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Digestible lysine levels in diets for laying Japanese quails

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ABSTRACT - The objective of this study was to estimate the digestible lysine requirement of Japanese quails in the egg-laying phase. A total of 336 female Japanese quails (*Coturnix coturnix japonica*) of average initial age of 207 days were distributed in a completely randomized experimental design, composed of 6 treatments (lysine levels) with 7 replicates and 8 birds per experimental unit, with duration of 84 days. Experimental diets were formulated from a basal diet, with corn and soybean meal, with 2.800 kcal ME/kg and 203.70 g/kg crude protein, showing levels of 9.50; 10.00; 10.50; 11.00; 11.50; and 12.00 g/kg digestible lysine; diets remained isoprotein and isocaloric. The following variables were studied: feed intake (FI); lysine intake (LI); egg production per bird per day (EPBD); egg production per bird housed (EPBH); production of marketable eggs (PME); egg weight (EW); egg mass (EM); utilization efficiency of lysine for egg mass production (UELEM); feed conversion per mass (FCEM); feed conversion per dozen eggs (FCDZ); bird availability (BA); percentages of yolk (Y), albumen (A) and shell (S); specific egg weight (SW); nitrogen ingested (NI); nitrogen excreted (NE); and nitrogen balance (NB). Significant effect was only observed for LI, EW, EM, UELEM, FCEM, Y, A and SW. The digestible lysine level estimated in diets for laying Japanese quails is 11.20 g digestible lysine/kg diet, corresponding to an average daily intake of 272.23 mg lysine.

Key Words: C*oturnix coturnix japonica*, digestible amino acids, egg production, performance variables

Introduction

Quail raising has stood out in the aviculture sector, especially for egg production, for being extremely attractive and profitable for the Brazilian agribusiness, which makes it a good option, be it for small or big farmers.

The advancements in the knowledge of the nutritional requirements of birds, at their many phases, has constantly brought improvement to the quality of the diet; firstly in the sense of reaching maximum production, followed by the search for the lowest price of the feed and for the conversion of these animals into egg numbers (Ceccantini & Yuri, 2008).Thus, the great knowledge of the metabolism of protein in birds and the production of amino acids on a commercial basis have enabled the utilization of the concept of ideal protein at the formulation of diets.

This concept can be defined, theoretically, as the exact balance of the amino acids in the diet capable of meeting, without excess or deficiency, the requirements of all the essential amino acids for production and maintenance of birds, expressing them as percentage in relation to the lysine which is adopted as reference amino acid.

Lysine is the second limiting amino acid in diets for birds; its use, in lower or excessive levels, regarding the nutritional requirement of this nutrient in birds, may bring metabolic damages, which could compromise bird performance (Kidd & Kerr, 1998).

For many decades, studies on the utilization of lysine, based on the concept of ideal protein in the diets of birds, have been developed, because of the great applicability, ease of utilization in the formulation of diets and low costs of the acquisition of L-lysine-HCl; however, in quail raising, these studies are recent.

Estimating the digestible lysine requirement for Japanese quails at laying, Pinto et al. (2003) suggested the level of 11.17 g digestible lysine/kg of diet for diets containing 195.60 g crude protein (CP)/kg of diet. Rodrigues et al. (2007) evaluated the digestible lysine nutritional requirements in diets for Japanese quails in the laying phase and concluded that the digestible lysine requirement was 10.30 g/kg of the diet. Assessing the digestible lysine nutritional requirement in diets for Japanese quails in the laying phase containing 195.0 g CP/kg of diet, Demuner et al. (2009a) concluded that the digestible lysine requirement estimated was 10.90 g/kg of diet.

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The objective with this research was to estimate the digestible lysine level in diets for Japanese quails during the egg-laying phase.

Material and Methods

A total of 336 female quails of the Japanese subspecies *Coturnix coturnix japonica* of 207 days of age with initial body weight of 179.82±0.73 g were distributed in a completely randomized experimental design composed of six treatments (lysine levels), with seven replicates and eight birds per experimental unit. The experiment lasted 84 days. Birds were housed in galvanized wire cages equipped with nipple drinkers and trough feeder, at an animal density of 106 cm²/bird per experimental unit.

The lighting program was of 16 daily hours and maximum and minimum temperatures were measured once daily at 8h00; relative air humidity of the facility was measured twice daily, at 8h00 and 16h00, with maximum minimum thermometers and dry and wet bulb thermometers, placed at the center of the shed, at the height of birds.

Water and feed were supplied *ad libitum*. Feed was supplied twice daily, aiming at avoiding waste. Collection and counting of eggs were performed every day, in the morning.

Experimental diets were formulated to meet quail nutritional requirements, following recommendations of the NRC (1994), except for amino acids ratios: threonine (55%), digestible tryptophan (21%), digestible methionine + cystine (84%), digestible arginine (1.16%), digestible valine (75%) and digestible isoleucine (65%), which were based, respectively, on the recommendations of Umigi et al. (2008), Pinheiro (2006), Reis (2009), Reis et al. (2010), Paula et al. (2010a) and Paula et al. (2010b). These diets were elaborated from a basal one containing 2800 kcal metabolizable energy (ME)/kg, as determined by Moura (2007) and 203.70 g CP/kg of diet, utilizing corn and soybean meal, supplemented with L-lysine HCl, substituting glutamic acid, in protein equivalent, to keep the 9.50; 10.00; 10.50; 11.00; 11.50; and 12.00 g levels of digestible lysine/kg of diet; all diets were formulated with the same protein and calorie level (Table 1). The differences due to balancing for protein equivalents of lysine and glutamic acid at the different lysine levels under evaluation were compensated by starch.

The digestible lysine levels utilized in the formulation of diets were based on studies with broilers. There are no sufficient studies to determine feedstuff digestibility of amino acids with quail use. Thus, the composition, the nutritional values and the digestibility values of the ingredients utilized in the formulation of diets were according to Rostagno et al. (2005).

The following performance variables were evaluated: feed intake (g/bird.day), lysine intake (mg/bird.day), egg production per bird per day (%), egg production per bird housed (%), egg weight (g), egg mass (g/bird.day), utilization efficiency of lysine for egg mass production (egg mass/digestible lysine intake, expressed in grams of mass produced per grams of digestible lysine intake), feed conversion per egg mass (kg of diet/kg of eggs) and per dozen eggs (kg of diet/egg dz), bird availability (total dead birds - total live birds × 100), nitrogen ingested (g), nitrogen excreted (g) and nitrogen balance (g).

As for the variables of internal and external egg quality, these were assessed: production of marketable eggs (total intact eggs/total eggs produced × 100) yolk weight (g), yolk percentage (%), albumen weight (g), albumen percentage (%), eggshell weight (g), eggshell percentage (%) and specific egg weight (g/cm³).

For quantification of egg components, four eggs of each experimental unit were randomly collected on the 19th, 20th, 21st, 40th, 41st, 42nd, 61st, 62nd, 63rd, 82nd, 83rd and 84th days of the experimental period (84 days). Eggs were weighed individually on a 0.001 g precision scale. After weighing, eggs were identified and cracked. The yolk of each egg was weighed, and its shell was washed and dried in the air, for determination of its weight; albumen weight was calculated by the difference between egg weight and yolk weight plus eggshell weight.

Specific egg weight was determined through immersion of all intact eggs collected into NaCl solutions with densities varying from 1.055 to 1.090 g/cm³, with 0.005 g/cm³ intervals and evaluated for density or specific egg weight, by the Archimedes principle (Thompson & Hamilton, 1982; Yannakopoulos & Tserveni-Gousi, 1986).

For the estimate of nitrogen balance, at the end of the experimental period, in four randomly chosen replicates of each treatment, eight birds were housed in galvanized wire cages on a battery pattern, provided with trough feeders and drinkers, on galvanized metal sheet and PVC, respectively, and galvanized metal sheet tray coated with plastic, for the collection of excreta. Birds were subjected to an experimental adaptation period of three days, and right after, excreta collection started, twice a day, for three consecutive days; excreta were stored in freezer. After collection period, the material was weighed, homogenized and samples were taken and dried in an oven. Feed intake in the collection period was recorded and experimental diets corresponding to each experimental unit were sampled for further laboratory analyses.

Analyses of dry matter and total nitrogen, experimental diets and excreta collected were performed according to

Table 1 - Composition of experimental diets (g/kg as fed)

Ingredients	Lysine level (g of lysine/kg of diet)					
	9.50	10.00	10.50	11.00	11.50	12.00
Corn	560.86	560.86	560.86	560.86	560.86	560.86
Soybean meal (45% crude protein)	326.29	326.29	326.29	326.29	326.29	326.29
Corn starch	1.00	1.34	1.69	2.78	4.64	6.53
Glutamic acid	14.00	12.65	11.19	8.65	4.68	0.60
L-lysine HCl (79%)	0.00	0.63	1.27	1.90	2.53	3.17
DL-methionine (99%)	2.55	2.93	3.35	3.77	4.19	4.61
L-tryptophan (99%)	0.00	0.00	0.05	0.15	0.26	0.36
L-arginine (99%)	0.00	0.00	0.00	0.30	0.88	1.46
L-valine (99%)	0.00	0.00	0.00	0.00	0.37	0.74
L-isoleucine (99%)	0.00	0.00	0.00	0.00	0.00	0.08
Soybean oil	12.60	12.60	12.60	12.60	12.60	12.60
Limestone	66.27	66.27	66.27	66.27	66.27	66.27
Dicalcium phosphate	10.62	10.62	10.62	10.62	10.62	10.62
Salt	3.21	3.21	3.21	3.21	3.21	3.21
Choline chloride (60%)	1.00	1.00	1.00	1.00	1.00	1.00
Mineral premix[1]	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin premix[2]	1.00	1.00	1.00	1.00	1.00	1.00
Antioxidant[3]	0.10	0.10	0.10	0.10	0.10	0.10
Total	1000.00	1000.00	1000.00	1000.00	1000,00	1000,00
Calculated composition						
Metabolizable energy (kcal/kg)	2.800	2.800	2.800	2.800	2.800	2.800
Crude protein (g/kg)	203.70	203.70	203.70	203.70	203.70	203.70
Digestible lysine (g/kg)	9.50	10.00	10.50	11.00	11.50	12.00
Digestible methionine + cystine (g/kg)	7.98	8.40	8.82	9.24	9.66	10.08
Digestible threonine (g/kg)	6.64	6.64	6.64	6.64	6.64	6.64
Digestible tryptophan (g/kg)	2.16	2.16	2.21	2.31	2.42	2.52
Digestible valine (g/kg)	8.24	8.24	8.24	8.24	8.63	9.00
Digestible isoleucine (g/kg)	7.72	7.72	7.72	7.72	7.72	7.80
Digestible arginine (g/kg)	12.46	12.46	12.46	12.76	13.34	13.92
Total phenylalanine + tyrosine (g/kg)	16.46	16.46	16.46	16.46	16.46	16.46
Total histidine (g/kg)	5.28	5.28	5.28	5.28	5.28	5.28
Total glycine + serine (g/kg)	17.83	17.83	17.83	17.83	17.83	17.83
Available phosphorus (g/kg)	3.00	3.00	3.00	3.00	3.00	3.00
Calcium (g/kg)	29.00	29.00	29.00	29.00	29.00	29.00
Sodium (g/kg)	1.45	1.45	1.45	1.45	1.45	1.45
Crude fiber (g/kg)	27.40	27.40	27.40	27.40	27.40	27.40

[1] Composition/kg of product: Mn - 160 g; Fe - 100 g; Zn - 100 g; Cu - 20 g; Co - 2 g; I - 2 g; excipient qs - 1,000 g.
[2] Composition/kg of product: vit. A - 12,000,000 IU; vit. D3 - 3,600,000 IU; vit. E - 3,500 IU; vit. B1 - 2,500 mg; vit. B2 - 8,000 mg; vit. B6 - 5,000 mg; pantothenic acid - 12,000 mg; biotin - 200 mg; vit. K - 3,000 mg; folic acid - 1,500 mg; nicotinic acid - 40,000 mg; vit. B12 - 20,000 mg; selenium - 150 mg; excipient q.s. - 1,000 g.
[3] Butylated hydroxytoluene, BHT (99%).

the methodology described by Silva & Queiroz (2002). Nitrogen balance was calculated by the difference between the amount of nitrogen excreted and ingested by quails.

The data were analyzed on software SAEG (Sistema para Análises Estatísticas e Genéticas, version 9.1), developed at Universidade Federal de Viçosa, 2007, by means of procedures for variance and regression analyses. The study adopted $\alpha = 0.05$.

Results and Discussion

The maximum average temperature reached was 30.56±3.2 ºC, and the minimum was 20.03±0.92 ºC. The average relative air humidity was 80.4±2.6% in the morning and 69.9±6.4 % in the afternoon. In the adult phase, the thermal comfort range or thermoneutral zone of quails is between 18 and 22 ºC and the relative air humidity, between 65 and 70% (Oliveira, 2004). Thus, according to the values recorded for average air temperature and relative air humidity, throughout the experiment, quails underwent periods of heat stress.

The digestible lysine levels did not affect ($P>0.05$) feed intake (Table 2); these results are similar to those found by Ribeiro et al. (2003) and Demuner et al. (2009a), who worked with Japanese quails in the laying phase. On the other hand, the results found do not corroborate those obtained by Rodrigues et al. (2007), who, evaluating five levels (8.80; 9.60; 10.40; 11.20; and 12.00 g) of digestible lysine/kg of diet for Japanese quails in the egg-laying phase, observed quadratic effect on feed intake. These authors explained that the increase in digestible lysine levels in the diet elevated feed intake.

Linear increase (P<0.05) was verified in digestible lysine intake as its concentration in the diet rose (Table 2); among the levels studied (9.50 - 12.00 g digestible lysine/kg of diet), every 0.50 g digestible lysine/kg of diet increased digestible lysine intake by 12.98 mg. These results are similar to those found by Pinto et al. (2003) and Rodrigues et al. (2007), who found linear increase of 25.8 and 21.7 mg in lysine intake for every 1.00 g digestible lysine/kg of diet increase, respectively.

Egg production per bird per day and per bird housed and production of marketable eggs were not affected (P>0.05) by the digestible lysine levels in the diets (Table 2). These results are similar to those found by Demuner et al. (2009 a,b), who evaluated the nutritional requirements of digestible lysine for Japanese quails at the laying phase. However, the values achieved are not in accordance with those presented by Rodrigues et al. (2007), who defined the level of 10.30 g digestible lysine/kg of diet, which resulted in higher percentages in the egg production of Japanese quails.

The digestible lysine levels utilized in experimental diets showed quadratic effect (P<0.05) for egg weight; the level of 11.20 g digestible lysine/kg of diet promoted the highest egg weight (Table 2). The results obtained in the present study are in agreement with those found by Oliveira et al. (1999), Pinto et al. (2003), Ribeiro et al. (2003) and Demuner et al. (2009b), who verified higher results for egg weight from Japanese quails as they increased the lysine level in the diet. For their part, Garcia et al. (2005), Rodrigues et al. (2007) and Demuner et al. (2009a) did not verify changes in egg weight of Japanese quails resulting from the increase in the lysine level in the diet.

Egg mass also varied (P<0.05) with digestible lysine levels; it increased quadratically up to the estimated level of 11.20 g digestible lysine/kg of diet (Table 2). The result achieved is consistent with those observed by Pinto et al. (2003), where the level of 11.17 g digestible lysine/kg of diet was the one which maximized egg mass. Contrarily, Ribeiro et al. (2003), Rodrigues et al. (2007) and Demuner et al. (2009a) did not verify effect of digestible lysine levels on the egg mass of Japanese quails. Since egg production did not vary between the treatments, the response pattern of egg mass is directly linked to the egg weight results.

In accordance with the results obtained for digestible lysine intake (Table 2), utilization efficiency of digestible lysine for egg mass production reduced linearly (P<0.05) as the concentration of digestible lysine in the diet increased. Taking only the extreme digestible lysine levels analyzed (9.50 and 12.00 g digestible lysine/kg of diet), the intake of one gram digestible lysine resulted in respective production of 42.0 and 34.6 g egg mass. Brumano (2008), who worked with white-egg-laying hens in the period from 42 to 58 weeks of age, observed quadratic effect of the digestible methionine + cistine to lysine utilization efficiency on total egg production.

Feed conversion per egg mass varied quadratically (P<0.05) with increase in lysine levels; it increased up to the estimated level of 11.20 g digestible lysine/kg of diet (Table 2). Corroborating this result, Pinto et al. (2003) and Demuner et al. (2009a) also verified positive influence of digestible lysine on feed conversion per egg mass of Japanese quails in the egg-laying phase; the best responses were obtained at levels 10.50 and 10.90 g digestible lysine/kg of diet, respectively.

Table 2 - Influence of digestible lysine level on performance variables in Japanese laying quails

Variable	Digestible lysine levels (g/kg of NM)						P-value			CV (%)
	9.50	10.00	10.50	11.00	11.50	12.00	Linear	Quadratic	Lack of fit	
FI (g/bird.day)	23.82	24.01	24.57	24.59	23.85	24.51	0.225	0.288	0.025	3.14
LI (mg/bird.day)[1]	226.33	240.09	257.98	270.51	274.32	294.10	0.001	0.370	0.022	3.20
EPBD (%)	86.04	86.74	88.45	89.93	85.58	89.22	0.318	0.529	0.040	4.93
EPBH (%)	79.66	82.74	83.33	85.27	80.68	83.38	0.576	0.423	0.273	9.78
PME (%)	98.01	97.28	98.29	98.64	97.97	97.43	0.910	0.239	0.074	1.41
EW (g)[2]	10.92	11.26	11.34	11.51	11.53	11.35	0.003	0.011	0.435	2.75
EM (g/bird.day)[3]	9.38	9.75	10.04	10.34	9.86	10.12	0.079	0.048	0.600	4.75
UELEM (g/g)[4]	42.03	41.04	39.29	38.59	36.15	34.68	0.001	0.443	0.370	4.96
FCEM (kg/kg)[5]	2.48	2.38	2.36	2.26	2.29	2.34	0.006	0.027	0.256	5.02
FCDZ (kg/dz)	0.331	0.335	0.336	0.328	0.339	0.334	0.701	0.950	0.250	5.77
BA (%)	89.29	93.23	93.23	93.75	93.75	91.52	0.581	0.244	0.658	8.14

NM - natural matter; CV - coefficient of variation; FI - feed intake; LI - digestible lysine intake; EPBD - egg production per bird per day; EPBH - egg production per bird housed; PME - production of marketable eggs; EW - egg weight; EM - egg mass; UELEM - utilization efficiency of digestible lysine for egg mass production; FCEM - feed conversion per egg mass; FCDZ - feed conversion per egg dozen; BA - bird availability.

[1] $\hat{Y} = -18.364 + 25.9458 \times X$ ($R^2 = 0.98$).

[2] $\hat{Y} = -14.238 + 4.6026 \times X - 0.20572 \times X^2$ ($R^2 = 0.97$).

[3] $\hat{Y} = 8.8927 + 0.05697 \times X - 0.00064 \times X^2$ ($R^2 = 0.69$).

[4] $\hat{Y} = 70.635 - 2.9774 \times X$ ($R^2 = 0.98$).

[5] $\hat{Y} = 10.773 - 1.5142 \times X + 0.06754 \times X^2$ ($R^2 = 0.91$).

No effect of digestible lysine levels was verified ($P>0.05$) on feed conversion per dozen eggs (Table 2). Likewise, Oliveira et al. (1999), Ribeiro et al. (2003), Rodrigues et al. (2007) and Demuner et al. (2009b) did not find effect of digestible lysine levels on the same variable. The fact that feed intake and egg production per bird per day or per bird housed did not vary by treatment explains the results obtained for feed conversion per dozen eggs.

Bird availability was not affected ($P>0.05$) by digestible lysine levels in the diets (Table 2), still presenting a mortality rate in the experimental period of 7.6%, corresponding to the weekly mortality of 0.63%. Although bird availability was not altered in between treatments, the average weekly mortality value of 0.63% in this study is considered high for the standards of this species. Analyzing data from 26 Japanese quail commercial raising broods, Oliveira (2007) found weekly mortality of 0.49%. A possible explanation for this higher mortality rate could be the temperature and air humidity effect, which were above the values of the thermal comfort range, which might have contributed to the discomfort of birds.

For yolk, quadratic effect ($P<0.05$) was observed in relation to the digestible lysine levels in the diets (Table 3). Reis et al. (2006), working with the total lysine nutritional requirement of European quails at egg-laying, assessing the levels of 8.50; 9.50; 10.50; 11.50; and 12.50 g digestible lysine/kg of diet, verified linear increase for yolk as the lysine levels in the diet increased. Different results were observed by Ribeiro (2003) and Rodrigues et al. (2007), who did not find any effect of digestible lysine levels on the yolk weight of Japanese quail eggs.

Quadratic effect ($P<0.05$) of digestible lysine levels was observed on albumen (Table 3). These results are in accordance with those found by Cupertino (2006), who, assessing the digestible lysine nutritional requirement of laying hens from 54 to 70 weeks of age, obtained increasing linear effect of digestible lysine levels on the quantity of egg albumen. On the other hand, the results obtained by Ribeiro et al. (2003), Reis et al. (2006) and Rodrigues et al. (2007) did not show effect of lysine levels on albumen in quail eggs.

No effect ($P>0.05$) of digestible lysine levels related to eggshell or percentages of yolk, albumen and shell was observed. The results corroborate those found by Ribeiro et al. (2003) and Rodrigues et al. (2007).

There was quadratic effect ($P<0.05$) of digestible lysine levels on specific egg weight (Table 3). The level of 10.90 g digestible lysine/kg of diet resulted in 1.072 g/cm³, enabling the occurrence of eggs with lower shell quality as compared with other levels of lysine studied. However, in studies conducted by Rodrigues et al. (2007), the digestible lysine levels did not have effect on specific egg weight of Japanese quails. Nevertheless, even showing a 0.19% variation between the highest specific egg weight (1.074 g/cm³) and the lowest specific egg weight (1.072 g/cm³), which could result in eggs with thinner shell, we can observe that there was no interference with eggshell quality, which can be confirmed by the production of marketable eggs, which, in absolute values, presented the greatest percentage (98.64%), close to the level estimated for the highest egg weight (11.20 g digestible lysine/kg of diet).

Likewise, according to the equation obtained, the level of 11.20 g of lysine/kg of diet resulted in higher egg mass, obtained from the higher egg weight and a high egg production per bird per day, which possibly could have contributed to a worse specific egg weight, but not interfering with production of marketable eggs, which was also kept high.

Digestible lysine levels did not affect ($P>0.05$) nitrogen intake, nitrogen excretion or nitrogen balance (Table 4). These results are similar to those achieved by Matos et al. (2009). They suggested that the amount of nitrogen excreted by the organism for maintenance and egg production was met by birds in all experimental groups.

Table 3 - Digestible lysine levels on weight and percentage of yolk, albumen, shell and specific egg weight (SW) of Japanese laying quails

Variable	Digestible lysine levels (g/kg of NM)						P-value			CV (%)
	9.50	10.00	10.50	11.00	11.50	12.00	Linear	Quadratic	Lack of fit	
Yolk (g)[1]	3.29	3.47	3.47	3.48	3.46	3.49	0.004	0.032	0.034	3.08
Albumen (g)[2]	6.97	7.06	7.19	7.36	7.23	7.19	0.005	0.012	0.102	2.59
Shell (g)	0.872	0.912	0.902	0.907	0.895	0.916	0.060	0.285	0.014	2.97
Yolk (%)	29.50	30.31	29.97	29.62	29.84	30.12	0.516	0.868	0.009	2.14
Albumen (%)	62.65	61.71	62.22	62.65	62.43	61.97	0.705	0.818	0.002	1.07
Shell (%)	7.85	7.98	7.81	7.73	7.73	7.91	0.433	0.170	0.013	2.21
SW (g/cm³)[3]	1.074	1.073	1.073	1.072	1.072	1.073	0.074	0.001	0.047	0.06

NM - natural matter; CV - coefficient of variation.
[1] $\hat{Y} = -3.918 + 1.3194 \times X - 0.05868 \times X^2$ ($R^2 = 0.76$).
[2] $\hat{Y} = -7.922 + 2.7245 \times X - 0.12210 \times X^2$ ($R^2 = 0.86$).
[3] $\hat{Y} = 1.141 - 0.0126 \times X + 0.000574 \times X^2$ ($R^2 = 0.80$).

Table 4 - Digestible lysine levels on the values of nitrogen ingested, nitrogen excreted and nitrogen balance of laying Japanese quails

Variable	Digestible lysine levels (g/kg of NM)						P-value			CV (%)
	9.50	10.00	10.50	11.00	11.50	12.00	Linear	Quadratic	Lack of fit	
Nitrogen ingested (g)	0.680	0.701	0.698	0.719	0.702	0.703	0.104	0.083	0.146	2.69
Nitrogen excreted (g)	0.127	0.122	0.125	0.120	0.130	0.124	0.939	0.670	0.183	9.05
Nitrogen balance (g)	0.553	0.580	0.574	0.598	0.572	0.579	0.149	0.074	0.057	3.61

NM - natural matter; CV - coefficient of variation.

The level of 11.20 g digestible lysine/kg of diet increased egg weight, egg mass, feed conversion per egg mass, yolk weight and albumen weight, which demonstrates that this level promoted satisfactory results on Japanese quail performance and egg quality.

Conclusions

The digestible lysine level estimated in diets for Japanese quails in the egg-laying phase was 11.20 g digestible lysine/kg of diet, corresponding to a daily intake of 273.23 mg digestible lysine/bird or 26.61 mg digestible lysine/g of egg mass.

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