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Production of laying hens in different rearing systems under hot weather

Daniel Araújo Netto[1*], Heder José D'Avila Lima[1], Júlia Rodrigues Alves[1], Bianca Corrêa de Morais[1], Mauricio Silva Rosa[1] and Tatiana Marques Bittencourt[2]

*[1]Departamento de Zootecnia e Extensão Rural, Universidade Federal de Mato Grosso, Av. Fernando Corrêa da Costa, 2367, 78060-900, Cuiabá, Mato Grosso, Brazil. [2]Departamento de Zootecnia, Universidade Federal dos Vales do Jequitinhonha e Mucuri, Diamantina, Minas Gerais, Brazil. *Author for correspondence. E-mail: daniel_araujo_6@hotmail.com*

ABSTRACT. The environment is very important for the performance of laying hens; thus, techniques are required to improve production systems, providing better welfare for poultry and consequent increase in the quality of the final product, the egg. This study aimed to evaluate the effects of rearing system, on the floor and in cage, on the performance and egg internal and external quality of laying hens. A total of 320 Hysex Brown laying hens, with 34-43 weeks days of age, was distributed in a completely randomized design, with two treatments, floor and cage, with 10 replicates each. The parameters evaluated were: individual feed intake, egg production per replicate, feed conversion per dozen eggs, egg weight; weight and percentage participation of shell, albumen and yolk, specific gravity, body weight variation and viability of birds. The results show that the birds raised on the floor showed best results as to egg production, besides the best internal and external quality, with greater weight of egg, yolk, albumen, shell and with lower losses of eggs. Because of the negative effects of the cage system, in general, hens presented lower results when compared to results of those raised on the floor.

Keywords: laying hens, cage, egg quality, alternative system.

Avaliação da produção de galinhas poedeiras criadas em diferentes sistemas em clima quente

RESUMO. É de suma importância o ambiente no desempenho de galinhas poedeiras, sendo necessárias técnicas que viabilizem a melhoria dos sistemas de produção e ambiência, proporcionando bem-estar às aves e consequente incremento na qualidade do produto final, o ovo. O objetivo com este trabalho foi avaliar os efeitos do sistema de criação, em piso e gaiola sobre o desempenho e a qualidade dos ovos (interna e externa) de galinhas poedeiras. Foram utilizadas 320 galinhas poedeiras da linhagem Hysex Brown, de 34 a 43 semanas de idade, os dois tratamentos foram distribuídos em delineamento inteiramente casualizado, piso e gaiola, com 10 repetições cada. As variáveis avaliadas foram: consumo de ração individual, taxa de postura por repetição, conversão alimentar por dúzia de ovos, peso do ovo; peso e participação percentual da casca, da gema e do albúmen, gravidade específica, variação de peso corporal e viabilidade das aves. Pelos resultados foi observado que as aves criadas em piso apresentaram melhores valores de produção de ovos, além da melhor qualidade interna e externa, com maior peso do ovo, gema, albúmen e casca e com menores perdas de ovos. As aves alojadas nas gaiolas, por terem sofrido efeitos negativos do sistema de criação, apresentaram, de maneira geral, resultados inferiores quando comparado ao das aves criadas em piso.

Palavras-chave: aves de postura, gaiola, qualidade do ovo, sistema alternativo.

Introduction

The animal rearing model has been a topic discussed in recent years. This objection towards the creation of chickens in cage, the most common method theses days, is mainly related to the restriction of the freedom of birds due to the lack of space, contact with the siol and no interaction with other birds, making natural activities impossible (Pereira, 2013).

To create a system that produces comfort and well-being for birds, it is necessary to maintain a relationship between well-being, stress and animal behavior, and for this it is important to conceptualize the term animal welfare. According to Broom (1986), the well-being of an individual is its state in relation to the attempts to adapt to its environment, being a characteristic of an animal, not something imposed to it (Broom, 1991). Thus, the importance of allowing these animals to express their natural behavior, preventing them from creating some kind of atypical behavior and hampering their development.

In relation to the breeding and rearing systems of laying hens, with the exception of a few countries where there is legislation prohibiting the use of cages, these facilities constitute the predominant system for laying poultry.

Jin and Craig (1988) have shown that rearing conditions can affect growth and egg production, and Anderson and Adams (1994) reported that chickens raised in cages produce heavier eggs and are more accustomed to handling than those raised on the floor at the end of the production cycle.

Some advantages of the cage system are excreta management, better control of parasites and ability to house a high density of animals. As a disadvantage, one can cite the need for specialized sheds and equipment, promoting greater initial investment (Rocha et al., 2008).

In the physiological aspect, Hughes, Carmichael, Walker and Grigor (1997) attributes aggressions and stress of the birds to the competition for resources in the small space provided by the cages. However, Hunton (1995) points out that disturbances such as aggressiveness and competition among birds may be the fruit of genetic selection, which aims almost exclusively to increase egg production.

Knowledge of bird behavior becomes of paramount importance for the evaluation of rearing systems, ensuring that animals are raised so that welfare is not affected.

The behavioral repertoire of birds is complex, comprising the main behaviors: to scratch, to wade, to look for insects and seeds, to perch, to take a sand bath, to make nests, to investigate feathers, among others (Campos, 2000).

According to Burbier (1996), the behaviors of investigating and scratching are priorities and can be considered a necessity for birds.

Laying hens may have their performance impaired by stress, which is the main reason and triggers a series of undesirable behaviors, such as aggression, feather pecking and social deviance. The aggressions can be caused both in intensive rearing conditions and in small groups of animals that are kept in a semi-intensive system and can result in serious injuries, high mortality and great variability in production, as observed by Schmid and Wechsler (1997).

Studies are required to show results obtained when comparing both rearing systems, both in the productive and economic spheres. Also, nutritional studies are important aiming at the best performance of laying hens kept under the environmental conditions of the State of Mato Grosso.

The goal of this study was to evaluate the effects of the rearing system, on the floor and in cages, and of the environment on performance and egg internal and external quality of laying hens.

Material and methods

The experiment was carried out at the Experimental Farm, Poultry Sector, Department of Animal Science and Rural Extension, Federal University of Mato Grosso, located in the municipality of Santo Antônio do Leverger, State of Mato Grosso, in an area situated at the geographical coordinates of 15.8° South latitude and 56.2° West longitude, and altitude of 140 m, in the region denominated Baixada Cuiabana. The climate of the region is tropical, with two periods: rainy (October to March) and dry (April to September).

This work was approved by the Ethics Committee in the Use of Animals, Federal University of Mato Grosso, on June 16th, 2015 (protocol 23108.092960/2015-80).

The experiment lasted 63 days, divided in 3 periods of 21 days each, starting on June 27th, 2015 and ending on August 29th, 2015 (dry season), according to methodology described by Assunção, Martins, Lima, Martins and Souza (2017); Martins, Assunção, Lima, Martins and Souza (2017). A total of 320 Hysex Brown laying hens, 34 to 43 weeks of age, was distributed in a completely randomized design with two treatments, floor and cages, with 10 replicates each.

Boxes (T1), on the floor, were lined with wood shavings to ensure safety and welfare to the animals, had nests, automated tubular feeder and pendulum drinking fountain. The boxes on the floor were 4.4 x 5.1 m, offering a density of approximately 1,4 m^2 bird^{-1}, and in the cage (T2) with dimension 25 x 46 cm, providing 0,057 m^2 bird^{-1}, equipped with nipple drinker and trough feeder, housing 2 birds in each.

A total of 17 hours of light per day was provided during the entire experimental period. This light supply was controlled by an automatic timer, which enabled the lights to be turned on and off during the night.

Both treatments received the same feed and the formulation was calculated from the requirement for commercial laying hens presented by Rostagno et al. (2011) in the Brazilian Tables for Poultry and Swine (Table 1).

Table 1. Percentage composition and experimental ration calculated, on the basis of natural matter.

Ingredients	% MN
Ground corn	62
Soybeans meal	25
Limestone	8.1
Core posture*	1.8
Soybean oil	1.5
Phosphate	1.1
Common Salt	0.5
Nutritional Composition Calculated	%
Crude Protein	17.0
Metabolizable Energy (kcal kg^{-1})	2900
Calcium	4.2
Total Phosphorus	0.300
Digestible Phosphorus	0.270
Lysine Total	0.870
Digestible Lysine	0.774
Methionine Total	0.426
Digestible Methionine	0.387
Methionine +Cystine Total	0.783
Methionine + Cystine Digestible	0.704

*Composition: calcium (max.) 210 g, calcium (min.) 170 g, Phosphorus (min.) 45 g, Methionine (min.) 10 g, vitamin A (min.) 140,000 U. I, vitamin D3 (min.) 35,000 U. I, vitamin E (min.) 140 U, Thiamine (B1) (min.) 10 mg, Riboflavin (B2) (min.) 75 mg, Pyridoxine (B5) (min.) 20 mg, Vitamin B12 (min.) 120 mcg, vitamin K3 (min.) 30 mg, Folic Acid (min.) 6 mg, Niacin (min.) 300 mg, calcium pantothenate (min.) 120 mg , Hill (min.) 5000 mg, sodium (min.) 30 g, manganese (min.) 1600mg, zinc (min.) 1300mg, copper (min.) 160 mg, iron (min.) 630mg, iodine (min.) 20 mg, selenium (min.) 6 mg, Phytase (min.) 10,000 FTU and zinc Bacitracin 500 mg.

Data on maximum and minimum temperature and humidity were provided by the Bioclimatology Station of the Experimental Farm. Management with the birds at the beginning of the experiment were debeaking and trimming the wing feathers of the birds in order to avoid changes between the boxes.

Daily management involved feeding, ad libitum, morning and afternoon, water replenishment in the troughs and collection of eggs (counting whole eggs, broken, abnormal) in the afternoon.

Variables of the evaluated birds were: individual feed intake (g $bird^{-1}$), egg laying rate per replicate (%), feed conversion per dozen eggs. And the parameters evaluated for the eggs were: egg weight (g); weight (g) and percentage participation (%) of shell, yolk, albumen, specific gravity (g cm^{-3}). Besides the evaluation of the body weight variation and viability of the birds.

At the end of each period (21st, 42nd and 63rd days), the amount of feed provided for each replicate was estimated through the difference between the feed provided and the leftovers. Feed conversion was obtained by dozen eggs, expressed as the total feed intake in kilograms divided by the dozens of eggs produced (kg dz^{-1}). On the 19th; 20th; 21st; 40th; 41st; 42nd; 61st; 62nd and 63rd days 4 viable eggs were randomly selected per replicate.

Next, the specific gravity test was performed, which was determined by the salt flotation method, according to the methodology described by Hamilton (1982). Eggs were immersed in NaCl solutions with density varying from 1.070 to 1.095 g cm^{-3}, at intervals of 0.005 g cm^{-3} between them. The density of the solutions was measured using an INCOTERM - OM - 5565 densimeter.

The same eggs were then used to evaluate the components, which were obtained by weight of the yolk, albumen and shell in relation to the weight of the egg. Eggs were weighed individually on a scale accurate to 0.001 g. It was weighed and recorded the yolk and the respective shells were air dried to obtain the weight to obtain the shell weight. Albumin weight was obtained by the difference between total egg weight and yolk weight plus shell weight.

All birds were weighed at the beginning and at the end of the experiment to determine body weight variation. The total number of dead birds was recorded daily and the cumulative number was subtracted from the total number of live birds, and the values obtained were converted into percentage at the end of the experiment to determine the viability of the birds. In order to maintain the same density of birds throughout the experiment, the dead birds were replaced by others.

Data collected were subjected to analysis of variance at the 5% probability level, and the means were compared by the F-test using the Statistical Assistance software (Silva & Azevedo, 2016).

Results and discussions

There were high temperatures during the experimental period evaluated (June to August), the maximum observed was 36.8°C and the minimum was 16.2°C and a reduction in humidity, both maximum and minimum, 88.3 and 52.5% respectively (Table 2).

Table 2. Temperature and humidity in the region of Santo Antonio every period.

Indexes	1º period	2º period	3º period
Maximum temperature (ºC)	31.0	34.2	36.8
Minimum temperature (ºC)	17.9	16.2	18.0
Maximum humidity (%)	88.3	83.3	70.8
Minimum humidity (%)	52.5	36.0	29.4

Source: Bioclimatology the Experimental Farm Station UFMT.

The thermoneutrality range for laying hens, according to Rusal, Shinder, Malka and Yahav (2011), is between 15 and 28ºC. In this sense, during the experiment, the birds were subjected to periods of heat stress.

According to Oliveira et al. (2014), when the birds are under the temperature conditions between 20 and 26°C, they are within the zone of thermal comfort, having no damages on the production nor the standards of egg quality.

The heat loss in birds is through the blood flow in the body surface, modifying the respiratory tract (Abreu, Abreu, Coldebella, Jaenish, & Paiva, 2007), so when birds are under heat stress they remain part of the time with the beak open. Birds try to perform an energy exchange with the environment, making physiological adjustments essential for the maintenance of thermal equilibrium (Silva, 2008).

The feathers on the skin of the birds interfere directly with the action of radiation, convection and conduction as mechanisms of heat elimination in these animals (Malheiros et al., 2000; Silva & Sevegnani, 2001). Areas with less feathers such as the legs and face are of paramount importance in the thermoregulatory process, as well as the highly vascularized regions of the body, such as crest and barb (Castilho et al., 2015).

The evaluation of the internal and external quality of eggs of hens raised in alternative environments, such as on litter, is fundamental for the promotion of this rearing system. In order to determine the effects of the rearing environment on the performance and welfare of birds, the analysis of productive parameters and egg quality are examples of some measures adopted (Alves, Silva, & Piedade, 2007).

Regarding the productive performance (Table 3), statistical differences between the two treatments, floor and cage, were detected. The birds on the floor presented higher ($p < 0.05$) individual intake (140 g), consequently the egg production/period was higher compared to the rearing system in cages.

Table 3. Productive performance and egg quality of laying hens raised on floor and cage.

Parameters	Floor	Cage	CV%
Individual consumption of birds (g)	140.0^{A}	84.0^{B}	5.38
Feed Conversion (Kg Dz^{-1})	1.95^{B}	1.45^{A}	5.40
Laying rate (%)	89.75^{A}	70.21^{B}	3.25
Specific gravity (g cm^{-3}) ^{NS}	1.088	1,089	0.07
Egg Weight (g)	61.28^{A}	54.60^{B}	4.04
YolkWeight (g)	14.79^{A}	12.95^{B}	3.34
Albumen Weight (g)	40.16^{A}	35.85^{B}	4.19
Shell Weight (g)	6.09^{A}	5.8^{B}	3.61
% Yolk	24.32^{A}	23.65^{B}	2.86
% Albumen ^{NS}	65.55	65.66	1.13
% Shell	9.94^{B}	10.63^{A}	2.59
Birds viability (%)	100	96.25	-
Body weight variation (g bird^{-1})	42.0	-141.0	-

NS = not significant ($p < 0.05$); A and B = significant ($p > 0.05$); CV = coefficient of variation.

In this way, analyzing the body weight variation in a descriptive way, because it did not follow a normal distribution, on the floor, there was a weight gain of 42 g bird^{-1} at the end of the experiment, but the birds presented the worst feed conversion, 1.95 (kg dz^{-1}), compared to birds housed in cages, 1.45 (kg dz^{-1}). Although the worse feed conversion of birds on the floor than those housed in cages, the higher intake provided higher egg production and weight.

According to Alves et al. (2007), the absence of floor material, such as litter, and space for movements that aid in heat loss, as well as high density per area are factors that contribute to the higher thermal stress in the cage rearing system.

Laying hens in a state of heat stress have, as the first consequences, a lower feed intake and higher water intake, which reduce the availability of essential nutrients for production (Vercese et al., 2012). These conditions may explain the loss of body weight found in the experiment. Scott and Balnave (1988) also reported the weight loss of birds; the fall in production was found by Muiruri and Harrison, (1991) and reduction in egg weight by Balnave and Muheereza, (1997).

Adverse factors such as increased thermal stress, high density and reduced intake have hampered the viability of the cage system. On the other hand, with other techniques for heat dissipation, such as bathing in the litter, for example, coupled with a lower density, the viability of the floor system was 100%. In cage, the viability of birds was 96.25%, which can be justified by the high temperatures in the evaluated period.

According to Alves et al. (2007), birds reared on wood shaving litter in systems with greater comfort when compared to cage systems, show no differences in productivity in both systems, which indicates that alternative systems when well managed can provide results similar to the cage system.

In the present study, using the system of rearing laying hens on the floor with the use of litter proved to be a good alternative, because when applied and managed properly, it provided the optimization of egg production. The egg laying rate in the floor was higher than that of the cage, 89.75 and 79.21%, respectively.

In relation to egg quality, it is noticed that the egg weight on the floor and in cages were 61.28 and 54.60g, respectively. As for the weight of the other egg components, yolk, albumen and shell, they also differed statistically ($p < 0.05$). On the floor, they presented higher values than in cages, considering the negative effects of the thermal discomfort imposed to the birds housed in cages.

In agreement with Watkins et al. (2003), when birds are subjected to thermal discomfort, there is interference with the formation of the yolk, leading to changes in consistency and making it easier to break.

Oliveira, Gomes, Silva, Delgado and Ferreira (2011) found a decrease in egg weight when birds were housed in a cage, without any artificial ventilation. Mashaly et al. (2004) verified a difference of 7.5 g between eggs laid under conditions of comfort and thermal stress and attributed as a consequence of the reduction in food consumption in the period.

When the birds are raised in conditions of greater thermal comfort, it can promote egg shell quality and decrease egg losses through cracks (Alves et al., 2007).

No effect ($p > 0.05$) was detected for specific gravity and percentage of albumen in both treatments. In the same way, Camerini, Oliveira, Silva, Nascimento and Furtado (2013) verified that there was no difference ($p > 0.05$) between rearing systems (enriched cage and alternative system).

Alves et al. (2007) found values lower than the present study, 1.076 g in the cage and 1.081 g on the floor.

For feed conversion, the results were similar to those found by Mostert, Bowes and Van Der Walt (1995), being 1.95 (kg dz^{-1}) on the floor and 1.45 (kg dz^{-1}) in the cage. As in the floor system, laying hens are free to display their natural behaviors, increased movement and consequent higher energy expenditure, this caused high feed intake related to the production of a dozen eggs.

Alves et al. (2007) evaluated the productive performance of Light and heavy duty laying hens in bedding systems compared to the performance obtained in a cage rearing system, and noted that there was no difference in feed conversion between rearing systems.

Conclusion

Birds raised on the floor present better results for egg production, in addition to better egg internal and external quality, with higher weight of egg, yolk, albumen and shell.

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