Brazilian Journal of Poultry Science
Revista Brasileira de Ciência Avícola
ISSN 1516-635X Jul - Sept 2018 / v.20 / n.3 / 617-624

http://dx.doi.org/10.1590/1806-9061-2018-0688

Factors that Influence the Production, Environment, and Welfare of Broiler Chicken: A Systematic Review

■Author(s)

Baracho MS[I]
Nääs IA[I]
Betin PS[I]
Moura DJ[I]

[I] State University of , College of Agricultural Engineering. Rua Candido Rondon 501, , SP, Brazil.

■Mail Address

Corresponding author e-mail address
Irenilza de Alencar Nääs
State University of , College of Agricultural Engineering. Rua Candido Rondon 501, , SP, Brazil.
Phone: +55 19 32581129
Email: Irenilza@feagri.unicamp.br

■Keywords

Broiler production, intensive rearing, poultry housing.

Submitted: 17/November/2017
Approved: 10/January/2018

ABSTRACT

The objective of the present study was to characterize the scientific production regarding the factors that influence broiler chicken production, and that were published from 2000 to 2015 in journals indexed in the database of Google Scholar, Scielo, and ScienceDirect. The research was done in the Thermal Comfort Laboratory at FEAGRI-UNICAMP, and the concept of the systematic review was applied. The research criterion was initially defined (the keywords) aiming to identify and evaluate the variables that describe the experimental characteristics and the animals. The primary keywords identified were: broiler chicken from commercial strains, broiler production, rearing conditions, thermal environment, air quality, acoustic environment, light intensity, management, and heat stress. Those were the key words searched in the database of the online libraries. The selected articles were registered into an electronic spreadsheet with the title, the name of the authors, year of publication, language, the journal where it was published, the keyword, the period when the research was done, source/ database, and the abstract. A total of 167 articles were selected, and only 34 were added to the review. The use of the systematic review of the literature allowed identifying the main variables that positively influence the broiler performance, such as the temperature near the thermal comfort, the use of roof lining, besides the use of adiabatic cooling and cast bricks in the laterals. The presence of positive ventilation, as well as the use of yellow curtains and constant lighting, has also influenced a better performance to broilers.

INTRODUCTION

Brazilian poultry industry is highly relevant for the country economy. In 2016 a total of 13 million tons of broiler meat was produced, and nearly 35% was exported. (ABPA, 2017). Broiler production is carried out in several variations of house design. However, most of the production in the integrated system is done in open-sided houses with lateral polypropylene curtains, and with solar orientation East-West. The inside cooling is a combination of natural and forced ventilation (axial fans) associated with the fogging system. Modern houses adopt the closed sides using a more resistant curtain, and the inside ventilation may be done with positive pressure by using axial fans or exhausting fans associated with adiabatic cooling.

The systematic review (SR) of literature is the scientific technique that aims to review and evaluate the published literature using methods to identify and select the studies that are relevant. This technique has been used by authors in various circumstances. Kerr *et al.* (2013) used the systematic review to identify the effectiveness of competitive exclusion and its effect on the prevalence of salmonella in broiler breeding. Rodrigues Filho & Gonçalves (2015) applied the

systematic review to identify the contribution of legal metrology to control processes, in addition to identifying the research needs of the sector. Offedo *et al.* (2016) reviewed the impact of interventions in the poultry market, aiming to reduce the contamination of humans by Avian Influenza, based on published scientific evidence. Średnicka-Tober *et al.* (2016) used the systematic review and meta-analysis from sixty-seven published papers to compare the nutrient content in organically produced beef compared to meat produced traditionally. Clarck *et al.* (2016) conducted a systematic review of scientific studies focusing on the reaction of consumers when informed about diseases in animal production in intensive systems. Clune *et al.* (2017) presented the results of a systematic review of the literature on greenhouse gas emissions for different food types, which offered the life cycle computation, aiming at recommending a sustainable food type.

The present study aimed to characterize the scientific publications on the topics of the factor that influences broiler production published between 2000 and 2015 in journals indexed in the databases of Google Scholar, Scielo, and ScienceDirect.

MATERIALS AND METHODS

The literature review was carried out at the Thermal Comfort Laboratory of FEAGRI-UNICAMP, using the concept and method of the systematic review. Figure 1 shows the flow of information from the systematic review used.

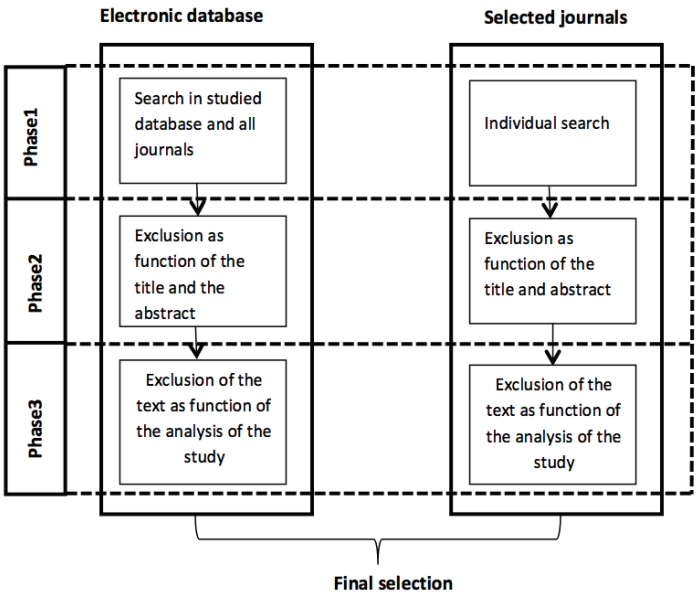

Figure 1 – Scheme of the systematic review process of scientific articles considered in the current study. (Adapted from Rodrigues Filho & Gonçalves, 2015).

The research criteria and the keywords were initially defined with the purpose of identifying and evaluating the variables that describe the experimental and animal characteristics. The main keywords identified were: commercial broilers, production, lodging conditions, thermal environment, air environment, acoustic environment, luminosity, handling, thermal stress) in databases (Google Scholar, ScienceDirect, and SciELO).

Table 1 shows the keywords used to search within the databases. The articles selected using the criteria were organized through the association of a database using a spreadsheet. The list contained the title, author, year of publication, language, and journal in which the title was published (inserted in the database), a period in which the research was carried out, the source/database, and the summary of the article (Andretta, 2011; Offedo *et al.*, 2016).

Table 1 – Keywords used in the systematic review.

Keywords	
Portuguese	English
Frango de Corte	Broiler
Frango de Corte e Conforto Térmico	Broiler and Behaviour
Frango de Corte e Ambiência	Broiler and Welfare
Frango de Corte e Alojamento	Broiler and Housing
Frango de Corte e Produção	Broiler and Conditions
Frango de Corte e Bem-Estar	Broiler and Stress
Frango de Corte e Luminosidade	Broiler and Management
Frango De Corte e Ambiência Aérea	Broiler and Lighting
Frango de Corte e Temperatura	Broiler and Heat Stress
Frango de Corte e Estresse Térmico	Broiler and Production
Frango de Corte e Ambiência Acústica	Broiler and Acoustic Environment
Frango de Corte e Ambiência Térmica	Broiler and Thermal Environment

The research criteria and the keywords were initially defined with the purpose of identifying and evaluating the variables that describe the experimental and broiler characteristics. The main ones were the commercial broilers, production, housing conditions, thermal environment, air quality and conditions, acoustic environment, luminosity, handling, and thermal stress in the studied databases (Google Scholar, ScienceDirect, and SciELO).

The second step was to check the titles and summaries of the articles to identify the articles that were related to influence factors in the production of broiler chicken, as suggested by Średnicka-Tober *et al.* (2016). The third step was to analyze each article to decide inclusion and exclusion criteria (Table 2).

Table 2 – Adopted criteria for inclusion and exclusion of the keywords

Criteria	Definition
Inclusion	Study with broilers and available production and performance data
Exclusion	Study with broilers and unavailable production and performance data

RESULTS

A total of 167 scientific articles were identified (Figure 2) using a critical analysis as recommended by Riera *et al.* (2006). From the total scientific articles selected, 22 articles were found in the Google Scholar database, 92 on ScienceDirect, 53 on SciELO. A total of 99 articles were in English and 68 in Portuguese. The year that presented the highest number of publications was during 2010 (24 articles), followed by 2014 (21 articles), as shown in Figure 3.

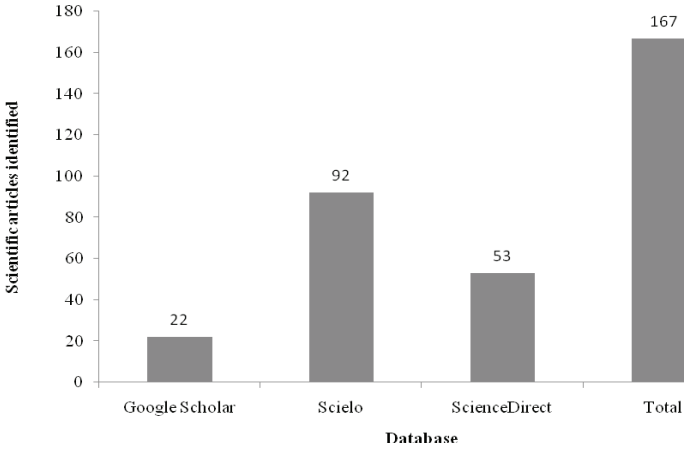

Figure 2 – The total of scientific articles identified in the studied databases.

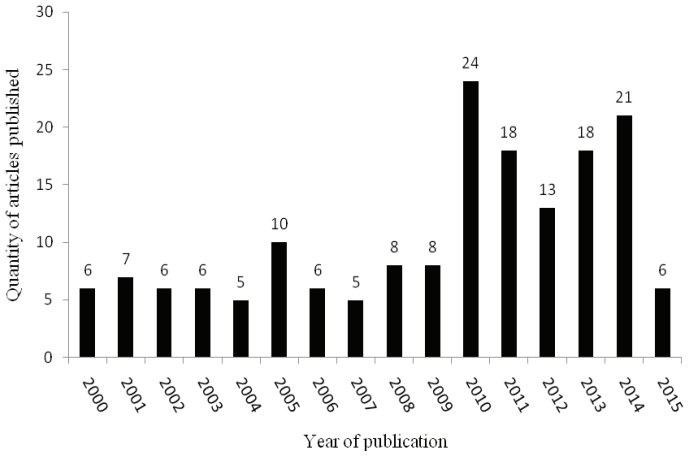

Figure 3 – The total of scientific articles found in the studied databases in each year.

The year 2014 was the one that presented the most significant number of articles published in English, and in Portuguese was in the year of 2010 (Figure 4). The higher number of papers published may not reflect qualitative advances. Therefore, systematic reviews have become essential tools for tracking evidence that accumulates in a particular field of interest (Andreta, 2011).

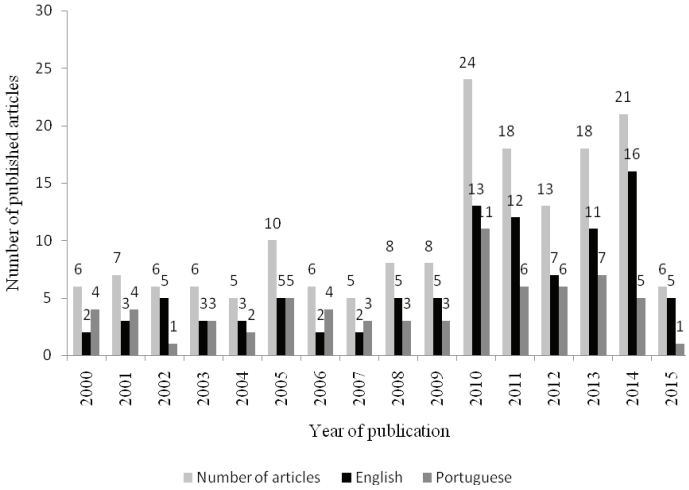

Figure 4 – Total of scientific publications by the year and the language.

Amongst the most various journals that publish articles on broiler production, the following may be highlighted: Applied Behavior (15%), Engenharia Agrícola/Agricultural Engineering (12%) and Brazilian Journal of Animal Science (12%). From the 167 articles selected, after applying the critical review (Figure 1) only 34 were considered in the review (Table 3).

DISCUSSION

The discussion is presented relating the effects identified in the systematic review.

Effect of the thermal rearing environment in broiler production

Neto *et al.* (2000) reported that the ambient temperature influenced the weight gain, which was 16% lower in birds kept under heat stress (32.3 ± 0.31°C) than those maintained in thermal comfort (23.3 ± 0.58°C). Similar to the weight gain, it was verified that the high temperature (32°C) determined a 19% increase in the feed conversion rate of the birds.

For Sartori *et al.* (2001) the weight and the weight gain of the birds reared in the warm environment were lower than those of the birds kept in the thermoneutral and cold environment. These results probably occurred due to the lower feed intake of the birds in the heated chamber when compared to the birds raised in the thermoneutral and cold climatic chambers. Among the birds housed in the thermoneutral and coldchambers, feed intake was lower for birds housed in the thermoneutral chamber, indicating that the

Table 3 – Scientific articles selected for the systematic review, following the established criteria.

Title	Author	Year of publication	Language	Journal, volume , and issue
Desempenho Produtivo e Bioeconômico de Frangos de Corte Criados em Diferentes Sistemas de Aquecimento	Abreu *et al.*	2000	Portuguese	Rev. Bras. Zootec. v.29 n.1
Efeito da Temperatura Ambiente e da Restrição Alimentar sobre o Desempenho e a Composição da Carcaça de Frangos de Corte	Lana *et al.*	2000	Portuguese	Rev. Bras. Zootec. v.29 n.4
Efeito da Temperatura Ambiente sobre o Desempenho e Características de Carcaça de Frangos de Corte Alimentados com Dieta Controlada e Dois Níveis de Energia Metabolizável	Neto *et al.*	2000	Portuguese	R. Bras. Zootec. v.29 n.1
Efeito do Isolamento Térmico de Telhado Sobre o Desempenho de Frangos de Corte Alojados em Diferentes Densidades	Oliveira et al	2000	Portuguese	Rev. Bras. Zootec. v.29 n.5
Efeito da Temperatura Ambiente e da Restrição Alimentar sobre o Desempenho e a Composição de Fibras Musculares Esqueléticas de Frangos de Corte	Sartori *et al.*	2001	Portuguese	Rev. Bras. Zootec. v.30 n.6
Sistemas de resfriamento evaporativo e o desempenho de frangos de corte	Sartor *et al.*	2001	Portuguese	Sci. Agric. v.58 n.1
Avaliação do desempenho e rendimento de carcaça de quatro linhagens de frangos de corte criadas em Goiás	Stringhini *et al.*	2003	Portuguese	Rev. Bras. Zootec. v.32 n.1
Influência do sistema de criação sobre o desempenho, a condição fisiológica e o comportamento de linhagens de frangos para corte	Silva *et al.*	2003	Portuguese	Rev. Bras. Zootec. v.32 n.1
Evaluating two systems of poultry production: conventional and free-range	Lima e Nääs	2005	English	Rev. Bras. Cienc. Avic. v.7 n.4
Efeito do bebedouro e da densidade no desempenho de frangos alojados em alta temperatura	Silva *et al.*	2005	Portuguese	Rev. Bras. Eng. Agríc. Ambient. v.9 n.4
Índice térmico ambiental de produtividade para frangos de corte	Medeiros *et al.*	2005	Portuguese	Rev. Bras. Eng. Agríc. Ambient. v.9 n.4
Comparação entre tecnologias de climatização para criação de frangos quanto a energia, ambiência e produtividade	Bueno e Rossi	2006	Portuguese	Rev. Bras. Eng. Agríc. Ambient. v.10 n.2
Efeito da temperatura ambiente sobre o desempenho e as características de carcaça de frangos de corte dos 22 aos 42 dias	Oliveira *et al.*	2006	Portuguese	Rev. Bras. Zootec. v.35 n.4
Efeitos da temperatura e da umidade relativa sobre o desempenho e o rendimento de cortes nobres de frangos de corte de 1 a 49 dias de idade	Oliveira *et al.*	2006	Portuguese	Rev. Bras. Zootec. v.35 n.3
Efeitos de diferentes sistemas de acondicionamento ambiente sobre o desempenho produtivo de frangos de corte	Furtado *et al.*	2006	Portuguese	Rev. Bras. Eng. Agríc. Ambient. v.10 n.2
Condições térmicas ambientais e desempenho de aves criadas em aviários com e sem o uso de forro	Abreu *et al.*	2007	Portuguese	Arq. Bras. Med. Vet. Zootec. v.59 n.4
Efeitos dos programas de luz sobre desempenho, rendimento de carcaça e resposta imunológica em frangos de corte	Moraes *et al.*	2008	Portuguese	Arq. Bras. Med. Vet. Zootec. v.60 n.1
Behavioural time budgets of broiler chickens reared in varying light intensities	G.M. Alvino*et al.*	2009	English	Applied Animal Behaviour Science 118 54–61
Índices de conforto térmico e concentração de gases em galpões avícolas no semiárido paraibano	Furtado *et al.*	2010	Portuguese	Eng. Agríc., v.30, n.6, p.993-1002
Conforto térmico e desempenho de pintos de corte submetidos a diferentes sistemas de aquecimento no período de inverno	Cordeiro *et al.*	2010	Portuguese	Rev. Bras. Zootec., v.39, n.1, p.217-224
Avaliação do desempenho e do rendimento de carcaça de quatro linhagens de frangos de corte em dois sistemas de criação	Madeira *et al.*	2010	Portuguese	Rev. Bras. Zootec., v.39, n.10, p.2214-2221
Efeito da automatização nas diferentes estações do ano sobre os parâmetros de desempenho, rendimento e qualidade da carne de frangos de corte	Souza *et al.*	2010	Portuguese	Acta Scientiarum. Animal Sciences, v. 32, n. 2, p. 175-181.
Desempenho produtivo de frangos de corte em diferentessistemas de instalações semiclimatizadas no sul do Brasil	Menegali, I. *et al.*	2010	Portuguese	Engenharia na Agricultura, v.18 n.6

Table 3 – Scientific articles selected for the systematic review, following the established criteria.

Title	Author	Year of publication	Language	Journal, volume , and issue
Characterization of Heat Waves Affecting Mortality Rates of Broilers Between 29 Days and Market Age	Vale *et al.*	2010	English	Brazilian Journal of Poultry Science v.12, n.4, 279-285
Avaliação do uso de ventilação mínima em galpões avícolas e de sua influência no desempenho de aves de corte no período de inverno	Vigoderis *et al.*	2010	Portuguese	Rev. Bras. Zootec., v.39, n.6, p.1381-1386
Avaliação do bem-estar de frangos de corte em dois galpões comerciais climatizados	Damasceno *et al.*	2010	Portuguese	Ciênc. Agrotec., v. 34, n. 4, p. 1031-1038
Efeito do ambiente de produção sobre frangos de corte sexados criados em galpão comercial	Amaral *et al.*	2011	Portuguese	Arq. Bras. Med. Vet. Zootec. v.63 n.3
Evaluation of litter material and ventilation systems in poultry production: I. Overall performance	Abreu *et al.*	2011	English	Rev. Bras. Zootec. v.40 n.6
Curtain color and lighting program in broiler production: I – general performance	Abreu *et al.*	2011	English	Rev. Bras. Zootec., v.40, n.9, p.2026-2034
Evaluation of litter material and ventilation systems in poultry production: I. Overall performance	Abreu *et al.*	2011	English	Rev. Bras. Zootec. v.40 n.6
Effect of floor type (dirt or concrete) on litter quality, house environmental conditions, and performance of broilers	Abreu, *et al.*	2011	English	Brazilian Journal of Poultry Science, v.13, n.2, 127-137
Eficiência de sistemas evaporativos e dos níveis de energia na ração no desempenho de frangos de corte em crescimento	Barbosa *et al.*	2012	Portuguese	Semina: Ciências Agrárias, v. 33, n. 4, p. 1589-1598
Behavior of broiler chickens in four different substrates: a choice test	Villagrà *et al.*	2014	English	Brazilian Journal of Poultry Science, v.16, n.1, 67-76
Effects of housing systems on behavior, performance, and welfare of fast-growing broilers	Zhao et al	2014	English	Asian Australas. J. Anim. Sci., v. 27, n. 1, 140-146
Growth performance of broilers under two rearing systems in three different housing zones in an environmentally controlled house during winter	Bilal et al	2014	English	The Journal of Animal & Plant Sciences, 24(4): Page: 1039-1044
Behavior of broiler chickens in four different substrates: a choice test	Villagrà, *et al.*	2014	English	Brazilian Journal of Poultry Science, v.16, n.1, 67-76
Light emitting diode (led) use in artificial lighting for broiler chicken production	Santana *et al.*	2014	English	Eng. Agríc., v.34, n.3, p.422-427
Effects of housing systems on behavior, performance, and welfare of fast-growing broilers	Zhao et al	2014	English	Asian Australas. J. Anim. Sci., v. 27, n.1, 140-146
Performance, carcass characteristics and litter moisture in broilers housed at two densities	Gopinger *et al.*	2015	English	Acta Sci., Anim. Sci., v.37 n.1
Effects of different rearing systems on growth performance, nutrients digestibility, digestive organ weight, carcass traits, and energy utilization in male broiler chickens	Wang *et al.*	2015	English	Livestock Science, v.176, p. 135-140

cold temperature caused an increase in the voluntary consumption of food. The ambient temperature affected the broiler performance.

Oliveira *et al.* (2006) indicates that, in all the analyzed periods, birds kept in the thermal comfort environment presented the highest values of feed intake and weight gain and the worst feed conversion. According to the authors (Oliveira *et al.*, 2006), the best results of weight gain and absolute weights of the breast, thigh, and carcass of male broilers of the Avian Farms strain were obtained in the birds reared at inside temperature from 24 to 26, 3°C. Ambient temperatures below 24°C and above 26.3°C negatively influenced the weight gain and the absolute weights of chest, thigh, and carcass.

Heaters provide a reliable, low-maintenance source of heat for young birds. Cordeiro *et al.* (2010) showed that the heating system conjugating several radiant heaters is more efficient because it maintains the house in better thermal conditions on condition that offers welfare for the birds in the first and second weeks of grow-out, which provides improved productive performance. The system with minimal ventilation significantly reduces the temperature inside the house, compromising thermal comfort and damaging animal performance, evaluated through feed conversion,

slaughter weight and productive efficiency (Vigoderis *et al.*, 2010).

Broilers reared close to the ventilation system presented better performance in a hot environment (Bilal *et al.*, 2014).

Effect of the housing, flock density, and the use of adiabatic cooling

Houses with evaporative cooling systems associated with ventilation provided higher values of broiler weight gain and lower values of feed conversion and mortality (Sartor *et al.*, 2001).

Bueno & Rossi (2006) observed in both housing systems (conventional and high density) that the daily weight gain was below, while the feed conversion was above the Ross lineage standard (Agroceres Ross, 2000). The analysis of the primary variables the high-density housing showed, on average, better results when compared to those of the conventional shed.

Furtado *et al.* (2006) in an experiment evaluating three systems (sprinkler system, ventilation system, misting system) reported that the values observed and the productive indexes remained within the ideal ranges for the chicken industry. In the positive pressure system, the best results were obtained for the performance indexes of the birds, for the parameters live weight and feed conversion (Menegali *et al.*, 2010). On the other hand, according to Vigoderis *et al.* (2010) in non-ventilation sheds, birds presented better performance.

Results from two different cooling systems wetted porous plates of cellulose associated with fogging and moistened plates of plastic shade related to fogging, and did not differ from the values of feed intake, weight gain and feed conversion (Damasceno *et al.*, 2010).

Different ventilation systems used by Abreu *et al.* (2011), did not show significant differences in poultry performance, mortality rate and the presence of foot injuries. Barbosa *et al.* (2012) detected that the use of the evaporative adiabatic cooling system was more efficient when associated with the evaporative system of wet hollow bricks, providing a more comfortable and homogeneous environment showing the effect on the performance parameters, and favoring feed conversion.

The semi-intensive breeding system provided conditions that increased bird welfare, positively influencing performance, even under conditions of thermal stress (Silva *et al.*, 2003). In studies conducted by Lima & Naas (2005) comparing two systems of broiler breeding (Conventional-A and Semi-extensive-B), feed conversion was 1.97 and 2.98 in A and B, respectively. Conventionally bred broiler chickens had better feed conversion than broiler chickens in the semi-extensive system. Wood *et al.* (2010) reported that data on weight gain, feed intake, feed conversion, and mortality were not affected by the breeding system (confinement and semi-confinement).

In studies by Souza *et al.* (2010) non-automated sheds and during winter and spring, birds presented better performance. Furtado *et al.* (2010), analyzing two sheds (ceramic tile and another with fiber cement tile) did not observe a significant difference between the mean values of the variables live weight, daily weight gain, feed conversion and mortality rate in the two systems analyzed.

Other identified effects

Roof insulation

Oliveira *et al.* (2000) observed that the use of roof thermal insulation gave birds greater feed intake, higher weight gain and better feed conversion than the environment without thermal insulation. There was a decrease of 4.06% in poultry mortality in the housing with thermal insulation compared to the house without thermal insulation. Abreu *et al.* (2007) reported that the use of the polyethylene on roof insulation of the house, results in better conditions of thermal comfort for the birds and better results of live weight, weight gain and feed consumption and feed conversion not was influenced by the use of the roof insulation.

Genetic strains and sex

In the study presented by Stringhini *et al.* (Ross, Cobb, Arbor Acres and Avian Farms) showed a proper performance and the Ross strain had the weight gain and slaughter weight superior to the other strains at 44 days of age; however, the result was not the same in the different phases. The Avian Farms and Arbor Acres strains showed higher cumulative feed intake at 48 days of age. At this stage, Arbor Acres and Avian Farms chickens had a cumulative feed intake statistically superior to the Cobb strain at 168.65 and 148.49 g, respectively. The Ross strain showed better feed conversion (1.667) about Avian Farms (1.779) and Arbor Acres (1.780) from 1 to 44 days of age. Males had superior performance and carcass weight than the females, but carcass yield characteristics were similar. According to Amaral *et al.* (2011), higher body mass was found in males when compared to females.

Semi-intensive and extensive way of rearing

Data from broilers reared in a semi-intensive mode, data of weight gain of the birds was influenced by the genetic strain and birds of the Ross strain presented more significant weight gain when compared to the Master Griss and Vermelhão Pesado strains, which did not differ from each other. Label Rouge birds had lower weight gain, according to Madeira *et al.* (2010). Zhao *et al.* (2014) showed that the mortality rate of broiler breeder raised outdoors was significantly higher than for those reared inside the housing.

Flock density and season of the year

Silva *et al.* (2005) researched broilers with flock densities from 10 to 14 birds m^{-2} and observed that the flock density did not affect the feed conversion in any of the grow-out phases. However, the increase in flock density reduced the weight gain in 19-38 days of grow-out and the total time of growth, and in the fall feed conversion was high, on average, 3.27. Gopinger *et al.* (2015) increased density from 11.08 to 13.20 m^{-2} birds and observed that the flock density did not affect broiler performance in the tested range.

Lighting

The live weight of the birds was higher in the treatment with increasing light, and the feed consumption was lower, according to Moraes *et al.* (2008). Abreu *et al.* (2011) a program of almost continuous lighting and yellow curtains provide better performance of broilers. However, this program causes increases in the mortality rate and the consumption of electricity. Santana *et al.* (2014) showed that the use of LEDs of different colors had the same effect of fluorescent lamps on the performance and carcass yield of broilers.

Floor

The research presented by Abreu *et al.* (2011), showed that there is no difference in the performance parameters in broilers raised on two types of floors (concrete and dry land).

Wang *et al.* (2015) reported that chickens reared in three types of poultry facilities using multiple layers of cages, compared to broiler chickens raised on slatted plastic, were not affected by the housing or floor condition.

Table 4 shows the summary of the primary variables that positively influenced broiler performance.

Table 4 – Main variables that positively influenced broiler chicken performance

Variables
Thermal comfort
Environmental temperature of 24 to 26.3ºC
Roof thermal insulation
Increased lighting
Brooding heating system
Non-automatic ventilation system – cold season
Positive ventilation system
Low ventilation during the winter
Male broiler
Yellow curtains and continuous lighting
Adiabatic evaporative cooling +hollow clay bricks

CONCLUSIONS

The use of systematic review of the literature allowed us to identify the primary variables that influence the performance of the broiler chicken. These are related to the maintenance of temperatures close to the thermal comfort of the birds, which can be achieved with the use of roof thermal insulation, as lining, besides the use of adiabatic cooling and the use of brick cast on the sides. The presence of positive ventilation, as well as the use of yellow curtains and the continuous lighting, also positively influences the performance of the broiler chickens. The sex of the chicken seems to influence the performance.

REFERENCES

ABPA- Associação Brasileira de Proteína Animal. Annual report 2017 [cited 2017 Sept 10]. Available from: http://abpa-br.com.br/storage/files/final_abpa_relatorio_anual_2017_ingles_web.pdf.

Abreu PG, Abreu VMN, Coldebella A, Jaenisch FRF, Paiva DP. Condições térmicas ambientais e desempenho de aves criadas em aviários com e sem o uso de forro. Arquivo Brasileiro de Medicina Veterinária e Zootecnia 2007;59(4):1014-1020.

Abreu PG, Baêta FC, Abreu VMN, Soares PR, Perdomo CC, Silva MA. Desempenho produtivo e bioeconômico de frangos de corte criados em diferentes sistemas de aquecimento. Revista Brasileira de Zootecnia 2000;29(1):159-167.

Abreu VMN, Abreu PG de, Coldebella A, Jaenisch FRF, Santos Filho JI dos, Paiva DP de. Curtain color and lighting program in broiler production:I - general performance. Revista Brasileira de Zootecnia 2011b;40(9):2026-2034.

Abreu VMN, Abreu PG de, Coldebella A, Jaenisch FRF, Silva, VS. Evaluation of litter material and ventilation systems in poultry production:I. overall performance. Revista Brasileira de Zootecnia 2011a;40(6):1364-1371.

Abreu VMN, Abreu PG de, Jaenisch FRF, Coldebella A, Paiva DP de. Effect of floor type(dirt or concrete) on litter quality, house environmental conditions, and performance of broilers. Revista Brasileira de Ciência Avícola 2011;13(2):127-137.

Andretta I, Kipper M, Lehnen CR, Hauschild L, Vale MM, Lovatto PA. Meta-analytical study of productive and nutritional interactions of mycotoxins in broilers. Poultry Science 2011;90(9):1934-1940.

Barbosa OR, de Lima M, Klosowski, ÉS, Carneiro de Paula Leite, M, Dalazen Castagnara D, Capossi C. Eficiência de sistemas evaporativos e dos níveis de energia na ração no desempenho de frangos de corte em crescimento. Semina: Ciências Agrárias 2012;33(4):1589-1598.

Bilal K, Mehmood S, Akram M, Imran S, Sahota AW, Javed K, *et al.* Growth performance of broiler sundert worearing systems in three different housing zones in an environmentally controlled house during winter. Journal of Animal and Plant Sciences 2014;24(4):103-104.

Bueno LG, Rossi LA. Comparação entre tecnologias de climatização para criação de frangos quanto a energia, ambiência e produtividade. Revista Brasileira de Engenharia Agrícola e Ambiental 2006;10(2):497-504.

Clarck B, Steward GB, Panzone LA, Kyriazakis I, Frewer LJ. A systematic review of public attitudes, perceptions and behaviours towards production diseases associated with farm animal welfare. Journal of Agricultural and Environment Ethics 2016;29:455–478.

Clune S, Crossin E, Verghese K. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production 2017;140:766-783.

Cordeiro MB, Tinôco IFF, Silva JN da, Vigoderis RB, Pinto FAC, Cecon PR. Conforto térmico e desempenho de pintos de corte submetidos a diferentes sistemas de aquecimento no período de invern. Revista Brasileira de Zootecnia 2010;39(1):217-224.

Damasceno FA, Yanagi Junior T, Lima RR, Gomes RCC, Moraes, SRP. Avaliação do bem-estar de frangos de corte em dois galpões comerciais climatizados. Ciência e Agrotecnologia 2010;34(4):1031-1038.

Furtado DA, Dantas RT, Nascimento JWB, Santos JT, Costa FGP. Efeitos de diferentes sistemas de acondicionamento ambiente sobre o desempenho produtivo de frangos de corte. Revista Brasileira de Engenharia Agrícola e Ambiental 2006;10(2):484-489.

Furtado DA, Rocha HP, Nascimento JWB, Silva JHV. Índices de conforto térmico e concentração de gases em galpões avícolas no semiárido Paraiban. Engenharia Agrícola 2010;30(6):993-1002.

Gopinger E, Avila VS, Perondi D, Catalan AAS, Krabbe EL, Roll VFB. Performance, carcass characteristics and litter moisture in broilers housed at two densities. Acta Scientiarum. Animal Sciences 2015;37(1), 35-39.

Kerra AK, Farrara AM, Waddell LA, Wilkins W, Wilhelmc BJ, Bucher O, *et al.* A systematic review-meta-analysis and meta-regression on the effect of selected competitive exclusion products on Salmonella spp. prevalence and concentration in broiler chickens. Preventive Veterinary Medicine 2013;111:112-125.

Lana GRQ, Rostagno HS, Albino LFT, Lana AMQ. Efeito da temperatura ambiente e da restrição alimentar sobre o desempenho e a composição da carcaça de frangos de corte. Revista Brasileira de Zootecnia 2000;2(4):1117-1123.

Lima AMC, Nääs IA. Evaluating two systems of poultry production: conventional and free-range. Revista Brasileira de Ciência Avícola 2005;7(4):215-220.

Madeira LA, Sartori JR, Araujo PC, Pizzolante CC, Saldanha ÉSPB, *et al.* Avaliação do desempenho e do rendimento de carcaça de quatro linhagens de frangos de corte em dois sistemas de criação. Revista Brasileira de Zootecnia 2010;39(10):2214-2221.

Menegali I, Baeta FC, Tinoco IFF, Cordeiro MB, Guimarães MCC. Desempenho produtivo de frangos de corte em diferentes sistemas de instalações semi climatizadas no sul do Brasil. Engenharia na Agricultura 2010;18:461-471.

Moraes DT, Lara LJC, Baião NC, Cançadan SV, Gonzalez ML, Aguila CAL, *et al.* Efeitos dos programas de luz sobre desempenho, rendimento de carcaça e resposta imunológica em frangos de corte. Arquivo Brasileiro de Medicina Veterinária e Zootecnia 2008;60(1):201-208.

Offeddu V, Cowling BJ, Malik Peiris JS. Interventions in live poultry markets for the control of avian influenza: a systematic review. One Health 2016;2:55–64.

Oliveira GA, Oliveira RM, Donzele JLsC, Roberto P, Vaz RGMV, Orlando UAD. Efeito da temperatura ambiente sobre o desempenho e as características de carcaça de frangos de corte dos 22 aos 42 dias. Revista Brasileira de Zootecnia 2006;35(4):1398-1405.

Oliveira JE, Sakomura NK, Figueiredo AN, Lucas Júnior J, TMB dos S. Efeito do isolamento térmico de telhado sobre o desempenho de frangos de corte alojados em diferentes densidades. Revista Brasileira de Zootecnia 2000;29(5):1427-1434.

Oliveira Neto ARH C, Gasparino, E. Efeito da temperatura ambiente sobre o desempenho e características de carcaça de frangos de corte alimentados com dieta controlada e dois níveis de energia metabolizável. Revista Brasileira de Zootecnia 2000;29(1):183-190.

Oliveira Neto AR, Oliveira, RFM, Donzele, JL, Rostagno HS, Ferreira RA, Maximiano, HCE. Efeito da temperatura ambiente sobre o desempenho e características de carcaça de frangos de corte alimentados com dieta controlada e dois níveis de energia metabolizável. Revista Brasileira de Zootecnia 2000; 29(1):183-190.

Oliveira RFM de, Donzele JL, Abreu MLT, Ferreira RA, Vaz VRGM, Cella PS. Efeitos da temperatura e da umidade relativa sobre o desempenho e o rendimento de cortes nobres de frangos de corte de 1 a 49 dias de idade. Revista Brasileira de Zootecnia 2006;35(3):797-803.

Riera R, Abreu MM, Ciconelli RM. Revisões Sistemáticas e Metanálises na Reumatologia. Revista Brasileira de Reumatologia 2006;46(1):8-11.

Rodrigues Filho BA, Gonçalves RF. Legal metrology, the economy and society:A systematic literature review. Measurement 2015; 69:155–163.

Sartor V, Baeta FC, Luz, ML, Orlando, RC. Sistemas de resfriamento evaporativo e o desempenho de frangos de corte. Scientia Agricola 2001;58(1):17-20.

Sartori JR, Gonzales, E, Dal Pai, V, Oliveira, HN, Macari M. Efeito da temperatura ambiente e da restrição alimentar sobre o desempenho e a composição de fibras musculares esqueléticas de frangos de corte. Revista Brasileira de Zootecnia 2001;30(6):1779-1790.

Silva JHV, Jordão Filho J, Silva EL, Ribeiro MLG, Furtado DA. Efeito do bebedouro e da densidade no desempenho de frangos alojados em alta temperatura. Revista Brasileira de Engenharia Agrícola e Ambiental 2005;9(4):636-641.

Silva MAN, Hellmeister Filho P, Rosário MF, Coelho AAD, Savino VJM, Garcia AAF, *et al.* Influência do sistema de criação sobre o desempenho, a condição fisiológica e o comportamento de linhagens de frangos para corte. Revista Brasileira de Zootecnia 2003;32(1):208-213.

Souza VLF, Buranelo GS, Gasparino E, Cardozo RM, Barbosa MJB. Efeito da automatização nas diferentes estações do ano sobre os parâmetros de desempenho, rendimento e qualidade da carne de frangos de corte. Acta Scientiarum - Animal Sciences, 2010; 32(2):175-181.

Średnicka-Tober D, Barański M, Seal C, Sanderson R, Benbrook C, Steinshamn H, *et al.* Composition differences between organic and conventional meat: a systematic literature review and meta-analysis. British Journal of Nutrition 2016;115:994-1011.

Stringhini JH, Laboissiére M, Muramatsu K, Leandro NSM, Café MB. Avaliação do desempenho e rendimento de carcaça de quatro linhagens de frangos de corte criadas em Goiás. Revista Brasileira de Zootecnia 2003;32(1):183-190.

Vigoderis RB, Cordeiro MB, Tinôco, IFF, Menegalil, Souza Júnior JP, Holanda MCR. Avaliação do uso de ventilação mínima em galpões avícolas e de sua influência no desempenho de aves de corte no período de invern. Revista Brasileira de Zootecnia 2010;39(6):1381-1386.

Zhao WZ, Li J, Li X, Bao J. Effects of housing systems on behaviour, performance and welfare of fast-growing broilers. Livestock Science 2015;176:135-140.