. The cages were equipped with trough-type feeders and nipple-type waterers. Feed and water were provided ad libitum, and the quails were fed twice a day, at 08:00 am and 04:00 pm. The lighting program consisted of 16 hours daily, with 12 hours of natural light plus 4 hours of artificial light.

The sodium content with you in the water supplied to the birds during the experimental period is between 27.07 mg/L 36.00 mg/L according to the Autonomous Water and Sewage Service of Viçosa (SAAE), (2017). The levels mentioned are considered normal and derisory according to Macari (1996), in addition, the same water was provided for all treatments.

Five experimental diets were formulated (Table 1), in order to be isocaloric, isonitrogenous and isoaminoacidic. The diets were based on corn and soybean meal, with five levels of sodium (0.08%, 0.12%, 0.16%, 0.20%, and 0.24%), and an electrolyte balance of 250 mEq/kg. described. The chemical composition and nutritional values of the ingredients followed Rostagno et al. (2011).

Table 1 - Percentual composition of the experimental diets, on natural matter basis (Composição percentual das dietas experimentais, na base da matéria natural).

Ingredients (%)	Sodium levels (%)				
	0.08	0.12	0.16	0.20	0.24
Maize	54.27	54.27	54.27	54.27	54.27
Soybean meal (45.0%)	31.89	31.89	31.89	31.89	31.89
Soy oil	2.53	2.53	2.53	2.53	2.53
Limestone	7.38	7.38	7.38	7.38	7.38
Dicalcium phosphate	1.05	1.05	1.05	1.05	1.05
Mineral mixture[1]	0.05	0.05	0.05	0.05	0.05
Vitamin mixture[2]	0.10	0.10	0.10	0.10	0.10
DL-Methionine (98.2%)	0.33	0.33	0.33	0.33	0.33
L-Lysine HCl (78.8%)	0.20	0.20	0.20	0.20	0.20
Antioxidants[3]	0.01	0.01	0.01	0.01	0.01
Choline chloride (60.0%)	0.10	0.10	0.10	0.10	0.10
Salt	0.21	0.34	0.46	0.59	0.71
Inert	1.88	1.75	1.63	1.50	1.38
Total	100	100	100	100	100
Calculated and analyzed composition					
Metabolizable energy (kcal/kg)	2.800	2.800	2.800	2.800	2.800
Crude protein (%)	19.30	19.30	19.30	19.30	19.30
Digestible lysine (%)	1.080	1.080	1.080	1.080	1.080
Digestible methionine + cystine (%)	0.864	0.864	0.864	0.864	0.864
Digestible tryptophan (%)	0.226	0.226	0.226	0.226	0.226
Digestible threonine (%)	0.593	0.593	0.593	0.593	0.593
Calcium (%)	3.090	3.090	3.090	3.090	3.090
Available phosphorus (%)	0.300	0.300	0.300	0.300	0.300
Sodium (%)*	0.100	0.150	0.200	0.250	0.300
Crude fiber (%)	2.660	2.660	2.660	2.660	2.660

[1]Composition/kg: manganese: 160g, iron: 100g, zinc: 100g, copper: 20g, cobalt: 2g, iodine: 2g, excipient q.s.p.: 1000 g. [2]Composition/kg: vitamin A:12.000.000 U.I., vitamin D_3:3.600.000 U.I., vitamin E: 3.500 U.I., vitamin B_1 :2.500 mg, vitamin B_2: 8.000 mg, vitamin B_6:5.000 mg, pantothenic acid: 12.000 mg, biotin: 200 mg, vitamin K: 3.000 mg, folic acid: 1.500mg, nicotinic acid: 40.000 mg, vitamin B_{12}: 20.000mg, selenium: 150 mg, excipient q.s.p.: 1.000g. [3]Butyl hydroxytoluene. *Analyzed composition.

Fonte: Autor (2020).

The electrolyte balance of the diets (EBD) was calculated according to Mongin (1980), through the equation:

Equation 1 - Calculation of the electrolyte balance according to Mongin (1980).

$$Number\ of\ Mongin\ (NM) = mEqNa + (+mEqK) + (-mEqCl) - (\frac{mEq}{kg})$$

The maximum and minimum temperatures were recorded daily, at 04:00 pm. The average temperature and relative humidity were recorded twice a day, at 08:00 am and 04:00 pm. The maximum and minimum temperature averages were 30.8 + 2.7° C and 20.1 ± 2.8° C, respectively. The temperature average was 25.6 + 3.8° C and the relative humidity average was 66.3 + 13.8%.

The parameters evaluated were feed intake (g/bird/day), egg production per bird per day (%), egg weight (g), egg mass (g egg/bird/day), feed conversion per egg mass (kg/kg), feed conversion per dozen eggs (kg/dz), egg components (g and %), body weight variation (g) and viability of the quails (%).

Feed intake was calculated from the difference between the amount of feed provided and the remains after each period, corrected for mortality. The eggs were collected daily in the morning and the egg production average was obtained by counting the number of eggs produced, including broken, cracked and abnormal eggs.

All of the eggs produced on the 19th, 20th, 21st, 40th, 41st, 42nd, 61st, 62nd and 63rd days were weighed in a precision balance (0.001 g), and the weight values were divided by the total number of eggs to obtain the egg weight average. Afterwards, the yolks were weighed and the eggshells were washed and air-dried for 72 hours, and then weighed. Albumen weight was obtained by subtraction of the eggshell weight and yolk weight from the egg weight.

The egg mass was obtained by multiplying the egg weight by the number of eggs produced during the experiment. The egg mass was then divided by the total amount of quails and days of the experiment (g egg/quail/day). Feed conversion was calculated by dividing the feed intake by dozen number of eggs (kg/dz), and by the egg mass (kg/kg).

All of the quails were weighed at the beginning and the end of the experiment, in order to determine any variations in body weight. During the experiment, deaths were recorded to determine the viability.

The data were analyzed using the software SAEG (Sistema para Análises Estatísticas e Genéticas, UFV, 2007). We performed ANOVA at a probability of 5%, and the linear and quadratic regression models best estimated the effects of the sodium levels, according to the best adjustment obtained for each variable and considering the biological behavior of the birds.

3. Results and Discussion

No effects were observed (p>0.05) on feed intake, egg production, egg weight, egg mass, feed conversion per egg mass, feed conversion per dozen egg or viability (Table 2). Similarly, Erener et al. (2002), when providing sodium chloride for Japanese quails from 1 to 42 days, did not observe differences in body weight variation, feed intake or feed conversion (g/g). Lima et al. (2011), feeding Japanese quails (1 to 42 days of age) 0.07, 0.12, 0.17, 0.22, 0.27 or 0.32% of sodium, also did not observe effects on feed intake, body weight gain or feed conversion (g/g).

Table 2 - Productive performance of Japanese quails (Desempenho produtivo de codornas japonesas).

Performance traits	Sodium levels (%)					
	0.08	0.12	0.16	0.20	0.24	CV* (%)
Feed intake^{ns} (g/bird/day)	24.49	24.48	24.31	24.80	24.65	4.03
Egg production per bird per day^{ns} (%)	83.18	84.31	82.14	84.44	83.25	6.67
Egg weight^{ns} (g)	11.52	11.70	11.44	11.65	11.59	2.75
Egg mass^{ns} (g/bird/day)	9.58	9.85	9.38	9.85	9.65	6.54
Feed conversion by egg mass^{ns} (kg/kg)	2.56	2.49	2.59	2.52	2.56	5.79
Feed conversion by dozen eggs^{ns} (kg/dz)	0.35	0.35	0.36	0.35	0.36	5.74
Viability^{ns} (%)	96.42	98.21	92.85	87.50	92.85	9.66
Body weight variation[1] (g)	8.87	9.72	5.44	11.85	6.96	-

*Coefficient of variation. NSNot significant (p>0.05). [1]The parameter does not follow a normal distribution, and a descriptive analysis was performed.

Fonte: Autor (2020).

Nevertheless, it is important to note that egg production was numerically higher in our work when quails were fed 0.20% of sodium, although the viability of the birds was lower. Costa et al. (2012) found that a sodium level of 0.242% in the diet could improve the number of eggs and the egg production at 41 to 63 days of age. In addition, the mortality recorded in the present research was caused by accidents in the cages, and was not related to nutritional aspects of the experiment. According to Ito et al. (2009), many primitive characteristics remain in domestic quails, which may increase mortality.

Feed intake and body weight values indicate that the minimum inclusion of 0.08% of sodium did not cause a decrease in performance and there were no symptoms of sodium deficiency during the experimental period. These results are similar to those found by Lima et al. (2015), evaluating the inclusion of 0.10, 0.15, 0.20, 0.25 and 0.30% of sodium in the diet

of laying Japanese quails. It did not result in any effects ($p>0.05$) on performance traits, and the minimum inclusion of sodium did not cause loss in egg production.

Similarly, Costa et al. (2012) did not observe any loss in feed intake when adding sodium (0.06, 0.12, 0.18, 0.24 and 0.30%) to the diet of Japanese quails from 1 to 21 days of age. Similarly, Mencalha et al. (2013) did not find any effects on feed intake and body weight variation when adding 0.10, 0.17, 0.24, 0.31 and 0.38% of sodium to the diet of Japanese quails. Figueiredo et al. (2004), when adding sodium levels of 0.11%, 0.14%, 0.17%, 0.20% and 0.23%, did not observe any effects on feed intake. Those results are in accordance with those found in this research.

Figueiredo et al. (2004) and Murakami et al. (2006), when adding sodium to the diet of Japanese quails, did not report any effects on egg weight. Barreto et al. (2007), evaluating the addition of 0.083%, 0.149%, 0.215% and 0.281% of sodium, did not find any effects on feed conversion per dozen eggs or on eggshell percentage.

Pizzolante et al. (2006), added from 0.10% to 0.22% of sodium to the diets of Japanese quails at 54 weeks of age. They did not find any effects on egg weight, egg production (bird/day), egg mass, feed intake, feed conversion per dozen eggs, eggshell thickness or eggshell percentage. Costa et al. (2008), when adding 0.08%, 0.16%, 0.24%, 0.32% and 0.40% of sodium to Japanese quail diets, did not find any effects on egg weight, feed conversion per dozen eggs or feed conversion per egg mass. Those results are similar to those in the present study.

No effects ($p>0.05$) were found on egg quality traits (Table 3). Numerically, eggshell weight and eggshell percentage were higher at the level of 0.2% of sodium, possibly because sodium might cause an increase in eggshell resistance. Chlorine, a constituent of table salt, in adequate amounts can improve eggshell quality since it increases the solubility and absorption of minerals because of its acidogenic nature (Ribeiro et al., 2007; Bezerra et al., 2011). This might explain the values of eggshell weight and eggshell percentage that we found.

The results of the present research are similar to those found by Lima et al. (2015), who added 0.10, 0.15, 0.20, 0.25 and 0.30% of sodium to the diets of laying Japanese quails. Aside from not finding effects on performance, the authors did not find any negative effects on egg quality traits, such as weight and percentage of yolk, albumen and eggshell, or on specific gravity. The authors recommended the addition of 0.10% (26.1 mg) of sodium, since no symptoms of sodium deficiency, such as reduction of growth and egg production or depressed appetite, were observed.

Table 3 - Egg quality traits of Japanese quails (parâmetros de qualidade de ovos de codornas japonesas).

Parameters analyzed	Sodium levels (%)					
	0.08	0.12	0.16	0.20	0.24	CV* (%)
Yolk weight^{ns} (g)	3.70	3.68	3.71	3.68	3.63	3.58
Albumen weight^{ns} (g)	7.17	7.41	7.35	7.50	7.46	3.69
Eggshell weight^{ns} (g)	0.93	0.92	0.96	0.97	0.94	3.25
Yolk percentage^{ns} (%)	31.36	30.65	30.88	30.33	30.18	2.56
Albumen percentage^{ns} (%)	60.72	61.70	61.14	61.64	62.02	1.42
Eggshell percentage^{ns} (%)	7.90	7.63	7.96	8.01	7.79	3.45

*Coefficient of variation. ^{NS}Not significant (p>0.05).

Fonte: Autor (2020).

Lima et al. (2015), and Pizzolante et al. (2006), recommended 0.10% of sodium in the diet of laying Japanese quails, and this might be indicative that a minimal amount of sodium could meet the requirements of the quails. We found similar results.

Murakami et al. (2006) recommended 0.15% of sodium for laying Japanese quails considering performance and egg quality; similarly, Barreto et al. (2007) recommended 0.149% based on egg production and number of marketable eggs. Higher values can also be found in the literature, such as Costa et al. (2008), whose recommendation is 0.231% (56.6 mg) of sodium for laying quails. Also, considering digestibility and energy metabolism, Farias et al. (2009) recommended that diets for laying quails should contain 0.18% to 0.24% of sodium.

Lima et al. (2011), recommended 0.23% of sodium for quails at 1 to 42 days, and showed a linear effect on water intake and a quadratic effect on digestibility and metabolized energy. Costa et al. (2012), recommended 0.222% of sodium for 1 to 21 days Japanese quails, and 0.253% for 22 to 40 days Japanese quails, but showed no effect on feed intake.

Protein, energy, and mineral metabolism, in addition to the acid-base regulation, are interrelated processes that influence the performance of birds (Costa et al., 2012), and are mediated by sodium. Sodium is important in order to maintain functioning of bird metabolism, since it is involved in many physiological processes, such as the maintenance of osmotic pressure and electrolyte balance (Lima et al., 2011).

4. Conclusions

The inclusion of 0.08% of sodium in the diet of Japanese laying quails, which corresponds to 19.59 mg of sodium per day, was satisfactory to maintain egg production without losses in performance, egg quality, feed intake and feed conversion.

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Percentage of contribution of each author in the manuscript

Heder José D'Avila Lima – 75%

Marcos Vinícius Martins Morais – 10%

Sergio Luiz de Toledo Barreto – 05%