Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1806-2636
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v36i2.21822

Digestible lysine levels in semi-heavy laying hens in the period from 28 to 44 weeks of age

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ABSTRACT. This study aimed to evaluate the performance of laying hens subjected to heavy semi-low crude protein (14.0%) and lysine levels while maintaining the same relation of digestible amino acid/ digestible lysine. A commercial line of 420 Isa Brown laying hens, in the period from 28 to 44 weeks of age, were distributed in 42 experimental plots. A completely randomized design with six treatments and seven replicates in four periods of 28 days/each was used. The treatments were: Control - Formulated according to the nutritional requirements proposed in the strain, containing 16.92% crude protein, 0.750% digestible lysine. Treatments 1 to 5, with crude protein levels of 14% and 0.600% of digestible lysine, 0.675%, 0.750%, 0.825% and 0.900%, respectively. The requirement of lysine, in relation to other digestible amino acids, can be estimated at 0.750% in diet with 14% crude protein, which corresponds to the average daily intake of 876 mg lysine dig. hen^{-1} day^{-1}, without compromising the performance of hens.

Keywords: ideal protein, digestible amino acid, Isa Brown.

Níveis de lisina digestível para poedeiras semipesadas no período de 28 a 44 semanas

RESUMO. O objetivo da pesquisa foi avaliar o desempenho de poedeiras semipesadas submetidas a dietas com baixo teor proteína bruta (14,0%) e diferentes níveis de lisina, mantendo a mesma relação aminoácidos digestíveis/ lisina digestível. Foram utilizadas 420 poedeiras da linhagem comercial Isa Brown de 28 a 44 semanas de idade, distribuídas em 42 parcelas experimentais. Foi utilizado um delineamento inteiramente casualizado com seis tratamentos e sete repetições, em quatro períodos de 28 dias/cada. Os tratamentos foram: Controle – ração formulada de acordo com as exigências nutricionais propostas no manual da linhagem, contendo 16,92% proteína bruta e 0,750% lisina digestível. Os tratamentos testes do 1 ao 5, tiveram a redução proteica, 14% de proteína bruta e diferentes níveis de lisina digestível de 0,600%; 0,675%; 0,750%; 0,825% e 0,900%, respectivamente. A exigência de lisina digestível, em relação aos demais aminoácidos digestíveis, pode ser estimada em 0,750% em dieta com 14% de proteína bruta, o que corresponde ao consumo médio diário de 876 mg lisina digestível, sem comprometer o desempenho das aves.

Palavras-chave: proteína ideal, aminoácidos digestíveis, Isa Brown.

Introduction

The increasing global trend of conventional protein source price rise and the requirements imposed to the control of pollutant excretion have encouraged researchers and nutritionists to create alternative diets. Such diets are more economically effective and proper to meet the nutritional requirements of animals without compromising their performance.

Egg production is currently one of the most effective animal protein production in terms of expenses. Thanks to the genetic improvements made in recent decades, new commercial lines have introduced laying hens with higher production potential, which has consequently increased the nutritional requirements for best conversion at minimal cost (COSTA et al., 2008; JORDÃO FILHO et al., 2006b).

Considering that the growth and performance of hens are greatly affected by the energy and protein levels included in their diets (LEESON; SUMMERS, 2001), costs related to these nutrients, which encumber ration (TOLEDO et al., 2004), may affect the profitability of farmers (MARTINS, 2008).

According to Toledo et al. (2004), for many years the formulations for poultry diet have been based on the concept of crude protein (nitrogen content x 6.25). This has often been associated with diets containing higher content of amino acids, or with unbalanced poultry diet ratios that do not meet their needs.

Moura (2004) believes that the current trend to reduce these costs is to reformulate new nutritional arrays, reducing the amount of traditional protein sources in the diet, and including synthetic amino acids according to their availability in the market.

There is a current need to determine the proper amino acid poultry requirement without affecting their performance, as well as a need to reduce nitrogen excretion (ROCHA et al., 2009) and ammonia emissions, in order to protect the environment (ROBERTS et al., 2007).

Isolated estimates of amino acid requirement may not be as efficient when compared with estimates of the ideal ratio of lysine and other amino acids, commonly known as ideal protein (JORDÃO FILHO et al., 2006a; ROCHA et al., 2009, SÁ et al., 2007; SHIMIDT et al., 2008).

The recommendations for amino acids in rations for laying hens need to be updated in view of their genetic progress, along with environmental and economic factors. The use of synthetic amino acids has become an important tool to reduce the levels of protein in their diet and maintain high performance (BERTECHINI, 2006).

The objective of this research was to evaluate the performance responses of Isa Brown hens subjected to reduced protein (14.0% CP), with different digestible lysine levels, maintaining the same ratio of digestible amino acid/lysine.

Material and methods

This present research was conducted at the Poultry Section of the Department of Agricultural Sciences of IFMG - Bambuí Campus, from April to August, 2011, divided into four periods of 28 days/each, totaling 16 experimental weeks.

A total of 420 Isa Brown laying hens, in the period from 28 to 44 weeks of age, were distributed in a completely randomized design with 6 treatments and 7 replicates/each, totaling 42 experimental plots with 10/hens each. The plot consisted of five cages, measuring 25 x 40 x 38 cm, with 2 hens/ each, totaling 500 cm^2 hen^{-1}. Hens were selected at the pre-experimental period according to their production of eggs.

Treatments were: Control - Ration formulated according to the nutritional requirements proposed in the strain, containing 16.92% crude protein (CP), and 0.750% digestible lysine. Treatment 1: 14.00% CP; 0.600% digestible lysine. Treatment 2: 14.00% CP; 0.675% digestible lysine. Treatment 3: 14.00% CP; 0.750% digestible lysine. Treatment 4: 14.00% CP; 0.825% digestible lysine. Treatment 5: 14.00% CP; 0.900% digestible lysine. Table 1 shows the nutritional composition and percentage of experimental diets. Bromatological analyzes (amino acid profile) of treatments were made. Table 2 shows the values of nutritional composition and percentage.

Table 1. Composition of the experimental diets and percentage of Isa Brown laying hens subjected to the respective treatments in the period from 28 to 44 weeks of age.

[1]Composition and percentage of experimental diets						
Ingredients	Control	T1	T2	T3	T4	T5
Corn	62.432	68.467	68.181	67.895	67.609	67.323
Gluten Corn 60%	1.500	1.500	1.500	1.500	1.500	1.500
Far Soybeans 45%	23.735	12.129	12.164	12.199	12.234	12.269
Soy Oil	1.015	1.000	1.000	1.000	1.000	1.000
Limestone Powder	4.438	4.444	4.443	4.443	4.443	4.443
Limestone Gravel	4.438	4.444	4.443	4.443	4.443	4.443
Dicalcium Phosphate	1.417	1.506	1.507	1.508	1.509	1.510
[1.1]Mineral Premix	0.100	0.100	0.100	0.100	0.100	0.100
[1.2]Vitamin Premix	0.100	0.100	0.100	0.100	0.100	0.100
Salt	0.346	0.348	0.347	0.347	0.347	0.346
DL-methionine 99%	0.181	0.153	0.222	0.292	0.361	0.431
L-lysine HCL 99%	0.000	0.171	0.267	0.362	0.458	0.554
L-threonine 98.5%	0.000	0.052	0.111	0.169	0.227	0.285
L-tryptophan 98.5%	0.000	0.025	0.043	0.060	0.078	0.095
L-valine 98.5%	0.000	0.057	0.130	0.202	0.275	0.348
L-arginine 99%	0.000	0.000	0.060	0.120	0.179	0.239
L-isoleucine 99%	0.000	0.009	0.067	0.125	0.183	0.241
L-phenylalanine 99%	0.000	0.000	0.023	0.047	0.070	0.094
Alanine 99%	0.000	1.548	1.161	0.774	0.387	0.000
Kaolin	0.300	3.947	4.130	4.314	4.497	4.680
Total	100.00	100.00	100.00	100.00	100.00	100.00

[1]Diets formulated in accordance with the requirements proposed by the manual of the strain ISA Hendrix Genetics Company, Nutrition Layer Management Guide (ISA, 2007) and Rostagno et al. (2011); [1.1]Mineral Premix Composition per 100 g of product: manganese 7.5 mg, iron 5000 mg, iodine 150 mg, zinc 7000 mg, copper 850 mg, cobalt 20 mg; [1.2]Vitamin Premix Composition per 100 g product: vitamins: A 80000 µ, B12 100 mg, D3 200000 µ, E 1500 mg, K3 200 mg, B2 400 mg, B6 100 mg, niacin 1990 mg, pantothenic acid 535 mg, folic acid 20 mg, selenium 250 mg, antioxidant 10000 mg.

Table 2. Bromatological analyses of the experimental diets, amino acid composition and nutritional percentage.

Nutritional Analysis (g 100 g^{-1} - Product in Natural Matter)						
Support Analyses*	Control	T1	T2	T3	T4	T5
Dry Matter	90.48	90.73	89.52	89.92	90.18	89.44
Crude protein	16.98	14.40	14.08	13.94	13.55	14.45
Total Amino Acids*						
Lysine	0.889	0.742	0.803	0.880	0.937	0.910
Threonine	0.649	0.490	0.598	0.622	0.641	0.663
Methionine	0.498	0.348	0.485	0.541	0.595	0.507
Cystine	0.247	0.213	0.230	0.204	0.207	0.222
Methionine + Cystine	0.745	0.562	0.716	0.745	0.802	0.730
Alanine	0.960	2.399	1.830	1.206	0.874	1.354
Arginine	1.182	0.773	0.768	0.789	0.844	0.834
Aspartic Acid	1.659	1.120	1.086	1.005	1.039	1.097
Glutamic Acid	3.358	2.297	2.273	2.026	2.221	2.408
Glycine	0.722	0.515	0.478	0.423	0.418	0.491
Histidine	0.425	0.336	0.344	0.302	0.333	0.305
Isoleucine	0.679	0.495	0.580	0.063	0.656	0.671
Leucine	1.609	1.294	1.293	1.170	1.226	1.331
Phenylalanine	0.893	0.668	0.672	0.660	0.750	0.705
Serine	0.880	0.617	0.611	0.558	0.575	0.638
Tyrosine	0.658	0.478	0.423	0.434	0.471	0.492
Valine	0.760	0.663	0.737	0.753	0.828	0.817
Tryptophan	0.190	0.148	0.169	0.190	0.190	0.191
*Free Amino Acids						
Lysine	0.012	0.148	0.271	0.309	0.406	0.317
Threonine	0.024	0.068	0.156	0.208	0.258	0.191
Methionine	0.215	0.169	0.291	0.348	0.421	0.301

*Analises performed by Ajinomoto® do Brasil/ Ajinomoto Animal Nutrition.

All diets of treatments 1 through 5 were isonitrogenous (14% CP) with L-Alanine for nitrogen balance, isocaloric (2800 kcal EM kg^{-1}), isocalcic (3.70%) and isophosphoric (0.35%) with different levels of lysine, keeping the same digestible amino acid/ digestible lysine ratio (Table 3).

Table 3. Ratio of digestible amino acids (DAC)/digestible lysine (DL) in the experimental feeds of Isa Brown laying hens subjected to the respective treatments in the period from 28 to 44 weeks of age.

*Dig AA/ Dig Lis	Control	T1	T2	T3	T4	T5
Arg/ Lys	1.350	1.105	1.070	1.042	1.019	1.000
Ile/ Lys	0.872	0.760	0.760	0.760	0.760	0.760
Met/ Lys	0.582	0.585	0.622	0.651	0.675	0.695
M + C/ Lys	0.910	0.910	0.910	0.910	0.910	0.910
Thr/ Lys	0.760	0.760	0.760	0.760	0.760	0.760
Trp/ Lys	0.233	0.230	0.230	0.230	0.230	0.230
Val/ Lys	0.956	0.950	0.950	0.950	0.950	0.950
Leu/ Lys	2.031	2.014	1.787	1.606	1.458	1.335
His/ Lys	0.575	0.529	0.469	0.422	0.383	0.351
Phe/ Lys	1.057	0.947	0.875	0.818	0.771	0.732
Phe + Tyr/ Lys	1.799	1.620	1.473	1.356	1.260	1.180

*Amino acid ratios based on values proposed by Rostagno et al. (2011).

All diets of treatments 1-5 had the same levels of protein (14% CP) with L-Alanine for nitrogen balance, calories (2800 kcal kg^{-1}), calcium (3.70%) and phosphorus (0.35 %) with different levels of lysine, maintaining the same digestible amino acid/ lysine ratio.

Hen fed *ad libitum*, and received 16.5 h light^{-1} day^{-1}. Ration was placed in a feeding trough twice a day, and the water in nipple drinkers.

The following animal performance variables were assessed: Production (% eggs hen^{-1} day^{-1}): with daily evaluation, and productivity calculations were expressed in hen day^{-1} percentage. Feed intake (g hen^{-1} day^{-1}): ration was supplied in buckets to their respective plot, weighed at the end of each week to determine the mean consumption of ration hen^{-1} day^{-1}. Mean egg weight (g) at the end of each week, all intact eggs produced were weighed (digital scale with precision of 0.05 g). Feed conversion per mass (g g^{-1}): calculated on the basis of the variables mentioned above. Final weight of hens (g): 60% of hens per experimental unit were weighed at the beginning and end of the experimental period to determine mean weight.

Data were statistically analyzed with the statistical program, system of analysis of variance SISVAR (FERREIRA, 2000), performing contrasts by the Scheffé test between the control treatment and the other test diets. Regression analysis was used to determine the quantitative levels of digestible lysine for treatments 1 to 5 and experimental periods.

Results and discussion

There was significant interaction ($p < 0.01$) among treatments and experimental periods for egg production (Table 4).

Table 4. Effect of protein reduction at different levels of lysine on the egg production of Isa Brown laying hens from 28 to 44 weeks of age.

Treatment/ level Digestible Lysine	Egg Production (% hen^{-1} day^{-1}) Periods (days) 28	56	84	112
Control (C)	99.19	97.14	97.04	95.41
T1 (0.600% DL)	97.30	95.10	92.82^{2}	88.42^{2}
T2 (0.675% DL)	97.50	96.38	93.522^{1}	91.53^{2}
T3 (0.750% DL)	97.45	96.53	96.43	92.80
T4 (0.825% DL)	98.37	95.87	94.59	92.35^{1}
T5 (0.900% DL)	97.86	96.02	92.81^{2}	87.91^{2}
	CV = 3.40	LSD = 4.9970		

Continuous means ($^{2}p < 0.01$, $^{1}p < 0.05$) in a column statistically differ with the mean control by Scheffé test at 5% probability. CV = coefficient of variation, LSD = least significant deviation.

To analyze the proposed contrasts observed lower egg production ($p < 0.01$) for treatment 1 (0.600% DL) compared to control treatment (0.750% DL). Production was lower for the hens that received treatment 1, between 84 and 112 experimental days. The same was observed for treatment 2 (0.675% LD) with lower egg production in periods of 84 days ($p < 0.05$) and 112 days ($p < 0.01$) when compared to the control treatment. According to the experimental diets, the treatment has two levels similar to that proposed by Rostagno et al. (2011) nutrients, differing in crude protein (T2 = 14.0 % vs. 15.6 % CP CP proposed by ROSTAGNO et al., 2011).

Egg production was lower ($p < 0.05$) in treatment 4 (consumption of 930 mg lys^{-1} hen^{-1} day^{-1}) in relation to egg production of the control treatment in the time period of 112 days. For treatment 5 (consumption of 994 mg dig. lys. hen^{-1} day^{-1}), a lower egg production ($p < 0.01$) was found for 84 and 112 days.

Based on these results, treatment 3 with 876 mg dig lys^{-1} hen^{-1} day^{-1} and production of 96.43 and 92.80%, respectively, in the periods of 84 and 112 days, may have resulted in similar production performance to that of control treatment, with 864 mg Lis and production of 97.04 and 95.41% in the same time periods. Similar nutrient intake in the ration did not affect the production performance of hen, even with low protein content used with supplementation of synthetic amino acids in treatment 3.

While studying laying hens, Rocha et al. (2009) have observed that when hens are subjected to 14.54% crude protein and consumption of 759 mg hen^{-1} day^{-1} of digestive lysine, they can achieve egg production of 94.26%. Significant interaction among treatments and experimental periods was not found by Figueiredo et al. (2012) in a study on different levels of digestible lysine and threonine in Hy-Line W36, from 42 to 58 weeks.

By analyzing treatments 1-5 within each experimental period, through a regression analysis on egg production, it was possible to observe a quadratic effect $y = -123.39x^2 + 186.49x + 24.961$ $R^2 = 0.7181$ ($p < 0.05$) for 84 days, and $y = -213.86x^2 + 320.52x - 27.089$ $R^2 = 0.9743$ ($p < 0.01$) for 105 days.

The significant effect on egg production for both treatments can be seen from the third and fourth quarter, we note that the lowest and highest levels of digestible lysine showed significant effects in production compared to the control treatment. Eliminating the possibility of antagonism or toxicity of amino acids according to Silva et al. (2000), we can infer the possibility of imbalance between amino acids for the treatment in question.

The derivative showed excellent point with 95.43% of production for the third period (84 days) and 93% of production in the fourth period (112 days), results for feeding 876 mg dig. lys. These results suggest that even with the reduced protein value of 2.92% crude protein, there was better egg production in hens receiving 0.750% dig. lys. in treatment 3.

Results are similar to those found by Jardim Filho et al. (2010), who found in light laying hens that 800 mg kg^{-1} of digestible lysine in ration have increased their production of eggs, with quadratic effect on its peak production at lysine level 799 mg kg^{-1} with estimated consumption of 684.1 mg hen^{-1} day^{-1}. Jordão Filho et al. (2006a) have also found significant production effect in semi-heavy laying hens during peak, according to digestible lysine levels.

No significant interaction ($p > 0.05$) of treatments and experimental periods was found for the following parameters: feed intake, mean egg weight, feed conversion, and final weight of hens (Table 5).

Table 5. Effect of reduced protein with different levels of lysine on the parameters: feed intake (FI), mean egg weight (MEW), feed conversion (FC) and final weight of hens (FWH) in Isa Brown hens from 28 to 44 weeks of age.

Parameters	Digestible lysine levels (%)							
	Control	0.600	0.675	0.750	0.825	0.900	CV1	LSD
FI	115.15	113.65	112.54	116.82	112.69	110.46^1	4.89	6.278
MEW	63.37	59.11^2	59.38^2	62.34	61.58^1	61.57^1	4.24	2.443
FC	1.8714	2.0539^2	2.0029^2	1.9611^2	1.9239	1.9211	5.40	0.099
FWH	2.0452	1.9914	1.9964	2.0452	1.9548	1.8809^2	4.89	0.182

Continuous means ($^2p < 0.01$, $^1p < 0.05$) in a line statistically differ with the mean control by Scheffé test at 5% probability. CV = coefficient of variation, LSD = least significant deviation.

By analyzing the contrast for the feed intake parameter, it is possible to notice a significant effect ($p < 0.05$) only for treatment 5 (0.900% dig. lys.), with lower consumption compared to the control treatment (0.750% dig. lys.). Rocha et al. (2009) found a significant increase in food intake with increased level of lysine in the diet, unlike the results found by Sá et al. (2007), who found no effect of lysine levels on hen food intake. Silva et al. (2006) mentions that the reduction of ration protein level from 16.5% to 15.25% and 14.00%, with no amino acid supplementation, did not affect feed intake and conversion per mass and per dozen eggs ($p > 0.05$), suggesting the possibility of using diets with protein levels below the recommended value.

The results of this study corroborate those found by Silva et al. (2000), who observed a decline in feed intake and weight gain in extreme levels of lysine, implying that excess lysine was not enough to develop antagonism or toxicity. Thus, the depression in food consumption and weight gain were basically influenced by imbalanced amino acids.

For the mean egg weight parameter, there has been a reduction in weight for treatments 1 and 2 ($p < 0.01$), and 4 and 5 ($p < 0.05$) compared to the mean of control treatment. This result differs from those of Matos et al. (2009) and Silva et al. (2006), who found no significant effect on this parameter, when studying digestible lysine levels. According to the nutritional levels found, hens fed 0.750 digestible lysine, representing a consumption of 876 mg dig lys. hen^{-1} day^{-1}, achieved mean egg weight similar to that of the control diet (864 mg dig lys. hen^{-1} day^{-1}) even when subjected to protein reduction of 2.92%.

For the final weight of hen, no significant effect ($p < 0.01$) was found except for treatment 5, where hens had lost 4.07% of body weight in relation to control. A 2.20% reduction in their body weight was noted by Yakout (2010) when working with protein reduction to 14% and supplementation of synthetic amino acids. These results agree with those found by Sá et al. (2007), who have found no effect on the body weight of light and semi-heavy laying hens subjected to digestible lysine levels.

The regression analysis of the quantitative levels of digestible lysine have shown significant effect ($p < 0.05$). Results are shown in Table 6.

Table 6. Effect of different levels of lysine, while maintaining the same relationships of digestible amino acid/ lysine for the experimental periods on the parameters: feed intake (g hen^{-1} day^{-1}), mean egg weight (g egg^{-1}), feed conversion (g feed g^{-1} of egg) and hen weight (g).

	% Digestible Lysine							
Parameters	0.600	0.675	0.750	0.825	0.900	CV	Effect	R^2
FI (g hen^{-1} day)	113.65	111.73	116.82	112.69	110.46	5.10	Q^1	0.4257
MEW (g)	59.11	59.38	62.34	61.58	61.57	4.36	Q^1	0.7557
FC (g g^{-1})	2.0543	2.003	1.9612	1.9238	1.9213	5.20	L^2	0.9335
FWH (g)	1991	1996	2019	1955	1881	5.03	NS	--

L - Linear effect ^{2}($p < 0.01$) and ^{1}($p < 0.05$); Q★★ - Quadratic effect ($p < 0.01$); CV - Coefficient of variation for time periods; R^2 – Coefficient of determination.

A quadratic effect ($p < 0.05$) was noted for feed intake, but the coefficient of determination was low, not considered a prediction equation. Rocha et al. (2009), when studying digestible lysine levels for light laying hens during production, have observed a linear response on consumption associated with an increase of digestible lysine levels. However, Jardim Filho et al. (2010) found a positive quadratic effect of supplemental digestible lysine for this parameter, when studying 0.600, 0.700, 0.800 and 0.900% of digestible lysine for light laying hens, finding lower feed intake for level 0.900%, respectively.

Quadratic effect:

$$y = -54.39x^2 + 91.085x + 23.687$$
$$R^2 = 0.7557\ (p < 0.05)$$

was found for mean egg weight of laying hens subjected to experimental diets 1-5.

The equation showed higher egg weight at level 0.825% of lysine, with mean egg weight of 61.82 g. These results agree with those found by Rocha et al. (2009), who have found a linear response over the mean weight associated with an increase of digestible lysine levels for light laying hens during production. In contrast, Sá et al. (2007) found quadratic effect for mean egg weight in light and semi-heavy strains, to different levels of digestible lysine.

Linear effect ($p < 0.01$)

$$y = -0.4602 + 2.3176$$
$$R^2 = 0.9335$$

was found for feed conversion. Treatments 1 and 2 presented the worst conversions. Based on the fact that the conversion of hens are determined according to consumption and mean egg weight, this result comes with lower levels of digestible lysine, where lower egg weight had been previously observed.

On the regression analysis of treatments 1-5, no effect ($p > 0.05$) on the weight of hens was noted. These results agree with Sá et al. (2007), previously mentioned. Considering treatment 5 the highest level of digestible lysine (0.900%), maintaining the same ratio among the amino acids. One can infer the effect of amino acid levels, as well as the observed lower feed intake (Table 5) on the final weight of hens. This behavior had been observed by Figueiredo et al. (2012), in studies with 16.07% crude protein and lysine levels ranging from 0.660% to 0.885% in Hy-Line W36 laying hens. This also infers recommending dietary level of 0.754, 0.772 and 0.804% of digestible lysine to maximize egg weight, egg mass and feed conversion.

Based on such results, the average consumption of 876 mg hen^{-1} day^{-1} of digestible lysine may be inferred, in 14% crude protein, maintaining the digestible amino acid/ lysine ratio proposed by Rostagno et al. (2011), as being enough to obtain similar performance to that of diet formulated according to the requirements proposed by the strain.

In studies, authors such as Rocha et al. (2009) have recommended level 0.770% of digestible lysine, for level 14.54% of crude protein in light laying hens from 24 to 40 weeks of age. As for 15.8% of crude protein, Jardim Filho et al. (2008) have suggested level 600 mg kg^{-1} of lysine, proper for laying hens between 24 and 48 weeks old for good egg quality and development of reproductive tract. However, Sá et al. (2007) have suggested levels 0.732 and 0.715% of digestible lysine for light and semi-heavy laying hens between 34 and 50 weeks of age, for 15.00% crude protein in the diet. At a higher level, Jordão Filho et al. (2006a) recommend 0.840% digestible lysine for semi-heavy laying hens from 30 to 46 weeks of age, subjected to 17.1% crude protein.

Conclusion

The requirement of digestible lysine in relation to other digestible amino acids can be estimated at 0.750% in diet containing 14% crude protein, which corresponds to the mean daily intake of 876 mg of digestible lysine, without harming the performance of hens.

Acknowledgements

We thank Ajinomoto® do Brasil/Ajinomoto Animal Nutrition for supporting our research and for donating amino acids.

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Received on September 5, 2013.
Accepted on February 13, 2014.