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Effects of crude protein levels on egg quality traits of brown layers raised in two production systems

Eduardo de Faria Viana[1], José Henrique Stringhini[2], Fabyola Barros de Carvalho[2], Débora Macedo Paronetto Viana[1], Miliane Alves da Costa[2*]

[1] *Instituto Federal Goiano, Departamento de Ciência Animal, Urutaí, GO, Brazil.*
[2] *Universidade Federal de Goiás, Escola de Veterinária e Zootecnia, Goiânia, GO, Brazil.*

ABSTRACT - The objective of this study was the evaluation of egg quality of 30 to 45-week-old brown layers, raised in cages or on floor, supplemented with amino acids, using the ideal protein concept with levels of 14, 15, 16, and 18% crude protein. A total of 400 birds (Hy-sex Brown) were used, distributed into two breeding systems (conventional cage or floor). The evaluated variables were the yolk relative weight, yolk height, albumen relative weight, albumen height, specific gravity, eggshell thickness, and eggshell weight. Treatments consisted of reduced levels of crude protein and were provided to both groups equally. We adopted a completely randomized design, in a factorial scheme, composed of two breeding systems and four levels of crude protein, totaling eight treatments. Five replicates per treatment and 10 birds per experimental unit were used. The breeding system on floor was configured as an option in the breeding of brown layers, of Hy-sex Brown commercial lineage, in the period between the 30th and the 45th week of age, since it presents results equivalent to the ones obtained in the breeding system in cages, having the egg quality as parameter. The system of production on floor is configured as an option in the farming of brown layers, of the commercial lineage Hy-sex Brown.

Key Words: brown layer, cage, egg, floor

Introduction

Layer poultry farming presented a considerable development in the last decade thanks to technological innovations in the areas of genetics, nutrition, environment, and management (Barbosa Filho et al., 2006). However, new technologies and market demands have stimulated the development of new breeding systems, aiming to promote animal welfare support, maintaining egg quality and productivity.

Protein and amino acid requirements may vary depending on body weight, growth rate, and egg production. Despite that, most recommendations found in the literature and published in the breeding manuals are based on studies that consider only the performance of the bird according to certain levels of intake, without evaluating the effects of the environment where they are raised.

The nutritional requirements may not be compatible with the demands of the different breeding systems, which justifies the implementation of studies to know specific nutritional requirements and more adequate nutrient levels (Angeles and Rosales, 2005).

Most of the protein recommendations issued by the breeding manuals are based on studies conducted under different conditions from those found by birds at the places where they are explored. The choice of the adequate level of protein is favorable both for the bird, which might perform its metabolic functions in a potentiated way, as well as for the producer, who might maximize its financial resources through saving with protein sources (Sakomura et al., 2002; Laudadio et al., 2012a; Laudadio et al., 2012b).

According to Zhang and Coon (1997) and Mizumoto et al. (2008), nutrition and breeding system influence egg quality. For laying hens, the level of protein in the diet is important for the formation of the yolk and especially of the albumen. Since the ability of laying hens to store protein is limited, the protein concentration in the feed should be equated to achieve the desired egg production (Pesti, 1992).

The study of different protein levels in diets for laying hens is of fundamental importance, since egg production

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***Corresponding author:** miliane_zootecnista@hotmail.com
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and size are dependent on protein intake (Sakomura et al., 2002). The objective of this study was the evaluation of egg quality in brown layers of Hy-sex Brown commercial lineage from 30 to 45 weeks of age, receiving diets with reduced levels of crude protein.

Material and Methods

This research project was approved by the Ethics Committee on Animal Use (CEUA), under case no. 312/11. The experiment was carried out in Urutaí, Goiás, Brazil (latitude: 17º27'49" S, longitude: 48º12'06" W, and altitude: 807 m). Four hundred brown layers of Hy-sex Brown lineage were used, in the laying phase, between the 30th and the 45th week of age.

Two sheds were used simultaneously, in which 200 birds were housed in pits lined with sawdust and other 200 in conventional cages. Individual weighing of the birds was performed for distribution in a completely randomized design. The birds were handled according to recommendations proposed in the breeding manual (Globoaves, 2006). The densities of 500 cm^2/bird in the cages and 3,333 cm^2/bird on the floor were adopted.

In the shed of the floor raising system, the birds were distributed in 20 boxes. Each box had a water fountain, a feeder, and a nest. The boxes were lined with sawdust up to a height of 10 cm and measured 2.2 × 1.5 × 3 m (length × width × height).

The water fountain used was of the pendular type with a coupled valve and the feeder, of the tubular type, had the capacity for 15 kg of feed. The nest, built of wood, had three partitions (33 × 40 × 45 cm) and an elevation of 10 cm in relation to the substrate.

The management of eggs and nests was carried out according to the recommendations of EMBRAPA Swine and Poultry (Albino et al., 2005).

The experimental diets were formulated based on the ideal protein concept, isoenergetic (2.900 kcal/kg of metabolizable energy) and isonutritive, using basic ingredients (corn and soybean meal) and industrial amino acids (Table 1) to meet the nutritional requirements according to Rostagno et al. (2011).

The studied variables were Haugh unit, yolk relative weight, yolk height, albumen relative weight, albumen height, specific gravity, eggshell thickness, and eggshell relative weight. Four experimental periods of 28 days (30th to 33rd, 34th to 37th, 38th to 41st, and 42nd to 45th week of age) were adopted.

Data on the environment temperature inside the experimental sheds were obtained by means of maximum and minimum, using thermometers of the Incoterm brand, positioned in the center of the sheds at the height of the birds. The reading of the thermometers was performed daily, always at 08:00 h.

A sample of four eggs per experimental unit was collected in the morning (08:00 h), identified, and used for determination, yolk height, albumen height, Haugh unity, and specific gravity.

The specific gravity was determined by the salt flotation method, according to the methodology described by Hamilton (1982). At the end of each experimental period, representative samples of four eggs per plot were selected; then, the eggs were immersed in saline solutions (NaCl) with the appropriate adjustments for the volume of 10 L of water, with densities ranging from 1.065 to 1.100

Table 1 - Composition of experimental rations

Ingredient	14% CP	15% CP	16% CP	18% CP
Corn grain	68.78	65.58	67.97	61.29
Soy bean 45%	17.91	20.62	13.48	18.87
Limestone	9.18	9.18	9.20	9.20
Corn gluten bran 60%	-	0.27	6.85	7.44
Soy oil	1.62	2.12	0.23	1.32
Dicalcium phosphate	1.05	1.03	1.04	0.99
Common salt	0.47	0.47	0.48	0.48
Dl-methionine	0.29	0.27	0.18	0.12
L-lysine HCl	0.21	0.12	0.29	0.11
L-valine	0.14	0.09	0.03	-
L-threonine	0.13	0.07	0.05	-
L-tryptophan	0.03	0.02	0.04	0.01
L-isoleucine	0.05	0.00	0.00	0.00
L-arginine	0.00	0.00	0.00	0.00
Vitamin supplement	0.10	0.10	0.10	0.10
Mineral supplement	0.05	0.05	0.05	0.05
BHT	0.01	0.01	0.01	0.01
Total	100.00	100.00	100.00	100.00
Nutritional composition				
Metabolyzable energy (Mcal/kg)	2.900	2.900	2.900	2.900
Crude protein (%)	14.00	15.00	16.00	18.00
Digestible lysine (%)	0.75	0.75	0.75	0.75
Digestible methionine + cystine (%)	0.69	0.69	0.69	0.69
Digestible methionine (%)	0.48	0.47	0.45	0.42
Digestible valine (%)	0.71	0.72	0.72	0.77
Digestible threonine (%)	0.57	0.57	0.57	0.60
Digestible tryptophan (%)	0.17	0.17	0.17	0.17
Digestible isoleucine (%)	0.57	0.57	0.60	0.70
Digestible arginine (%)	0.81	0.89	0.80	0.95
Digestible phenylalanine (%)	0.63	0.69	0.80	0.91
Glycine + serine (%)	1.32	1.43	1.45	1.67
Digestible histidine (%)	0.36	0.38	0.39	0.44
Digestible leucine (%)	1.24	1.32	1.79	1.96
Linoleic acid (%)	2.35	2.58	1.65	2.17
Calcium (%)	3.85	3.85	3.85	3.85
Available P (%)	0.28	0.28	0.28	0.28
Sodium (%)	0.21	0.21	0.21	0.21

CP - crude protein; BHT - butylated hydroxytoluene.
Supplementation levels (amount per kg of product): 10,000 IU vitamin A; 2,000 IU vitamin D3; 1,833 mg vitamin E; 2 mg vitamin B1; 1,000 mg vitamin B2; 3 mg vitamin B6; 0.015 mg vitamin B12; 12 mg pantothenic acid; 3 mg vitamin K3; 1 mg folic acid; 0.25 mg selenium, 33,333 mg manganese; 6,567 mg iron; 2,667 mg copper; 250 mg iodine; 26,667 mg zinc; 6,000 mg niacin; 70,000 mg choline; 680 mg etoxiquin; 8,333 mg halquinol.

with a range of 0.005, calibrated with a densimeter of the Incoterm brand. The eggs were placed in buckets with solutions, from the lowest to the highest density, and were removed as they floated; then, the densities corresponding to the solutions of the containers were recorded.

Haugh unit was calculated using the expression HU = 100 Log (h - 1.7 ew + 7.6), in which HU = Haugh unit, h = dense albumen height (mm), and ew = egg weight (Haugh, 1937).

Eggshell thickness (mm) was determined according to the methodology described by Barbosa Filho et al. (2006).

The data were analyzed in a completely randomized design in a 2 × 4 factorial scheme, with two breeding systems (cage and floor) and four levels (14, 15, 16, and 18%) of crude protein in the rations. Five replicates and ten birds were used per plot. For the crude protein levels, the polynomial regression model was adjusted when there was significance. Statistical analyses were performed using the SAEG 9.1 program. The data obtained were subjected to analysis of variance and when statistically different, were compared by Tukey's test (5%).

Variables were analyzed according to the following mathematical model:

$$Yijk = \mu + Fi + Nelj + FNelij + eijk,$$

in which Yijk = observation k of experimental unit subjected to treatments Fi and Nelj; μ = general constant; Fi = effects of production systems (floor and cage); Nelj = effects of rations with 14, 15, 16, and 18% crude protein; FNelij = effects of the interaction levels of Ca × P levels; and eijk = random error associated to each observation.

Results

The maximum and minimum temperature values observed and their respective averages were in the expected range for the place where the experiment was conducted (Urutaí, GO) (Table 2).

Table 2 - Means of ambient temperature (ºC) for the laying period in floor and cage raising systems

Temperature (ºC)	Age (weeks)				Mean
	30	35	40	45	
	Floor raising				
Maximum	29.5	30.7	30.1	29.3	29.9
Minimum	23.1	22.4	22.7	21.7	22.5
Mean	26.3	26.6	26.4	25.5	
	Cage raising				
Maximum	29.6	30.9	30.4	29.3	30.1
Minimum	23.0	22.4	22.2	21.5	22.3
Mean	26.3	26.6	26.3	25.4	

There was an effect (P<0.05) of the crude protein levels on yolk height (mm) in the first and fourth production periods (Table 3). In these periods, birds fed ration containing 15% crude protein had a higher yolk height, 14.60 and 14.23 mm, respectively.

Egg weight was influenced by breeding systems only in the second production period (34th to 37th week of age) and it was not possible to verify their relation with other quality parameters.

In the second production period, there was an effect (P<0.01) of the breeding systems (Table 4). In this period, eggs from the breeding system without cages presented higher yolk relative weight. In the fourth production period, there was a linear effect (P<0.01) of crude protein levels without yolk relative weight, according to equation Y = 23.09 + 0.19X.

There was an effect (P<0.05) of crude protein levels on albumen height in the third production period. However, birds fed a 16% crude protein diet presented lower albumen height when compared with birds from other treatments. Birds raised in cages presented higher albumen height (P<0.01) (Table 5).

For the albumen relative weight, there was an effect (P<0.05) of the breeding systems only in the fourth production period. In this period, eggs from birds raised in cages had a higher albumen relative weight (Table 6).

There was no interaction (P>0.05) of crude protein levels of rations and raising systems. There was no effect (P>0.05) of crude protein levels and raising systems on the Haugh unit (Table 7).

There was no interaction (P>0.05) of crude protein levels of rations and raising systems. There was also no isolated effect of crude protein levels and raising systems on specific gravity throughout the experimental period (Table 8).

There was no interaction (P>0.05) between crude protein levels and breeding systems. There was no isolated effect of crude protein levels and breeding systems on shell thickness throughout the experimental period (Table 9).

Regarding the bark relative weight, there was an effect (P<0.01) of breeding systems in the second production period. In this period, birds raised in cages presented higher shell relative weight (Table 10).

Discussion

Sekeroglu and Altuntas (2009), when evaluating the effects of egg weight of laying hens (Lohmann Brown) raised in conventional cages in the period between 33 and

45 weeks of age on parameters of internal egg quality, observed a direct effect of the egg weight on the yolk height. However, Gharahveysi et al. (2012), evaluating the effects of age on egg quality, observed an increase of yolk height with advancing age, as well as its decrease from the 43rd week of age.

Regarding the yolk relative weight, our results do not agree with Mousavi et al. (2013), who investigated the effects of different levels of crude protein (15.5, 16.5, 17.5, and 18.5%) on the quality of the eggs of Lohmann LSL and Hy-Line W-36 lines between 25 and 33 weeks of age. These authors used diets formulated from the concept

Table 3 - Yolk height (mm) per production period and raising system

Production period (weeks)	CP	Raising system (S)		Mean CP	Probability			CV (%)
		Floor	Cage		CP	S	CP×S	
30-33	14	14.07	14.12	14.09	0.045	0.53	0.72	4.71
	15	14.55	14.65	14.60				
	16	13.89	13.87	13.88				
	18	13.80	14.21	14.00				
	Mean	14.07	14.21					
34-37	14	13.65	13.91	13.78	0.63	0.98	0.44	8.43
	15	14.20	14.25	14.22				
	16	13.81	13.85	13.83				
	18	14.50	13.65	14.07				
	Mean	14.04	13.91					
38-41	14	14.22	13.80	14.01	0.86	0.15	0.61	3.15
	15	14.27	14.25	14.26				
	16	14.17	13.77	13.97				
	18	14.05	13.99	14.02				
	Mean	14.18	13.95					
42-45	14	13.66	13.62	13.64	0.03	0.85	0.55	3.45
	15	14.26	14.20	14.23				
	16	13.56	13.59	13.57				
	18	13.67	13.82	13.74				
	Mean	13.78	13.80					

CP - crude protein; CV - coefficient of variation.

Table 4 - Yolk relative weight per production period and raising system

Production period (weeks)	CP	Raising system (S)		Mean CP	Probability			CV (%)
		Floor	Cage		CP	S	CP×S	
30-33	14	25.45	25.14	25.29	0.12	0.29	0.35	4.49
	15	27.35	25.72	26.53				
	16	26.12	25.66	25.89				
	18	25.74	26.57	26.15				
	Mean	26.16	25.77					
34-37	14	26.46	25.18	25.82	0.29	0.01	0.76	4.39
	15	27.39	26.49	26.94				
	16	27.96	26.07	27.01				
	18	27.44	25.98	26.71				
	Mean	27.31a	25.93b					
38-41	14	26.45	25.48	25.96	0.55	0.46	0.09	2.91
	15	27.01	25.99	26.50				
	16	26.00	25.85	25.92				
	18	25.83	26.29	26.06				
	Mean	26.32	25.90					
42-45	14	25.59	25.34	25.46	0.01	0.06	0.60	2.87
	15	26.98	26.21	26.59				
	16	26.63	25.56	26.09				
	18	26.73	26.25	26.48				
	Mean	26.48	25.84					

CP - crude protein; CV - coefficient of variation.
Means followed by the same lowercase letter in the row, and upper case in the column, do not differ by the Tukey test (P>0.05).

of ideal protein and stated that there was an interaction between protein levels and commercial lines and that the yolk relative weight decreased when reducing the protein level from 18.5 to 15.5%. The results of this work also diverge from those obtained by Varguez-Montero et al. (2012), who worked with hen breeding (Rhode Island Red) in alternative systems (shed with access to open areas, closed shed, or conventional cages) in a hot climate region. The authors evaluated the effects of systems on egg quality and productive performance in two periods (30 to

Table 5 - Albumen height (mm) per production period and raising system

Production period (weeks)	CP	Raising system (S)		Mean CP	Probability			CV (%)
		Floor	Cage		CP	S	CP×S	
30-33	14	5.60	5.89	5.74	0.719	0.782	0.547	13.99
	15	5.57	5.62	5.59				
	16	5.71	6.38	6.04				
	18	5.69	5.99	5.84				
	Mean	5.64	5.97					
34-37	14	5.13	4.93	5.03	0.95	0.98	0.71	21.39
	15	5.27	4.90	5.08				
	16	4.40	5.14	4.77				
	18	5.21	4.57	4.89				
	Mean	5.00	4.88					
38-41	14	5.67	4.91	5.29	0.02	0.98	0.06	7.44
	15	5.75	4.74	5.24				
	16	5.62	4.64	5.13				
	18	5.96	4.81	5.38				
	Mean	5.75	4.77					
42-45	14	4.91	5.81	5.36	0.92	0.01	0.38	9.43
	15	4.74	5.84	5.29				
	16	4.64	5.91	5.27				
	18	4.81	5.40	5.10				
	Mean	4.77b	5.74a					

CP - crude protein; CV - coefficient of variation.
Means followed by the same lowercase letter in the row and uppercase in the column do not differ by the Tukey test (P>0.05).

Table 6 - Albumen relative weight (%) per production period and raising system

Production period (weeks)	CP	Raising system (S)		Mean CP	Probability			CV (%)
		Floor	Cage		CP	S	CP×S	
30-33	14	61.13	63.07	62.10	0.50	0.11	0.41	4.96
	15	57.84	62.54	60.19				
	16	61.65	62.11	61.88				
	18	62.04	62.74	62.39				
	Mean	60.66	62.61					
34-37	14	59.58	61.18	60.37	0.08	0.09	0.51	1.90
	15	59.26	59.05	59.15				
	16	58.69	59.53	59.10				
	18	59.62	60.06	59.84				
	Mean	59.28	59.95					
38-41	14	59.17	59.28	59.22	0.65	0.90	0.30	1.99
	15	58.86	60.66	59.76				
	16	59.90	60.49	60.19				
	18	60.19	59.90	60.04				
	Mean	59.53	60.08					
42-45	14	60.51	61.41	60.96	0.09	0.02	0.06	2.13
	15	59.29	60.55	59.91				
	16	59.56	62.71	61.13				
	18	59.84	60.27	60.05				
	Mean	59.80b	61.23a					

CP - crude protein; CV - coefficient of variation.
Means followed by the same lowercase letter in the row and uppercase in the column do not differ by the Tukey test (P>0.05).

35 weeks and 40 to 45 weeks of age) and reported that the yolk relative weight was higher for the breeding system in conventional cages.

The internal quality of the egg decreases as the layer age advances, this being an irreversible phenomenon (Llobet et al., 1989). Van Den Brand et al. (2004), evaluating the effects of two production systems (conventional cages and shed with free-range access) on internal and external characteristics of brown layer eggs (Isa Brown) between 25 and 59 weeks of age, observed a decrease in albumen height with advancing age (between the 30th and 45th weeks of age) and higher albumen height for the floor

Table 7 - Haugh unit per production period and raising system

Production period (weeks)	CP	Raising system (S)		Mean CP	Probability			CV (%)
		Floor	Cage		CP	S	CP×S	
30-33	14	86.69	85.68	86.18	0.28	0.33	0.41	4.18
	15	85.10	84.31	84.70				
	16	85.02	85.78	85.40				
	18	86.49	85.01	85.75				
	Mean	85.82	85.19					
34-37	14	86.87	85.57	86.22	0.13	0.24	0.37	4.17
	15	85.28	84.20	84.74				
	16	85.20	85.67	85.43				
	18	86.59	84.90	85.74				
	Mean	85.98	85.08					
38-41	14	84.11	85.49	84.80	0.22	0.18	0.25	5.12
	15	85.58	84.72	85.15				
	16	84.81	83.93	84.37				
	18	84.02	85.40	84.71				
	Mean	84.63	84.88					
42-45	14	84.63	83.75	84.19	0.19	0.08	0.17	4.98
	15	83.84	85.22	84.53				
	16	85.31	84.45	84.88				
	18	84.54	83.66	84.10				
	Mean	84.58	84.27					

CP - crude protein; CV - coefficient of variation.

Table 8 - Specific gravity per laying period and raising system

Production period (weeks)	CP	Raising system (S)		Mean CP	Probability			CV (%)
		Floor	Cage		CP	S	CP×S	
30-33	14	1.080	1.080	1.080	0.98	0.21	0.85	5.28
	15	1.080	1.080	1.080				
	16	1.080	1.080	1.080				
	18	1.070	1.070	1.070				
	Mean	1.077	1.077					
34-37	14	1.080	1.080	1.080	0.45	1.00	0.45	7.45
	15	1.080	1.080	1.080				
	16	1.080	1.080	1.080				
	18	1.070	1.070	1.070				
	Mean	1.077	1.077					
38-41	14	1.080	1.070	1.075	0.92	1.00	0.54	3.41
	15	1.080	1.070	1.075				
	16	1.070	1.070	1.070				
	18	1.070	1.080	1.075				
	Mean	1.075	1.072					
42-45	14	1.080	1.080	1.080	0.92	0.94	0.69	4.99
	15	1.080	1.080	1.080				
	16	1.070	1.070	1.070				
	18	1.070	1.070	1.070				
	Mean	1.075	1.075					

CP - crude protein; CV - coefficient of variation.

raising system with free-range access. Silversides et al. (2004), when studying the relationship between quality parameters and functional albumen properties in eggs of brown layers (Isa Brown) collected at 32, 50, and 68 weeks of age and stored for five or 10 days, observed that the albumen height decreased with the increase of age and storage time.

Van Den Brand et al. (2004) evaluated the effects of two production systems (conventional cages and shed with access to free areas) on internal and external characteristics of eggs of semi-heavy laying hens (Isa Brown) between 25 and 59 weeks of age and found responses to albumen relative weight such as 60.05, 58.39, 58.95, and 57.39%, respectively, for the 33th, 37th, 41st, and 45th week of age. In a study of the effect of protein levels (15.5, 16.5, and 17.5% crude protein) on the relative weight of albumen, Costa et al. (2004) determined that birds fed a diet containing 17.5% crude protein presented higher values for this variable. Similarly, Rombola et al. (2004) also found that the increase in dietary protein level increased the albumen relative weight, with the 18% level giving the best result.

The most commonly used parameter for expressing albumen quality is the Haugh unit, which is a mathematical expression that relates the weight of the egg to the height of thick white. In general, the higher the value of the Haugh unit, the better the egg quality (Rodrigues, 1975). Alleoni and Antunes (2001) stated that the composition of the ration and the lineage of the birds may affect the Haugh unit values. Meanwhile, the season and the production system do not seem to affect this parameter. The effects of different levels of crude protein (14, 15, 16, and 17%) on the performance of brown layers (Bovans) in the initial stage of laying (20 to 40 weeks) were studied by Abioye et al. (2012), who obtained higher values for Haugh unit using ration with 17% crude protein.

The specific gravity is highly related to the shell quality, especially in relation to the thickness (Hamilton, 1982). However, this relationship was not observed in this study. Peebles and McDaniel (2004) considered the value of 1,080 as reference to classify the shell as good or bad. However, Barbosa Filho et al. (2006), when studying the welfare of commercial brown layers in different production systems and environmental conditions, observed that this limit was valid only for the condition of thermal comfort (26 °C). Koelkebeck et al. (1993) also observed no effect of protein levels on specific egg gravity. In a study comparing two breeding systems (floor and cages), Alves et al. (2007) observed that eggs from hens raised in cages presented thinner shells and, consequently, lower specific gravity, which implied differences between raising systems.

Alves et al. (2007) evaluated the performance and egg quality of semi-heavy laying hens and heavy-weight laying hens raised in conventional cages or floor and observed a

Table 9 - Eggshell thickness (mm) per production period and raising system

Production period (weeks)	CP	Raising system (S)		Mean CP	Probability			CV (%)
		Floor	Cage		CP	S	CP×S	
30-33	14	0.389	0.389	0.389	0.72	0.99	0.73	4.68
	15	0.391	0.390	0.390				
	16	0.391	0.390	0.390				
	18	0.389	0.391	0.390				
	Mean	0.390	0.390					
34-37	14	0.381	0.389	0.385	0.74	0.28	0.63	3.52
	15	0.380	0.381	0.380				
	16	0.380	0.391	0.385				
	18	0.381	0.379	0.380				
	Mean	0.380	0.385					
38-41	14	0.390	0.380	0.385	0.76	0.10	0.72	25.75
	15	0.400	0.391	0.395				
	16	0.411	0.370	0.390				
	18	0.401	0.391	0.396				
	Mean	0.400a	0.383b					
42-45	14	0.370	0.370	0.370	0.56	0.58	0.37	19.09
	15	0.368	0.361	0.365				
	16	0.360	0.359	0.360				
	18	0.359	0.360	0.360				
	Mean	0.364	0.362					

CP - crude protein; CV - coefficient of variation.
Means followed by the same lowercase letter in the row and uppercase in the column do not differ by the Tukey test (P>0.05).

Table 10 - Eggshell relative weight (%) per production period and raising system

Production period (weeks)	CP	Raising system (S)		Mean CP	Probability			CV (%)
		Floor	Cage		CP	S	CP×S	
30-33	14	10.83	10.91	10.87	0.40	0.99	0.83	5.20
	15	10.65	10.36	10.50				
	16	10.79	10.83	10.81				
	18	10.63	10.82	10.72				
	Mean	10.72	10.73					
34-37	14	10.27	10.87	10.57	0.29	0.01	0.30	3.00
	15	10.14	10.42	10.28				
	16	10.46	10.43	10.44				
	18	10.30	10.54	10.42				
	Mean	10.29b	10.56a					
38-41	14	11.02	11.17	11.09	0.39	0.29	0.91	3.30
	15	10.68	10.85	10.76				
	16	10.73	10.85	10.79				
	18	10.83	10.92	10.87				
	Mean	10.81	10.94					
42-45	14	10.57	10.39	10.48	0.77	0.81	0.85	4.72
	15	10.78	10.53	10.65				
	16	10.66	10.49	10.57				
	18	10.23	10.35	10.29				
	Mean	10.56	10.44					

CP - crude protein; CV - coefficient of variation.
Means followed by the same lowercase letter in the row and uppercase in the column do not differ by the Tukey test (P>0.05).

lower hull thickness in eggs of laying hens raised in cages. These authors attributed this condition to the greater stress and difficulty of birds in losing heat in the cages. They also clarified that the semi-heavy laying hens, due to their greater size, present greater heat intolerance. Evaluating the production and egg quality of heavy-weight laying hens and semi-heavy laying hens housed in two production systems (conventional cages or floor), Abrahamsson and Tauson (2009) observed lower production and feed conversion for birds raised on the floor. Regarding the internal quality of the eggs, there were no differences (P>0.05) between the production systems. Likewise, there was no difference (P>0.05) for shell thickness between these systems. According to Barbosa Filho et al. (2006), the cage rearing system provides a thinner eggshell, especially for semi-heavy laying hens under thermal stress conditions. Another relevant point is presented by Jacob et al. (2000), who warned that the problems in the shell may result in low egg classification, affecting its market value.

Evaluating the internal and external quality of the eggs of semi-heavy laying hens (Lohmann Brown) between 43 and 55 weeks of age, Costa et al. (2004) observed the effect of crude protein levels (15, 16, 17, and 18 %) on shell weight, in which the eggs of semi-heavy laying hens fed diets containing 16% of crude protein presented the highest weight of the eggshell. Oliveira et al. (2011) studied several physicochemical properties of eggs from conventional and organic production systems and reported lower shell relative weight in the organic production system when compared with the conventional system (cages).

Conclusions

The production of the commercial lineage Hy-sex Brown on floor, between the 30th and the 45th week of age presents results equivalent to the obtained in the raising cages, having variables related to egg quality and the crude protein levels as reference.

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