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Commercial Laying Hen Diets Formulated According to Different Recommendations of Total and Digestible Amino Acids

■ Author(s)

Casartelli EM*
Filardi RS
Junqueira OM
Laurentiz AC
Assuena V
Duarte KF

Departamento de Zootecnia, Universidade Estadual Paulista, Faculdade de Ciências Agrárias e Veterinárias, Campus de Jaboticabal, via de acesso Prof. Dr. Paulo Donato Castellane, s/n, Jaboticabal, São Paulo, Brasil.

■ Mail Address

Elena M Casartelli
Av. Líbero Badaró, 810
Centro
14.870-540. Jaboticabal, SP, Brazil.

E-mail: emcasartelli@yahoo.com.br

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Egg quality, layers, nutrition, performance, poultry.

ABSTRACT

An experiment was conducted to evaluate different commercial laying hen diets formulated based on recommendations for total and digestible amino acids. One hundred and twenty Lohmann LSL commercial laying hens aged 25 weeks were distributed in a completely randomized experimental design involving five replications of six birds in four treatments. Diet formulation on a total amino acid basis followed the recommendations of NRC (1994) and Rostagno *et al.* (2000), whereas formulation on digestible amino acids basis was according to Rostagno *et al.* (2000) and Degussa (1997) recommendations. The experimental period was divided into five periods of fourteen days. Performance parameters (egg production, feed intake, feed conversion, egg mass) were evaluated for each period, and on the last two days of each period, three eggs per replication were collected to evaluate egg quality parameters (Haugh unit, egg specific gravity, egg weight, eggshell thickness and percentage). Means were compared by orthogonal contrasts. Results on feed intake, egg production, egg mass, feed conversion and egg specific gravity showed that total amino acid recommendations promoted better bird responses than digestible amino acid recommendations.

INTRODUCTION

In spite of the well known importance of the amino acid composition of ingredients used for diet formulation, this knowledge is restricted due to the little information on digestible amino acids compared to the information on total amino acids in the majority of the ingredients that are used in animal feeding.

The low amino acid digestibility of an ingredient might be related to anti-nutritional factors, processing, physical or chemical traits or to high fiber levels (Parsons, 1992). Processing parameters, such as high temperature or pressure, might contribute significantly to the reduction of amino acid availability, especially in ingredients as sub-products of cereal, oilseed or animal by-product industry. Thus, when diets are formulated using such ingredients, the contents of digestible amino acids should be considered instead of total amino acid levels, in order to reduce mistakes in amino acid supplementation in the diet.

The benefits of diet formulation based on digestible amino acids and ideal protein have been demonstrated in many trials with broiler chickens (Rostagno *et al.*, 1995; Wang & Parsons, 1998; Douglas & Parsons, 1999; Araújo, 2001). On the other hand, there are not enough studies with commercial laying hens. Therefore, the objective of this study was to evaluate different recommendations of total (NRC, 1994, and Rostagno *et al.*, 2000) and digestible (Rostagno *et al.*, 2000 and Degussa, 1997) amino acids on performance and egg quality of commercial laying hens.



MATERIAL AND METHODS

The experiment was conducted at the Experimental Poultry Farm from Faculdade de Ciências Agrárias e Veterinárias (FCAV-UNESP), Jaboticabal, State of São Paulo, Brazil, during five periods of fourteen days.

A total of one hundred and twenty commercial Lohmann LSL layers at 25 weeks of age were distributed in a completely randomized experimental design with five replications of six birds each. Treatments were based on four different recommendations of amino acids; two diets were formulated to fulfill the requirements of total amino acid (NRC, 1994 plus 10% and Rostagno *et al.*, 2000) and two formulated on a digestible amino acid basis (Rostagno *et al.*, 2000 and Degussa, 1997), described as follows:

- **TA – NRC** - Diet based on total amino acid as recommended by NRC (1994) plus 10%;
- **TA – ROS** - Diet based on total amino acid as recommended by Rostagno *et al.* (2000);
- **DA – ROS** - Diet based on digestible amino acid as recommended by Rostagno *et al.* (2000);
- **DA – DEG** - Diet based on digestible amino acid as recommended by Degussa (1997).

All diets had the same levels of energy (2.85 Mcal ME/kg), calcium (3.65% Ca) and available phosphorus (0.34% Pd). Protein levels were the same within TA or DA treatments, i.e., 14.5% CP and 12.8% CP, respectively. Percentage compositions and calculated values of the diets are presented in Table 1.

At the end of the each period, bird performance was evaluated by feed intake (FI - g/bird/day), egg production (EP - %), egg mass (EM - g), egg weight (EW - g), and feed conversion (FC - kg feed/kg eggs).

The parameters relative to egg quality were evaluated during the last two days of each period. Three eggs were randomly collected per replication in order to determine eggshell thickness (ST - mm), Haugh units (HU), and eggshell percentage (SP - %). Egg specific gravity (ESG - g/cm³) was determined using all eggs of each replication on the evaluation days. It was used NaCl solutions with density ranging between 1.065 and 1.100 g/cm³ at 0.005 g/cm³ increments, according to the procedure described by according Moreng & Avens (1990).

The obtained data were submitted to the analysis of variance using the General Linear Models procedure (GLM) of the SAS® software (SAS Institute, 1996). Means were compared by orthogonal contrasts as follows:

- Contrast 1 → TA means vs DA means
- Contrast 2 → TA – NRC means vs TA–ROS means
- Contrast 3 → DA – ROS means vs DA–DEG means

Table 1 - Percentage composition of diets and calculated nutritional levels.

Ingredient (%)	TA - NRC¹⁰	TA - ROS	DA - ROS	DA - DEG
Corn	64.18	64.04	70.24	69.66
Soybean meal	18.33	18.34	12.78	13.10
Rice meal	5.00	5.00	5.00	5.00
Limestone	8.46	8.46	8.49	8.48
Dicalcium phosphate	1.29	1.29	1.32	1.32
Soybean oil	1.69	1.74	0.79	0.93
Sodium chloride	0.43	0.43	0.44	0.44
DL – Methionine (98%)	0.08	0.12	0.18	0.22
L – Lysine HCl (78%)	0.00	0.04	0.19	0.25
L – Threonine	0.00	0.00	0.00	0.02
L – Tryptophan	0.00	0.00	0.03	0.04
Antioxidant	0.04	0.04	0.04	0.04
Vitam. Min. Supplement*	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
Calculated Levels				
Met. Energy (Mcal/kg)	2.85	2.85	2.85	2.85
Crude protein (%)	14.50	14.50	12.50	12.50
Calcium (%)	3.65	3.65	3.65	3.65
Available phosphorus (%)	0.34	0.34	0.34	0.34
Total arginine (%)	0.91	0.91	0.75	0.77
Total lysine (%)	0.69	0.72	0.71	0.77
Total Met + Cys (%)	0.58	0.62	0.61	0.67
Total methionine (%)	0.33	0.36	0.39	0.44
Total threonine (%)	0.56	0.56	0.48	0.50
Total tryptophan (%)	0.16	0.16	0.16	0.16
Total leucine (%)	1.36	1.36	1.23	1.24
Total isoleucine (%)	0.60	0.60	0.50	0.50
Total valine (%)	0.68	0.68	0.59	0.59
Total histidine (%)	0.40	0.40	0.35	0.35
Digestible arginine (%)	0.85	0.85	0.70	0.71
Digestible lysine (%)	0.61	0.63	0.64	0.71
Digestible Met +Cys (%)	0.52	0.55	0.56	0.62
Digestible methionine (%)	0.30	0.34	0.37	0.42
Digestible threonine (%)	0.48	0.48	0.40	0.44
Digestible tryptophan (%)	0.15	0.15	0.15	0.15
Digestible leucine (%)	1.22	1.22	1.11	1.12
Digestible isoleucine (%)	0.52	0.52	0.43	0.44
Digestible valine (%)	0.59	0.59	0.50	0.51
Digestible histidine (%)	0.35	0.35	0.30	0.30
Sodium (%)	0.20	0.20	0.20	0.20

* Values added per kg of diet: Vit A – 8,000 IU; Vit D3 – 2,000 IU; Vit E – 50 mg; Vit K3 – 3 mg; Vit B1 – 1.5 mg; Vit B2 – 4 mg; Vit B6 – 0.12 mg; Vit B12 – 15 mcg; Folic acid – 0.6 mg; Pantothenic Acid 10 mg; Niacin – 30 mg; Biotin – 0.1 mg; Choline – 300 mg; Iron – 50 mg; Copper – 10 mg; Zinc – 70 mg; Manganese – 100 mg; Iodine – 1 mg; Selenium – 0.3 mg; Antioxidant 50 mg.

RESULTS

Analyzing performance results (Table 2), it was observed that feed intake, egg production, egg mass and feed conversion of contrast 1 were significantly different ($p < 0.01$). Hens fed diets formulated based on total amino acid basis had better performance that



those fed diets formulated based on digestible amino acid basis. Considering the same parameters, there were no significant differences between NRC (1994) and Rostagno *et al.* (2000) recommendations for total amino acid requirements or between Rostagno *et al.* (2000) and Degussa (1997) for digestible amino acids. Diets formulated on digestible amino acid basis according to Rostagno *et al.* (2000) promoted heavier eggs ($p < 0.05$) than Degussa (1997) formulation.

Table 2 – Performance of laying hens fed on total and digestible amino acids basis. FI: feed intake (g/bird/day); EP: egg production (%); EW: egg weight (g); EM: egg mass (g); FC: feed conversion (kg diet/kg eggs).

Treatments	FI	EP	EW	EM	FC
C1	22.70**	60.09**	1.99 ^{NS}	40.99**	14.07**
C2	0.71 ^{NS}	2.25 ^{NS}	0.48 ^{NS}	0.54 ^{NS}	0.00 ^{NS}
C3	0.24 ^{NS}	1.00 ^{NS}	8.26*	0.58 ^{NS}	0.02 ^{NS}
CV%	3.90	3.56	2.62	4.87	3.85
TA-NRC	100.20	95.53	61.29	58.55	1.712
TA-ROS	98.15	92.54	61.99	57.33	1.714
DA-ROS	91.81	82.10	62.09	51.03	1.824
DA-DEG	90.66	84.10	59.17	49.76	1.830

NS = non significant; * $p < 0.05$; ** $p < 0.01$. C1 - Contrast 1 → TA means *vs* DA means; C2 - Contrast 2 → TA - NRC means *vs* TA - ROS means; C3 - Contrast 3 → DA - ROS means *vs* DA - DEG means.

Table 3 shows the results of egg quality parameters. Haugh Unity was superior ($p < 0.01$) for hens fed diets formulated according to total amino acid requirements of NRC (1994) in comparison to Rostagno *et al.* (2000) recommendations. Rostagno *et al.* (2000) recommendations resulted in higher ($p < 0.05$) shell thickness than Degussa (1997) recommendations on digestible amino acid basis.

Table 3 – Egg quality of laying hens fed on total and digestible amino acids basis. HU: Haugh unity; SP: shell percentage (%); ST: shell thickness (mm); ESG: egg specific gravity (g/dm³).

Treatments	HU	SP	ST	ESG
C1	4.29 ^{NS}	0.58 ^{NS}	0.46 ^{NS}	6.22*
C2	9.38**	0.12 ^{NS}	0.97 ^{NS}	0.01 ^{NS}
C3	1.75 ^{NS}	1.09 ^{NS}	4.77*	1.57 ^{NS}
CV%	1.02	2.12	2.71	0.13
TA-NRC	96.60	9.51	0.388	1.0900
TA-ROS	94.70	9.55	0.395	1.0900
DA-ROS	96.97	9.67	0.396	1.0890
DA-DEG	96.15	9.53	0.381	1.0879

NS = non significant; * $p < 0.05$; ** $p < 0.01$. C1 - Contrast 1 → TA means *vs* DA means; C2 - Contrast 2 → TA - NRC means *vs* TA - ROS means; C3 - Contrast 3 → DA - ROS means *vs* DA - DEG means.

Total amino acid recommendations improved ($p < 0.05$) egg specific gravity compared to recommendations for digestible amino acids.

DISCUSSION

Bird performance was worse when diets were formulated based on digestible amino acids probably because of the low crude protein levels (12.5%) that were used in order to attend the requirements of digestible amino acids, although synthetic amino acids have been supplemented to fulfill methionine, methionine + cysteine, lysine, tryptophan and threonine requirements, the low protein level of these diets determined low levels of isoleucine and valine (around 13.02 and 5.4%, respectively), which might have caused lower intake of these amino acids and the consequent deficiencies compared to the birds fed diets formulated based on total amino acid requirements.

Although some studies using heavy hens (Lopes & Leeson, 1995) and lean laying hens (Hussein & Harms, 1994, Camps & Edghill, 1999) have shown the possibility of reducing the diet protein level when synthetic amino acids are supplemented, the present findings suggest that crude protein levels of 12.5% might reduce nitrogen availability to be used in the synthesis of non-essential amino acids. According to Keshavarz & Jackson (1992), essential amino acids might be converted to non-essential amino acids, reducing the availability of the former and, consequently, reducing bird performance.

Total or digestible amino acid recommendations did not produce marked differences in egg quality parameters but they had significant effects on performance traits. The crude protein level of 12.5% might have had a significant effect on the reduction of performance. However, the reduction in crude protein levels from 14.5% (total amino acids recommendations) to 12.5% (digestible amino acids recommendations), considering the supplementation with methionine, methionine+cysteine, lysine, tryptophan and threonine, did not affect egg quality. Similarly, Camps & Edghill (1999) observed that the reduction in crude protein from 16% to 12% CP in laying hen diets affected negatively bird performance, whereas no negative effects were seen on egg quality evaluated at 40 weeks of age due to the lower protein level.

CONCLUSION

In conclusion, total amino acid recommendations resulted in better performance and higher egg specific gravity in relation to digestible amino acid recommendations. However, there were no



differences between the two diets formulated according to total amino acid recommendations and between the two diets formulated on digestible amino acid basis.

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