Revista Brasileira de Zootecnia

ISSN 1806-9290
www.sbz.org.br

R. Bras. Zootec., v.41, n.10, p.2183-2188, 2012

Performance and nitrogen balance of laying hens fed increasing levels of digestible lysine and arginine

Fabyola Barros de Carvalho[1], José Henrique Stringhini[1], Maíra Silva Matos[1], Roberto Moraes Jardim Filho[1], Marcos Barcellos Café[1], Nadja Susana Mogyca Leandro[1], Maria Auxiliadora Andrade[1]

[1] *Departamento de Produção Animal, Escola de Veterinária e Zootecnia, UFG, Goiânia, GO, Brazil.*

ABSTRACT - The objective of this experiment was to evaluate the effect of two digestible lysine levels and four digestible arginine levels on laying hens from 24 to 48 weeks of age. Three hundred and twenty Lohmann LSL laying hens were allotted in a completely randomized design in a 2 × 4 factorial arrangement, with two levels of digestible lysine (700 and 900 mg/kg of diet) and four digestible arginine levels (700, 800, 900 and 1000 mg/kg of diet). Results indicated requirement of 884 and 830 mg of digestible arginine/kg of diet, considering an average feed intake of 95 g/hen/day and an average hen weight of 1.5 kg, aiming at lesser feed intake and better nutritional balance of nitrogen, respectively. High digestible lysine levels in the diet require higher digestible arginine supplementation for a better performance of hens.

Key Words: antagonism, digestibility, digestible amino acids, egg, production

Introduction

Modern hen diets have been formulated according to the requirements of crude protein, which may unbalance the levels of amino acids as well as the relation between them. The ingestion and metabolism of amino acids increases the temperature of the body (Musharaf & Latshaw, 1999), uric acid excretion (Latshaw & Zhao, 2011), energy waste (Leclercq, 1998), and water intake, which may result in aqueous feces, leading to performance problems (Emadi et al., 2010).

Modern diet formulas for laying hens must consider the concept of ideal protein, based on the amount of amino acids, which would be more efficiently used by the hens. For this reason, it is important to establish the relations between the amino acids that are better adapted to the digestion and absorption capacity of hens, reducing the necessity of spending excessive excretion of amino acids, thus saving body energy (Parsons & Baker, 1994). The concept of ideal protein uses lysine as a reference amino acid due to its specific function in the animal organism, which is the protein deposition, and for the great amount of information about its concentration and digestibility (Parsons et al., 1992). Nevertheless, as the level of lysine is increased in diet, arginine becomes the limiting amino acid for the best hen performance. However, higher levels of lysine result in higher arginine requirements (Macari et al., 2002).

There is evidence of considerable antagonism between arginine and lysine (Austic & Scott, 1975). One reason for this antagonism is the urinary losses of arginine, caused by the lysine competition for urinary tubular reabsorption (Macari et al., 2002). Because of this, it is important to find the correct adjustment of amino acid ratios for the development of ideal protein formulas, and the achievement of the best production efficiency (Gadelha et al., 2003; Silva et al., 2005).

In hens, only 35 to 45% of the nitrogen from the protein intake turns into meat and eggs. The rest of the nitrogen is excreted, and becomes a source of environmental contamination (Penz Junior, 1993). Synthetic amino acid supplementation in laying hen diets allows better protein utilization, contributing to a reduction of excreted nitrogen and, consequently, improvement in the performance of hens.

The objective of this experiment was to evaluate the ratios of lysine and arginine supplementation for commercial Lohmann LSL laying hens at the starter production phase, and their effect on performance and nutritional balance of nitrogen.

Material and Methods

The experiment was carried out at the poultry facilities of the Veterinary School of Universidade Federal de Goias, Brazil, from January to July, 2005. A total of 320 Lohmann

Received August 8, 2011 and accepted June 21, 2012.
Corresponding author: fabyolab@hotmail.com

LSL hens of 24 weeks of age were subjected to a performance trial. For the metabolic assays, 64 additional Lohmann LSL hens, at 34, 42 and 48 weeks of age, were used. The design was completely randomized, in a 2 × 4 factorial arrangement (digestible lysine vs. digestible arginine levels) with four replicates per treatment of 10 hens each.

A corn-soybean basal diet (Table 1) was formulated according to the feed composition and dietary requeriment, fulfilling the requirements established by Rostagno et al. (2000). In addition, 0.178% and 0.202% of L-lysine, as well as 0.0; 0.105; 0.211 and 0.316 of L-arginine were added to the diet in order to meet the suggested levels of 700 and 900 mg of digestible lysine/kg of diet, and of 700, 800, 900 and 1000 mg of digestible arginine/kg of diet, respectively.

At the end of each 28-day period, feed and nutrient intake, as well as the number of dead hens, were observed in order to correct consumption values. All the eggs produced were counted every day during all the experimental period, and the results were expressed in percentage. Feed conversion (kg/dozen and kg/kg egg mass) was obtained at each 28-day period. In the last three days of each period, 16 eggs per treatment per day were weighed and the egg mass was obtained.

Table 1 - Composition and nutritional value calculated as basal diet

Ingredient	g/kg as fed
Corn	646
Soybean meal 42%	97
Wheat bran	55
Corn gluten 60%	55
Limestone	90
Meat meal	40
Salt	0.039
Mineral and vitamin supplementation[1]	0.012
L-lysine HCL	0.017
L-arginine HCl	0.000
DL-methionine 99	0.016
L-tryptophan	0.007
Starch	0.061
Metabolizable energy (kcal/kg)	2,800
Crude protein (g/kg)	160
Calcium (g/kg)	40.5
Available phosphorous (g/kg)	3.8
Lysine (g/kg)	7.7
Digestible lysine (g/kg)	7.0
Arginine (g/kg)	7.5
Digestible arginine (g/kg)	7.0
Methionine + cystine (g/kg)	6.9
Methionine (g/kg)	3.9
Threonine (g/kg)	5.9
Tryptophan (g/kg)	2.0
Arginine:lysine	1.00

[1] Mineral and vitamin supplementation (composition/kg of feed): vit. A - 2,500,000 IU; vit. D3 - 625,000 IU; vit. E - 3,750 mg; vit. K3 - 500 mg; vit. B1 - 500 mg; vit. B2 - 1,000 mg; vit. B6 - 1,000 mg; vit. B12 - 3,750 mcg; niacin - 7,500 mg; acid pantothenate - 4,000 mg; biotin - 15 mg; folic acid -125 mg; choline - 75,000 mg; selenium - 45 mg; iodine - 175 mg; iron - 12,525 mg; copper - 2,500 mg; manganese - 19,500 mg; zinc - 13,750 mg; avilamycin - 20,000 mg.

Nitrogen balance was obtained during four days at 34, 42 and 48 weeks of age. Excreta was collected twice a day by the total excreta collection method, identified, stored and prepared for nitrogen analysis. The feed and the eggs weighed during the metabolic assay were used to calculate nitrogen balance and retention, expressed by milligrams of nitrogen per gram of egg mass produced.

Chemical analysis of diet and excreta were performed at the Laboratório de Nutrição Animal of Universidade Federal de Goias. Dry matter and total nitrogen were determined as proposed by Silva & Queiroz (2002). Nitrogen balance (NB) was determined as follows:

NB (g): ingested N – excreted N;

NB (g/g) = (ingested N – excreted N)/ ingested N * 100 and;

NB per egg mass (mg/g) = (ingested N – excreted N)/ egg mass * 100

Results were analyzed by ANOVA using SAEG (Sistema para Análises Estatísticas e Genéticas, version 7.1), and submitted to polynomial regression for the levels of digestible arginine tested.

Results and Discussion

Egg production, average egg weight, egg mass, feed conversion per gram of egg produced, and feed conversion per dozen egg produced were not affected (Table 2). On the other hand, feed intake, lysine intake and arginine intake showed significantly effect nutritional treatments.

Unlike the results obtained in this study, in which no difference was found for egg production and mass, regardless of the arginine:lysine ratio used, Araújo et al. (2005) tested six arginine:lysine diet levels (718:716; 790:716; 718:644; 790:644; 718:788; and 790:788) in 40-week old Lohmann Brown and Lohmann LSL hens, and found that these two variables were higher when using an arginine:lysine level of 718:716 mg, whereas the lowest egg weight was obtained with the 790:716 mg digestible lysine:arginine diet level.

Lima et al. (2007) worked with light and heavy hens fed two levels of digestible lysine (710 and 780 mg/kg of diet) and three levels of digestible arginine (640; 720 and 790 mg/kg of diet), and found statistical interaction of egg production and feed conversion per egg mass. In their study, the best results were obtained with 710 mg of digestible lysine and 790 mg of digestible arginine/kg of diet. Egg weight also showed to be affected, with the best results found at the lowest level of digestible lysine (710 mg) and arginine (640 mg) levels.

Table 2 - Performance of laying hens fed increasing levels of digestible lysine and arginine/kg of diet from 24 to 44 weeks of age

	Egg production (%)	Egg weight (g)	Egg mass (g)	Feed intake (g/hen/day)	Lysine intake (mg/hen/day)	Arginine intake (mg/hen/day)	Feed conversion (kg/kg eggs)	Feed conversion (kg/dozen eggs)
				Lysine (mg/kg of diet)				
700	90.16	58.84	52.97	94.78	663.51	783.42	1.793	1.265
900	90.59	58.59	53.17	94.60	851.45	811.00	1.787	1.254
				Arginine (mg/kg of diet)				
700	89.74	58.90	52.85	95.00	762.09	681.18	1.802	1.272
800	89.44	58.43	52.34	94.26	754.91	754.27	1.806	1.266
900	90.83	58.78	53.26	93.74	747.44	827.65	1.763	1.242
1000	91.50	58.76	53.82	95.77	765.49	925.73	1.787	1.260
				P value				
Lysine	0.728	0.560	0.818	0.828	0.001	0.001	0.819	0.547
Arginine	0.623	0.881	0.654	0.353	0.253	0.001	0.664	0.616
Lysine × arginine	0.409	0.793	0.729	0.004	0.003	0.006	0.118	0.078
CV %	3.9	2.1	4.5	2.5	2.5	2.5	4.2	3.8

CV (%) - coefficient of variation.

There was significant interaction (P<0.05) between the levels of digestible lysine and arginine for feed intake (Table 3). For the diet with 700 mg of digestible arginine/kg, there was lower feed intake the hens at the level of 700 mg of digestible lysine than at 900 mg/kg of diet. When the arginine level was incremented up to 900 mg/kg of diet, opposite results were observed.

Lysine intake (Table 3) occurred as expected, considering that the hens that were fed 900 mg of lysine/kg of diet presented higher lysine intake when compared with the ones that were fed 700 mg of lysine/kg of diet. As regards arginine intake, the only difference observed occurred with diets at the levels of 700 and 800 mg of arginine/kg of diet, with higher arginine intake for hens that received 900 mg of digestible lysine/kg of diet than the ones that received 700 mg.

Table 3 - Effect of interaction for laying hens fed increasing levels (mg/kg of diet) of digestible lysine and arginine from 24 to 44 weeks of age

	Arginine					
Lysine	700	800	900	1000	P value	CV %
			Feed intake (g/hen/day)			
700	92.91b	93.49	96.25a	96.51	0.117	2.5
900	97.10a	95.05	91.24b	95.04	0.024[1]	2.4
			Lysine intake (mg/hen/day)			
700	650.34b	654.42b	673.72b	675.60b	0.117	2.5
900	873.86a	855.42a	821.17a	855.38a	0.024[2]	2.4
			Arginine intake (mg/hen/day)			
700	650.34b	732.32b	834.13	916.89	0.001[3]	2.4
900	712.03a	776.22a	821.17	934.58	0.001[4]	2.6

Different letters in the column differ (0.05) by the F test.
CV - coefficient of variation.
[1] $900/Y = 206.885 - 0.258520 + 0.000146209X^2$ / $R^2 = 0.76$ / Minimum = 884 mg.
[2] $900/Y = 1861.97 - 2.32668X + 0.00131588X^2$ / $R^2 = 0.76$ / Minimum = 884 mg.
[3] $700/Y = 17.1690 + 0.901471X$ / $R^2 = 1.00$.
[4] $900/Y = 205.296 + 0.712594X$ / $R^2 = 0.96$.

Responses to the increasing levels of digestible arginine/kg of diet showed a quadratic effect for the consumption of feed and digestible lysine for hens fed diets with 900 mg of digestible lysine/kg of diet (Table 3), whereas digestible arginine intake showed expected linear increase as the levels of digestible arginine per kg/diet were increased from 700 mg to 1000 mg at the two levels of digestible lysine tested. On the other hand, Araújo et al. (2005), in a study previously mentioned, did not find differences for feed intake. In a similar study with the same hen lineages, Lima et al. (2005) also did not find changes.

The reduction in lysine intake observed with digestible arginine supplementation, when high levels of digestible lysine are adopted, can be explained by the antagonistic relationship between these two amino acids. As both amino acids use the same renal tubular transportation system, lysine and arginine compete for renal re-absorption. This may cause arginine loss through the urine, and may decrease hepatic transaminase activity due to excessive lysine (Macari et al., 2002). Increase in arginine consumption confirms the suggestion by Leeson & Summers (2001), in which absence of a functional urea cycle requires arginine supply in the diet. The more lysine is added to the diet, the more arginine is required.

The levels of digestible arginine in diets fed to 34-week old hens did not produce any changes in the nitrogen balance in grams, percentage, or per egg mass, in its intake or excretion (Table 4). Nitrogen intake was higher (P<0.05) in hens fed 900 mg digestible lysine/kg of diet.

Rizzo et al. (2004) did not find differences in nitrogen intake, excretion and balance in the diet supplemented with 850 and 1000 mg of digestible lysine and fed to 51-week old Hisex White hens. When metabolic assays were conducted with 42-week old animals, statistical interaction was found between the two amino acids, for all the variables studied (P<0.05) (Table 5).

Hens fed supplementation with 1000 mg of digestible arginine (Table 6) showed higher nitrogen balance in g, in percentage, and per egg mass when 900 mg of digestible lysine were used (P<0.05). The same was not seen for the other supplementation levels of arginine/kg of the diet. Increase of arginine in the diet with 700 mg of digestible lysine resulted in a quadratic effect (P<0.05) for nitrogen balance in grams, with a peak at the level of 844 mg of digestible arginine/kg in diet. Linear effect for nitrogen balance in grams, in percentage, and per egg mass was observed at the level of 900 mg of lysine.

When hens are fed diets containing excessive levels of either arginine or lysine, the activity of the enzyme arginase increases. Therefore, little excess of lysine in the diet may increase arginine degradation (Leeson & Summers, 2001). This antagonistic relationship may explain the increase seen in nitrogen balance in grams, in percentage, and per egg mass when the level of digestible arginine is increased in the diet.

Higher nitrogen intake was observed in the diet containing 900 mg of digestible lysine and 1000 mg of digestible arginine (Table 7); however, this did not occur for nitrogen excretion. A quadratic effect was observed for

Table 4 - Nitrogen metabolism of laying hens fed increasing levels of digestible lysine and arginine/kg of diet at 34 weeks of age

	N balance (g)	N balance (g/g DM)	N balance per egg mass (mg/g)	N intake (g)	N excretion (g)
			Lysine (mg/kg of diet)		
700	7.24	0.403	19.00	17.84b	10.60
900	7.76	0.404	19.76	19.20a	11.43
			Arginine (mg/kg of diet)		
700	6.91	0.392	17.22	17.57	10.75
800	7.52	0.406	19.68	18.56	11.03
900	7.75	0.398	20.39	19.11	11.35
1000	7.81	0.417	20.22	18.73	10.92
			P value		
Lysine	0.356	0.964	0.646	0.029	0.133
Arginine	0.660	0.905	0.496	0.376	0.879
Lys × arg	0.853	0.926	0.658	0.772	0.907
CV (%)	21.1	17.9	23.7	9.0	13.7

Different letters in the column differ by the F test (0.05).
CV - coefficient of variation; DM - dry matter.

Table 5 - Nitrogen metabolism of laying hens fed increasing levels of digestible lysine and arginine/kg of diet at 42 weeks of age

	N balance (g)	N balance (g/g DM)	N balance per egg mass (mg/g)	N intake (g)	N excretion (g)
			Lysine (mg/kg of diet)		
700	4.29	0.394	17.61	10.80	6.50
900	4.54	0.408	19.60	10.91	5.37
			Arginine (mg/kg of diet)		
700	3.52	0.364	13.57	9.55	5.12
800	4.01	0.376	17.97	10.51	5.50
900	5.47	0.454	23.73	11.99	5.52
1000	4.67	0.410	19.17	11.17	5.50
			P value		
Lysine	0.401	0.479	0.301	0.682	0.544
Arginine	0.007	0.078	0.054	0.001	0.411
Lys × Arg	0.001	0.001	0.001	0.018	0.021
CV (%)	18.7	14.4	28.6	7.4	9.4

CV - coefficient of variation; DM - dry matter.

Table 6 - Effect of interaction for laying hens fed increasing levels of digestible lysine (mg/kg of diet) and arginine (mg/kg of diet) at 42 weeks of age

			Arginine			
			Nitrogen balance (g)			
Lysine	700	800	900	1000	P value	CV (%)
700	3.99	4.38	5.43	3.37b	0.028[1]	19.5
900	3.05	3.64	5.50	5.97a	0.001[2]	17.9
			Nitrogen balance (g/g DM)			
Lysine	700	800	900	1000	P value	CV (%)
700	0.401	0.410	0.437	0.326b	0.076	14.1
900	0.326	0.341	0.471	0.495a	0.002[3]	14.7
			Nitrogen balance per egg mass (mg/g)			
Lysine	700	800	900	1000	P value	CV (%)
700	15.71	19.96	22.25	12.53b	0.100	30.6
900	11.43	15.97	25.21	25.81a	0.005[4]	26.9

Different letters in the column differ by the F test (0.05).
CV - coefficient of variation; DM - dry matter.
[1] 700/ $Y = -38.6547 + 0.103682X - 0.0000614676X^2$ / $R^2 = 0.68$ / Maximum = 844 mg.
[2] 900/ $Y = -4.46877 + 0.0106047X$ / $R^2 = 0.94$.
[3] 900/ $Y = -13.2713 + 0.0637081X$ / $R^2 = 0.89$.
[4] 900/ $Y = -24.9060 + 0.0523690X$ / $R^2 = 0.91$.

Table 7 - Effect of interaction for laying hens fed increasing levels (mg/kg of diet) of digestible lysine and arginine at 42 weeks of age

			Arginine			
			Nitrogen intake (g)			
Lysine	700	800	900	1000	P value	CV (%)
700	9.89	10.61	12.38	10.29b	0.015[1]	8.9
900	9.40	10.61	11.59	12.06a	0.001[2]	5.6
			Nitrogen excretion (g)			
Lysine	700	800	900	1000	P value	CV (%)
700	5.90	6.22	6.95	6.92	0.080	9.4
900	6.34	6.97	6.08	6.08	0.080	9.3

Different letters in the column differ by the F test (0.05).
CV - coefficient of variation.
[1] 700/ $Y = -41.5174 + 0.122195X - 0.0000701345X^2$ / $R^2 = 0.66$ / Maximum 871 mg.
[2] 900/ $Y = 3.30866 + 0.00895178X$ / $R^2 = 0.97$.

nitrogen intake (P<0.05), for supplementation levels of digestible arginine in a diet with 700 mg of digestible lysine/kg. There was a peak at the level of 871 mg of digestible arginine. Positive linear effect (P<0.05) was observed for hens fed 900 mg of digestible lysine/kg of diet. The same was not observed for nitrogen excretion.

Adding arginine when using 900 mg of digestible lysine resulted in an increase of nitrogen intake, but with no changes in nitrogen excretion. This result may be related to a greater biosynthesis of the nitric oxide, which is an arginine precursor (Bacila, 2003).

When hens reached 48 weeks of age, a statistical interaction (P<0.05) was found for levels of digestible lysine and arginine (Table 8). Supplementation with 800 mg of digestible arginine (Table 9) showed greater nitrogen balance in grams, in percentage and per egg mass for 700 mg of digestible lysine (P<0.05). However, when using 1000 mg of digestible arginine, nitrogen balance values in percentage and per egg mass were greater for 900 mg of digestible lysine/kg of diet.

Adding arginine to the diet containing 700 mg of digestible lysine resulted in a quadratic effect (P<0.05) for nitrogen balance in grams, in percentage and per egg mass, with peaks at the level of 821, 786 and 814 mg of digestible arginine/kg of diet, respectively (Table 9). No regression effect occurred for 900 mg of digestible lysine/kg of diet for the variables studied.

These values are similar to the 838 mg arginine/kg of diet suggested as the minimum amount required for digestible arginine for light hens fed 95 g of diet/hen/day and with average weight of 1.479 kg (Rostagno et al., 2005).

Table 8 - Nitrogen metabolism of laying hens fed increasing levels of digestible lysine and arginine/kg of diet at 48 weeks of age

	N balance (g)	N balance (g/g DM)	N balance per egg mass (mg/g)	N intake (g)	N excretion (g)
Lysine (mg/kg of diet)					
700	6.47	0.448	22.61	14.38	7.90
900	6.22	0.435	20.90	14.26	8.04
Arginine (mg/kg of diet)					
700	6.55	0.465	21.92	14.07	7.52
800	6.72	0.456	23.22	14.60	7.88
900	6.20	0.422	21.27	14.63	8.43
1000	5.90	0.423	20.60	13.97	8.07
P value					
Lysine	0.432	0.473	0.228	0.716	0.669
Arginine	0.287	0.260	0.591	0.340	0.238
Lys × Arg	0.001	0.002	0.001	0.014	0.037
CV (%)	14.0	11.9	18.1	6.3	11.0

CV - coefficient of variation; DM - dry matter.

The values found for nitrogen balance (Table 9) showed higher supplementation levels of digestible arginine/kg of diet (786 and 826 mg) for 700 mg of digestible lysine. It is must be emphasized that the recommendation above was found based on an average intake of 95 g/hen/day for light hens with average weight of 1500 g. To improve hen performance, higher levels of digestible lysine should be accompanied by supplementation of digestible arginine.

For 700 mg of digestible arginine (Table 10), there was lower consumption of nitrogen for 700 mg of digestible lysine, if compared with 900 mg (P<0.05). The opposite was seen for 800 mg of digestible arginine in the diet. When supplementation of 1000 mg of digestible arginine was used, greater excretion of nitrogen was seen for the lowest level of digestible lysine (700 vs. 900). Supplementation of digestible arginine with 700 mg of digestible lysine/kg

Table 9 - Effect of interaction for laying hens fed increasing levels (mg/kg of diet) of digestible lysine and arginine at 48 weeks of age

	Arginine					
Nitrogen balance (g)						
Lysine	700	800	900	1000	P value	CV (%)
700	6.16	8.05a	6.39	5.28	0.001[1]	9.2
900	6.93	5.39b	6.01	6.53	0.276	17.8
Nitrogen balance (g/g DM)						
Lysine	700	800	900	1000	P value	CV (%)
700	0.465	0.521a	0.432	0.375b	0.001[2]	8.2
900	0.466	0.390b	0.413	0.471a	0.266	14.9
Nitrogen per egg mass (mg/g)						
Lysine	700	800	900	1000	P value	CV (%)
700	22.63	27.79a	23.91	16.13b	0.001[3]	12.4
900	21.22	18.66b	18.64	25.06a	0.242	23.0

Different letters in the column differ by the F test (0.05).
CV - coefficient of variation; DM - dry matter.
[1] 700/ $Y = -43.0902 + 0.123127X - 0.0000749602X^2$ / $R^2 = 0.79$ / Maximum 821 mg.
[2] 700/ $Y = -125.684 + 0.445692X - 0.000283354X^2$ / $R^2 = 0.86$ / Maximum 786 mg.
[3] 700/ $Y = -187.133 + 0.526401X - 0.000323387X^2$ / $R^2 = 0.98$ / Maximum 814 mg.

Table 10 - Effect of interaction for laying hens fed increasing levels (mg/kg of diet) of digestible lysine and arginine at 48 weeks of age

	Arginine					
Nitrogen intake (g)						
Lysine	700	800	900	1.000	P value	CV (%)
700	13.27b	15.41a	14.75	14.08	0.002[1]	4.4
900	14.86a	13.79b	14.51	13.87	0.466	7.7
Nitrogen excretion (g)						
Lysine	700	800	900	1.000	P value	CV (%)
700	7.11	7.36	8.36	8.79a	0.010[2]	8.4
900	7.92	8.39	8.50	7.34b	0.415	13.0

Different letters in the column differ by the F test (0.05).
CV - coefficient of variation.
[1] 700/ $Y = -36.9625 + 0.121118X - 0.0000702136X^2$ / $R^2 = 0.85$ / Maximum 862 mg.
[2] 700/ $Y = 2.75763 + 0.00606073X$ / $R^2 = 0.95$.

generated a quadratic effect (P<0.05) with a peak at the level of 862 mg of digestible arginine. As for excretion, a linear effect was generated (P<0.05), with no difference for 900 mg of digestible lysine in the nitrogen intake or excretion.

For 700 mg of digestible lysine/kg of diet, nitrogen intake was maximum with 862 mg of digestible arginine, whereas greater nitrogen excretion was obtained with 1000 mg of digestible arginine, which is probably related to the balance of amino acids in the diet (Table 10).

Conclusions

As lysine is added to the diet, more arginine is required. Therefore, to improve performance of the hens and optimize nitrogen metabolism, increase in the levels of digestible lysine should be accompanied by digestible arginine supplementation.

References

ARAUJO, D.M.; VILAR DA SILVA, J.H.; LIMA, M.R. et al. Níveis de lisina e arginina digestível para poedeiras no pico de postura. In: CONFERÊNCIA APINCO DE CIÊNCIA E TECNOLOGIA AVÍCOLAS, 7., 2005, Santos. **Anais...** Campinas: FACTA, 2005. p.136.

AUSTIC R.E.; NESHEIM, M.C. Arginine, ornithine and proline metabolism of chicks: Influence of diet and heredity. **Journal of Nutrition**, v.101, p.1403-1414, 1971. Available at: <http://jn.nutrition.org/content/101/10/1403.full.pdf+html> Accessed on: July 6, 2011.

AUSTIC, R.E.; SCOTT, R.L. Involvement of food intake in the lysine-arginine antagonism in chicks. **Journal of Nutrition**, v.105, p.1122-1131, 1975. Available at: <http://jn.nutrition.org/content/105/9/1122.full.pdf> Accessed on: July 6, 2011.

BLOCH, K.[1946] The metabolism of 1(+)-arginine and synthesis of creatine in the pigeon. **Journal of Biological Chemistry**, v.165, p.477-484, 1946.

BACILA, M. **Bioquímica veterinária**. 2.ed. São Paulo: ROBE, 2003. p.583.

COON, C. Amino acid requirement of commercial laying hens. In: ASIAN PACIFIC POULTRY CONGRESS, 6., 1998, Nagoya. **Proceedings...** Nagoya: Japan Poultry Science Association, 1998. p.70-75.

EMADI, M.; KAVEH, K.; BEJO, M.H. et al. Growth performance and blood parameters as influenced by different levels of dietary arginine in broiler chickens. **Journal of Animal and Veterinary Advances**, v.9, p.70-74, 2010.

GADELHA, A.C.; DAHLKE, F.; FARIA FILHO, D.E. et al. Interação entre arginina e lisina altera as respostas produtivas e a incidência de problemas de pernas em frangos de corte. In: CONFERÊNCIA APINCO DE CIÊNCIA E TECNOLOGIA AVÍCOLAS, 5., 2003, Campinas. **Anais...** Campinas: FACTA, 2003. p.75.

LATSHAW, J.D.; ZHAO, L. Dietary protein effects on hen performance and nitrogen excretion. **Poultry Science**, v.90, p.99-106, 2011.

LECLERCQ, B. Specific effects of lysine on broiler production: comparison with threonine and valine. **Poultry Science**, v.77, p.118-123, 1998.

LEESON, S.; SUMMERS, J.D. **Nutrition of the chicken**. Guelph, Canadá: Department of Animal & Poultry Science, University of Guelph. 2001. p.591.

LEHNINGER, A.L.; NELSON, D.L.; COX, M.M. **Princípios de bioquímica**. 2.ed. São Paulo: SARVIER, 1995. p.839.

LIMA, M.R.; VILAR DA SILVA, J.H. Efeito da relação lisina:arginina digestível sobre o desempenho de poedeiras comerciais no período de postura. **Acta Veterinária Brasílica**, v.1, p.118-124, 2007.

LIMA, M.R.; VILAR DA SILVA, J.H.; ROCHA, J.K.P. et al. Relações lisina e arginina digestíveis para poedeiras leves e semipesadas no pós-pico de postura. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 42., 2005, Goiânia. **Anais...** Goiânia: SBZ, 2005. (CD-ROM).

MACARI. M.; FURLAN, R.L.; GONZALES, E. **Fisiologia aviária aplicada a frangos de corte**. Jaboticabal: FUNEP/UNESP, 2002. 375p.

MUSHARAF, N.A.; LATSHAW, J.D. Heat increment as aff ected by protein and amino acid nutrition. **World's Poultry Science Journal**, v.55, p.233-240, 1999.

NATIONAL RESEARCH COUNCIL - NRC. **Nutrient requirements of poultry.** 9.ed. Washington D.C.: National Academic Press, 1994. 155p.

NUNES, I.J. **Nutrição animal básica**. Proteínas. 2.ed. Belo Horizonte: FEP-MVZ, 1998. p.99-119.

PARSONS, C.M.; KOELKBECK, K.W.; LEEPER, R.W. et al. Effect of duration of fasting on post molt laying hen performance. **Poultry Science**, v.71, p.434-439, 1992.

PARSONS, M.C.; BAKER, D.H.The concept and use of ideal proteins in feeding of nonruminants, In: SIMPÓSIO INTERNACIONAL DE PRODUÇÃO DE NÃO-RUMINANTES, 31., 1994, Maringá. **Anais...** Maringá: SBZ, 1994. p.119.

PENZ JUNIOR, A.M. Digestibilidad de aminoácidos. In: SIMPÓSIO DE AVANCES TECNOLÓGICOS, 1993, República Dominicana. **Anais…** República Dominicana: NOVUS, 1993. p.35-48.

RIZZO, M.F.; ROMBOLA, L.G.; FARIA, D.E. et al. Alimentação de poedeiras com diferentes níveis de proteína e lisina: 1.utilização e excreção de nitrogênio. In: CONFERÊNCIA APINCO DE CIÊNCIA E TECNOLOGIA AVÍCOLAS, 6., 2004, Santos. **Anais...** Santos: FACTA, 2004. p.27.

ROSTAGNO, H.S.; ALBINO, L.F.T.; DONZELE, J.L. et al. **Tabelas brasileiras para aves e suínos**. Composição de alimentos e exigências nutricionais. Viçosa, MG: Editora UFV, 2005. 185p.

ROSTAGNO, H.S.; ALBINO, L.F.T.; DONZELE, J.L. et al. **Tabelas brasileiras para aves e suínos**. Composição de alimentos e exigências nutricionais de aves e suínos: tabelas brasileiras. Viçosa, MG: UFV, 2000. 141p.

SILVA, J.H.V.; JORDÃO FILHO J.; SILVA E.L. et al. Por que formular dietas para poedeiras com base no conceito de proteína ideal? **Revista Ave World**, v.3, p.50-57, 2005.

SILVA, D.J.; QUEIROZ, A.C. **Análise de alimentos**: métodos químicos e biológicos. 3.ed. Viçosa, MG: Editora UFV, 2002. 235p.