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Performance, physical egg quality, and economic index of laying hens under different rearing systems

Desempenho, qualidade do ovo e índice econômico de poedeiras em diferentes sistemas de criação

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ABSTRACT

The objective was to evaluate the performance, physical egg quality (weight and gravity), and economic index of laying hens reared in cage and cage-free systems. A total of 312 40-week-old Hy-line brown laying hens were distributed in a fully randomized design, split into two treatments (cage-free and cage) with 12 replicates in each system. We housed 144 birds in galvanized-wire cages (12 birds each) and 168 birds in a cage-free system in boxes with wood shaving bedding (14 birds each). The experiment lasted 112 days and divided into four 28-day periods. Regarding performance, feed intake (g) and feed conversion (g/g) of birds reared in the cage-free system were higher ($p<0.0001$) than the cage system, but no differences were observed ($p>0.05$) for the other performance parameters and also for egg quality. As for economic index, egg production in the cage-free system was higher ($p<0.0001$) than the cage system. In conclusion, birds reared in the cage-free system have higher feed consumption but worse feed conversion, increasing egg production cost compared to caged birds; however, there are no changes in egg production and physical quality.
Keywords: poultry, animal welfare, poultry litter, cages.

RESUMO

Objetivou-se avaliar o desempenho, qualidade de ovos e índice econômico de poedeiras semipesadas criadas em sistemas cage-free e em gaiolas. Foram utilizadas 312 poedeiras da linhagem *Hy Line* Brown, com 40 semanas de idade, distribuídas em um delineamento inteiramente casualisado (DIC), em dois tratamentos (cage-free e gaiolas) com 12 repetições em cada sistema, sendo 144 aves alojadas em gaiolas de arame galvanizado com 12 aves em cada gaiola e 168 aves alojadas em sistema cage-free, em boxes sobre cama de maravalha com 14 aves em cada repetição. O experimento teve duração de 112 dias, divididos em quatro períodos de 28 dias. Nos parâmetros de desempenho, o consumo de ração (g/aves/dia) e a conversão alimentar (g/g) foi maior

(P<0,0001) nas aves criadas no sistema cage-free comparado ao sistema de gaiolas, não sendo observado diferença (P>0,05) nos demais parâmetros de desempenho e também na qualidade de ovos. No índice econômico, a produção de ovos em sistema cage-free apresentou maior valor (P<0,0001) em relação ao sistema de gaiola. Conclui-se que as aves criadas em sistema cage-free apresentam maior consumo de ração, pior conversão alimentar ocasionando um maior custo nos ovos em relação às aves criadas em gaiolas, no entanto não há alteração na produção e qualidade dos ovos.
Palavras-chave: avicultura, bem-estar animal, cama de aviário, gaiolas.

INTRODUCTION

Currently, rearing laying hens in cages is the most used system by Brazilian poultry farmers, as it has high productivity rates and reduces housing and equipment costs (Batista et al., 2012). However, there are concerns about the negative impacts of caging on birds (Abrahamsson & Tauson, 1998; Barbosa Filho et al., 2005) since they become restricted from expressing certain natural behaviors such as wing stretching, perching, and nest egg laying (Abrahamsson & Tauson, 1998; Batista et al., 2012).

Therefore, a few alternative rearing systems have been proposed as an option for battery cages, such as cage enrichment with nests and perches or confined in a shed with nest bedding inside (cage-free) or semi-confinement (free-range). These systems provide greater freedom of movement and ability to express a wide range of behavior patterns (Gerzilov et al., 2012; Leite et al., 2021).

Poultry production in cage-free systems has increased worldwide. For example, in 2020, around 27% of poultry production in Spain was carried out in cage-free systems; in the same year, cages were banned in France (Selecciones Avícolas, 2022). In Brazil, discussions focus on farm automation, and nearly 5% of birds are reared in cage-free systems, with a lack of official data (Silva, 2019).

Although the number of eggs produced may be similar in both systems, facilities can negatively influence egg quality since the presence of dirty and broken eggs may be lower in cage systems (Barbosa Filho et al., 2005). Conversely, Gerzilov et al. (2012) reported that cages might positively affect bird performance for providing a cleaner environment. Analyses of production parameters and egg quality are used to determine rearing environment effects on poultry performance (Alves et al., 2007). However, little is known about production cost differences between both systems, and cage-free systems are speculated to have higher costs.

Thus, this study aimed to evaluate the performance, physical egg quality, and economic index of laying hens reared in cage-free and caged systems.

MATERIALS AND METHODS

The study was carried out at the Poultry Sector of the Department of Animal Production and Food Science, Agro-veterinary Science Center, Santa Catarina State University (UDESC) - Campus at Lages/Santa Catarina. The experiment was approved by the Animal Use Ethics Committee (CEUA) of the UDESC under protocol n° CEUA-5085250722.

A total of 312 40-week-old Hy-line brown laying hens were evaluated for

Rev. Bras. Saúde Prod. Anim., Salvador, v.24, 01 - 09, 20220022, 2023
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112 days, divided into four 28-day periods.

The birds were distributed in a fully randomized design and two treatments (cage-free and caged), with 12 replications in each. In the cage-free system, 168 birds were housed in boxes separated by a 0.5-mm-wire-mesh screens; each box (2 m² in size) had a masonry floor covered with 10-cm wood-shaving layer, and housed 14 birds. They contained one tube feeder, two nipple drinkers, and three nest cells (0.30 m x 0.30 m x 0.30 m). As for the cage system, cages were made of galvanized wire (0.40 m x 1.00 m x 0.50 m), a total of 144 birds were used, with 12 hens each cage, with one cage being considered the experimental unit. The cages were equipped with a front trough feeder and nipple drinkers.

Housing density in each rearing system followed the recommendations for the strain (guidelines), with 7.0 birds/m2 in the cage-free system and 416.7 cm^2/bird in the cages. The birds of each system were housed in different masonry sheds, 30 m laterally s
paced from each other.

Feed was formulated based on corn and soybean meal (Table 1), following the composition of ingredients and nutritional requirements in the Brazilian Tables for Poultry and Swine (Rostagno et al., 2017).

Table 1 - Calculated composition of experimental feed used in both rearing systems (cage-free and cage)

Ingredient	Inclusion (%)
Corn	53.6
Soybean meal	28.8
Wheat bran	0.00
Limestone	11.5
Dicalcium phosphate	1.35
Salt	0.24
Soy oil	3.76
DL-methionine (99%)	0.15
L-lysine (78.4%)	0.00
Premix*	0.40
Adsorbent	0.20
Total	100
Calculated value	
Metabolizable energy (kcal/kg)	2800
Crude protein (%)	17.0
Calcium (%)	4.20
Available phosphorous (%)	0.30
Digestible lysine (%)	0.77
Digestible methionine + cysteine (%)	0.70
Digestible threonine (%)	0.59
Sodium (%)	0.23
Potassium (%)	0.59

*Vitamin and mineral supplement per kg feed: Vit. A - 2,333 IU; Vit. D3 - 666,670 IU; Vit. E - 1,666 IU; Vit. K3 - 533,330 IU; Vit. B2 - 1000 mg; Vit. B12 - 2,666 mg; Niacin - 6,666 mg; Choline – 78,120 mg; B.C. Pantothenic – 1,166 mg; Copper – 2,666 mg; Iron - 16,670 g; Manganese – 23,330 g; Zinc - 16,670 g; Iodine – 400 mg; Selenium 66,670 mg; Zinc Bacitracin - 6,667 mg

During the entire experiment, birds received feed and water ad libitum, with a daily light period of 16 h, between natural and artificial, in both sheds.

Performance parameters were evaluated weekly, measuring feed intake (g/bird/day), egg production (% eggs/bird/day), egg mass (g/bird/day), and feed conversion (g/g). Average feed intake (g/bird/day) was obtained by the difference between the amount of feed supplied and consumed. Egg production was the ratio between the total number of eggs produced and number of birds in each experimental unit. Egg mass was calculated as the product between percentage of eggs produced and average egg weight. Feed conversion was evaluated as the relationship between the amount of feed consumed (g) and average egg weight (g). The arithmetic means of four weekly assessments corresponded to one cycle of the experimental period.

Physical egg quality (weight and gravity) was assessed using samples of eggs produced at the end of each experimental period. Average egg weight was measured on a precision analytical scale (0.001g) and expressed as grams. As for specific gravity (g/cm^3), saline solutions were prepared to start from a density of 1.050 with a gradient of 0.005 between them, up to a density of 1.100. First, eggs were dipped into the 1.050-density container, and so on, until they floated in the solution. Finally, economic index (EI) was estimated according to the following equation:

EI: Dozens of egg produced (dz) x price of one dozen of egg ($)

Feed consumption (kg) x feed costs ($)

One-dozen-egg price (R$ 4.50/dz) and feed costs (R$ 2.20/kg) were related to the prices practiced at data evaluation. Calculations were made for each experimental plot and both systems, considering the formulation used in the experiment (Table 1).

Results were subjected to analysis of variance (ANOVA) at 5% significance level, using the Statistical Analysis Software SAS (SAS Institute Inc., 2003).

RESULTS AND DISCUSSION

Bird feed intake in the cage-free system was significantly higher ($p<0.0001$) than the cage system (Table 2) in all evaluated periods (Figure 1).

Table 2 - Performance and physical egg quality of semi-heavy laying hens reared in cage-free and caged systems.

Variable	Cage-free	Cage	SEM	CV (%)	p-value
Performance					
Feed intake (g/bird/day)	122	115	5.66	4.79	0.0001*
Egg production (%)	88.1	89.4	4.12	4.63	0.1141^{ns}
Feed conversion (g/g - feed/egg)	1.84	1.74	0.09	4.93	0.0001*
Egg mass (g)	58.5	58.8	3.02	5.15	0.6173^{ns}
Quality physical eggs					

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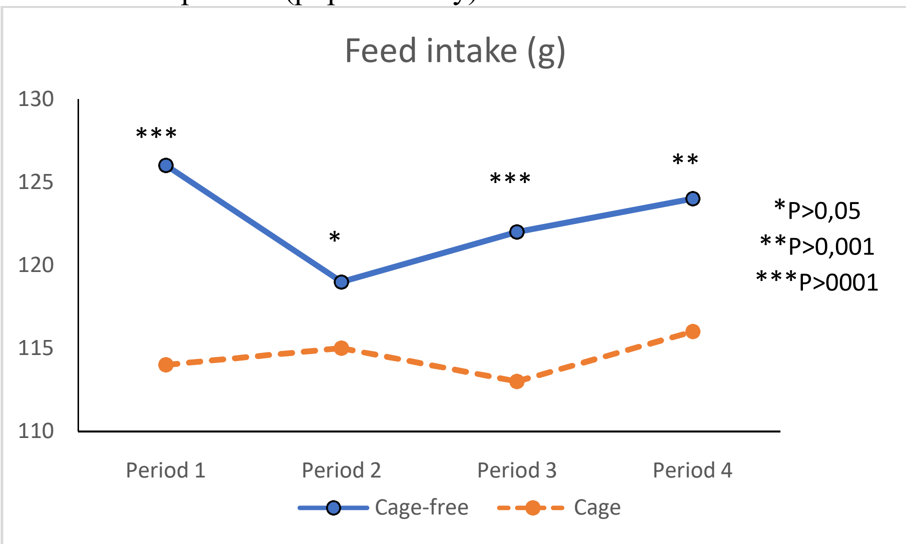
Egg weight (g)	66.4	65.9	1.52	2.29	0.0826[ns]
Specific gravity (g/cm^3)	1087	1087	1.49	0.14	0.9144[ns]
Economic index					
	1.44	132	0.09	6.41	0.0001*

SEM: Standard Error of the mean
CV: coefficient of variation
p: probability
* Means between creation systems on the same line differ significantly
NS: non-significant

Figure 1 – Feed consumption of birds reared in cage-free and cage systems for different evaluation periods (p: probability)



This result may be justified by the greater movement of birds reared in the litter system, spending energy for maintenance, production, and social interaction. In turn, birds reared in cages have movement restrictions, therefore, spend energy only for maintenance and production. Notably, the feed formulation provided to birds was based on the nutritional requirements for cage-reared laying hens; therefore, birds reared in cage-free systems may have other nutritional needs, as they are in greater movement (Silva, 2019). In brief, such a differentiated requirement might have been supplied by the increase in feed consumption.

Concerning egg production (Table 2), there was no difference (p>0.05) between the systems. This finding corroborates that of Alves et al. (2007), who also evaluated the effects of two rearing systems (cages and cage-free) on productive performance and egg quality of laying hens. According to these authors, production can be affected by several environmental factors, including temperature and humidity. In our study, given the proximity in location, both sheds were subjected to the same climatic

Rev. Bras. Saúde Prod. Anim., Salvador, v.24, 01 - 09, 20220022, 2023
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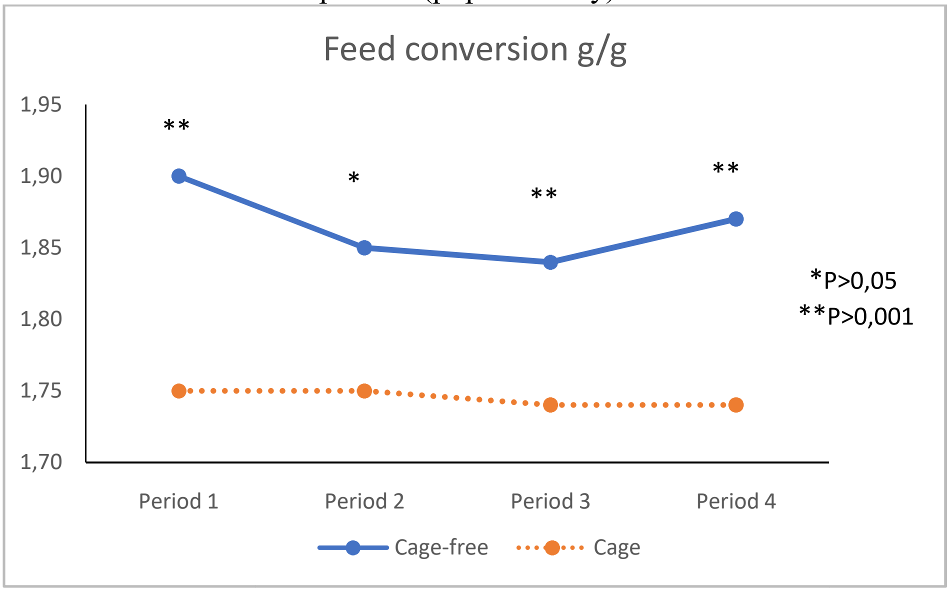
conditions, thus not interfering with production results. Moreover, we observed that egg production in both systems followed the guidelines for the strain per age group (40 to 56 weeks).

Feed conversion was significantly influenced (p<0.0001) and had a better effect in the cage system (Table 2), in all evaluation periods (Figure 2).

Figure 2 – Feed conversion (g/g) of birds reared in cage-free and cage systems for different evaluation periods (p: probability)



Such an outcome stems from the feed consumption already evidenced previously, as there were no weight differences among eggs used to estimate feed conversion. These results corroborate those by Mostert et al. (1995), who studied the influence of different rearing systems (cage-free and free-range and cage) on performance of four laying hen strains; they found no differences between both systems.

Egg mass (Table 2) did not differ significantly (p>0.05) between rearing systems. Similar result was reported by Camerini et al. (2013), who assessed semi-heavy layers housed in enriched cage and cage-free systems.

In terms of physical egg quality, weight, and specific gravity (Table 2) were not influenced (p>0.05) by the rearing system. The physical quality of eggs is related to the integrity of their shell, as shells are important for protecting egg internal contents. Any innovation in laying bird production must consider shell quality, which can be defined by egg density, as albumen and yolk of fresh eggs have a density almost equal to that of water, while shell density is greater than that of water. Likewise, Roll et al. (2009) did not find differences comparing cage-free and enriched cage systems on production performance, egg quality, and physical conditions of laying hens. In turn, Leite et al. (2021) observed improvement in egg quality requirements (weight, Haugh unit, and shell thickness) at peak production and final stage when analyzing eggs in a DET 6000-NABEL® machine, which estimates egg weight, shell strength, shell thickness, yolk height and color, and Haugh unit. In evaluating different

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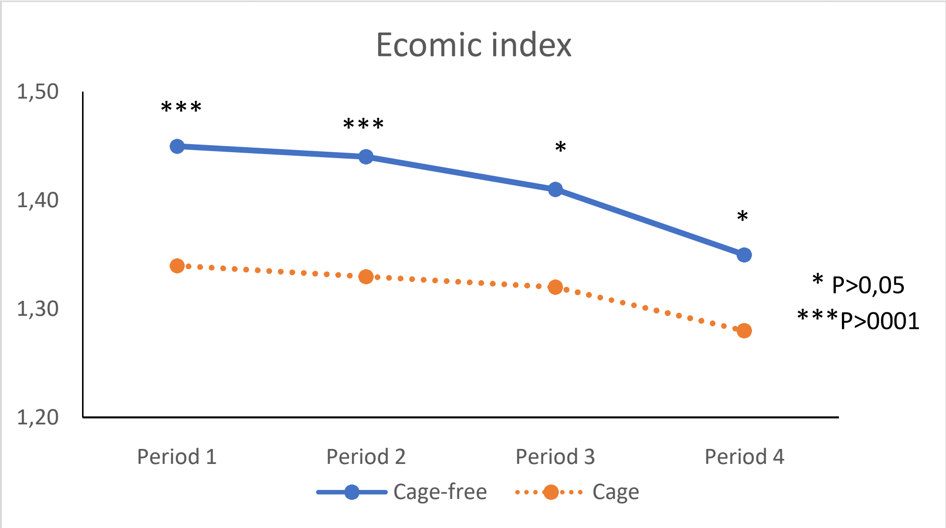
production systems (cages, cage-free, and free-range), Saccomani et al. (2019) observed good physicochemical quality for eggs produced in alternative systems; however, in the free-range system, eggs had lower weights and concentrations of protein and ether extract, which might have been due to the greater energy expenditure in the locomotion space.

Regarding EI (Table 2), results indicated that eggs of birds reared in the cage-free system had a higher ($p<0.0001$) cost than those of birds from cages in all evaluation periods (Figure 3).

It is worth mentioning that experiments and studies carried out abroad on animal welfare as an economic concept serve as a framework for developing alternative systems in Brazil (Silva, 2019). In addition, for a competitive insertion of commercial egg production into the market there must be a priority in changing production practices and alternative housing forms to conventional cages (Mazzuco et al., 2017). Therefore, economic evaluation is an important tool for analyzing production systems.

Figure 3 – Economic index of birds reared in cage-free and cage-free systems for different evaluation periods (p: probability)



Egg production systems and management practices are considered controversial by the consumer's perception, as they involve economic factors and respective knowledge about the well-being used in the production chain (Silva, 2019). One should highlight the study of Queiroz et al. (2014), who reported that in northeastern Brazil, egg price is the most determining factor in the purchase, for which 65% of consumers would not be willing to pay more for the product. Higher costs will imply higher prices for consumers.

In summary, laying hens reared in the cage-free system have higher feed consumption and worse feed conversion but no changes in egg production and egg quality; however, they have higher costs than caged birds.

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