NUTRIVISA

REVIEW ARTICLE

https://doi.org/10.59171/nutrivisa-2024v11e12781

Parameters for the evaluation of egg quality: a systematic review

Parâmetros para avaliação da qualidade do ovo: uma revisão sistemática

Pedro Abreu da SILVA NETO*[1] Beatriz Lopes da COSTA[1]
Magnólia Carneiro de OLIVEIRA[1,1] Maria Juciene Lima CHAVES[1]
Luana Guabiraba MENDES[2] Antônia Lucivânia de SousaMONTE[3]

*1Master's in Food Technology. Federal Institute of Education, Science, and Technology of Ceará (IFCE). Limoeiro do Norte, Ceará, Brazil.
2Doctor in Biotechnology. Federal Institute of Education, Science, and Technology of Ceará (IFCE). Limoeiro do Norte, Ceará, Brazil.
3Doctor in Animal Science. Federal Institute of Education, Science, and Technology of Ceará (IFCE). Limoeiro do Norte, Ceará, Brazil.
*Corresponding author: pabreunt@gmail.com

ABSTRACT

Eggs have economic and nutritional potential, being a source of animal protein and are widely consumed in meals. Due to their importance, the objective of this paper is to compile, through a systematic review, information on parameters in egg quality. The search was conducted through Scientific Electronic Library Online (SCIELO), CAPES Periodic, ScienceDirect, and Google Scholar using the following terms: "Quality parameters of eggs" and "physicochemical parameters of eggs". Eighteen studies were selected; out of the total, 33% of the contributions were from Brazil. Approximately 5 studies investigated age, bird genotypes, different forms of rearing and the influence of these factors on the quality of the eggs produced. Six papers sought to observe the effects of bird feeding on egg quality, while 3 works addressed the use of alternative methods for egg quality analysis. Two studies applied physical evaluations and microbiological analyses to verify the quality of commercialized eggs, and 2 studies presented different approaches involving physical or physicochemical methods for microbial control of eggs. It was concluded that egg quality can be determined by various parameters, whether with traditional methods or the application of alternative and innovative methodologies.

Keywords: birds; methods; animal products.

RESUMO

Os ovos apresentam um potencial econômico e nutritivo, são fonte de proteína animal, tornando-se amplamente consumidos nas refeições. Devido sua importância, o objetivo deste artigo é compilar através de uma revisão sistemática, informações sobre os parâmetros na qualidade de ovos. A busca ocorreu através da Scielo, Periódicos CAPES, Science Direct e Google Scholar com os seguintes termos: "Quality parameters of eggs" e "physicochemical parameters of eggs". Foram selecionados 18 estudos, desse total, 33% das contribuições eram provenientes do Brasil, cerca de 5 pesquisas investigaram sobre idade, genótipos das aves, diferentes formas de criação e a influência desses fatores na qualidade dos ovos produzidos, 6 artigos buscaram observar os efeitos da alimentação das aves na qualidade dos ovos, 3 trabalhos abordaram sobre o emprego de métodos alternativos para análise da qualidade de ovos, 2 pesquisas aplicaram avaliações físicas e análises microbiológicas para verificação da qualidade dos ovos comercializados, 2 estudos apresentaram diferentes abordagens envolvendo métodos físicos ou físico-químicos para controle microbiano dos ovos. Concluiu-se que a qualidade dos ovos pode ser determinada por diversos parâmetros, seja pelo emprego de métodos tradicionais ou aplicação de metodologias alternativas e inovadoras.

Palavras-chave:aves; métodos; produtos de origem animal.

Cite this article as

SILVA NETO, P. A. da; COSTA, B. L. da; OLIVEIRA, M. C. de; CHAVES, M. J. L.; MENDES, L. G.; MONTE, A. L. de S. Parameters for the evaluation of egg quality: a systematic review. Nutrivisa - Revista de Nutrição e Vigilância em Saúde, Fortaleza, v. 11, n. 1, 2024. DOI: 10.59171/nutrivisa-2024v11e12781. Disponível em: https://revistas.uece.br/index.php/nutrivisa/article/view/12781.

INTRODUCTION

Chicken eggs represent an important source of animal protein as they contain most of the essential amino acids for humans such as lysine, threonine, methionine, and tryptophan. They constitute low-cost food items and are thus more consumed during times of financial instability (oliveira *et al.*, 2020).

Despite the intense economic impact of the COVID-19 pandemic, the poultry industry remained robust in chicken eggs production, as observed in 2020 due to increased consumption by the population (ferreira *et al.*, 2022). According to the Brazilian Animal Protein Association, in 2020, per capita chicken eggs consumption increased by 9.1%, reaching 251 units per inhabitant and year, with national productivity reaching 53,5 billion units, representing growth compared to 2019, which totaled 49,05 billion units (abpa, 2022).

Most chicken eggs marketed in Brazil are produced with high technology by commercial laying hens with high genetic potential and efficiency in production. The growing global demand for animal protein has led producers to adopt advanced production practices and technologies to achieve maximum production with low cost, in less time, in the smallest possible area (corrêa netto *et al.*, 2018).

However, chicken eggs have been identified as carriers of various bacteria, mainly from the genus Salmonella ssp., causing outbreaks of foodborne illnesses. Quality has also become a concern for traders and consumers because defects in production can cause risks to public health. (klein *et al.*, 2017). The storage time of eggs in the market, room temperature, and the specific characteristics of the bird also influence the quality of the eggs offered to consumers (vasconcelos, 2018).

According to Rumão et al. (2020), there are challenges at the national level regarding contamination by deteriorating microorganisms. Some factors such as temperature and humidity are fundamental for microbial development and can directly affect egg quality. These data are important when analyzing the risk for eggs stored and sold in regions with higher temperatures since Brazilian legislation does not require egg refrigeration for sale, and there is no maximum expiration date established. The product is generally kept at a temperature of at least 20 °C from production to final distribution.

Since sanitary surveillance inspections in Brazil still operate in an incipient manner, it is fundamentally important for public health to ensure quality and safety for the final consumer. According to Tomaszewski (2020), among the ways to assist organizations in each country, laboratory analyses promote understanding and contribute to make decisions in favor of public health. Furthermore, knowledge about eggs characteristics allows the evaluation of the best method to be employed; techniques should be selected based on operator execution time and skill.

Other aspects such as the influence of breeding, age, feeding and species of birds, in addition to the storage of post-laying eggs can directly impact aspects of qualities and characteristics such as weight, shape, shell thickness and internal content, resistance and content nutritional composition of fatty acids, albumen and other nutrients present in eggs (nasri, *et al.*, 2020). The evaluation of quality can be made by Haugh Unit (narushin; romanov; griffin, 2021).

According to Helman *et al.* (2020), the quality of eggs evaluated by the Haugh Unit, indicative of freshness is determined considering the thickness and height of the albumen, being expressed by a scale of values above 72 Haugh units corresponds to the best quality.

Therefore, verifying which methodologies are most employed to assess egg quality is relevant as existing methods can be improved, resulting in greater applicability. Thus, the present paper aimed to compile, through a systematic review, information on the most used parameters to assess the quality of industrial or small-scale egg producers, based on strategies, characteristics, processes, and productions.

MATERIALS AND METHODS

This paper used the Preferred Reporting Items for Systematic Review and Meta-analysis (prisma) proposed by Salamed *et al.* (2020) as a methodological basis.

Search strategies

The papers used in this systematic review were found and selected using the following terms: "quality parameters of eggs" AND "physicochemical parameters of eggs", using boolean operators and quotation

marks to direct the search towards the objectives of the search. The search was conducted in English and Portuguese (BR) language.

The databases used to support this research were: Scientific Electronic Library Online (SCIELO), CAPES Periodic, ScienceDirect, and Google Scholar.

Criteria, paper selection process and data collection

Inclusion and exclusion criteria were applied to direct the search for articles: year, language, type of article and journal searched.

In the initial research, using a period of 2019 to 2023, a high volume of papers with the topic sought was identified, therefore, it was defined, through the search filter, a period of publication of studies between January 2020 and December 2021 as it contains relevant studies within the thematic.

National and international scientific journals were used for the search. After the selection, the titles and abstracts that were applicable to the study were read and the most appropriate ones were selected to compose the paper. It was applied exclusion criteria to monographs, dissertations, theses, and papers presented at events.

The remaining articles were selected by reading the title and abstract, excluding those that were not in accordance with the research, and the remainder were read to define those that would compose this paper.

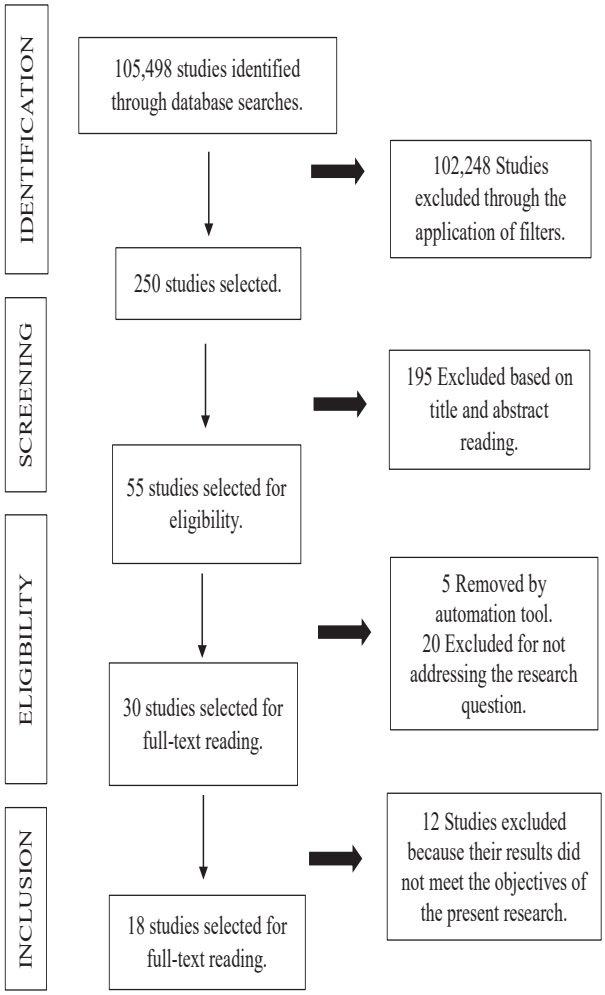
RESULTS AND DISCUSSION

Overall, when conducting the search using "quality parameters of eggs", ninety-four thousand, seven hundred fifty-nine papers related to the topic were detected, and for "physicochemical parameters of eggs", ten thousand, seven hundred thirty-nine papers were identified. However, with the decision to apply the filters of time (2020 to 2021), the works were reduced to one hundred eighty-six and sixty-four, respectively.

The papers were analyzed by the authors through the verification of titles and abstracts initially to understand which ones fit the search, leading to the exclusion of one hundred ninety-five papers that did not fit the study. The process continued with the reading of the fifty-five papers, however, five files failed to open and exhibited malfunction, not been possible to found other in function, and twenty did not answer the study question because it was too embracing.

Out of the remaining thirty, twelve were excluded because the results did not meet the objective of this paper, leaving only eighteen for use in the review. The segment and parameters used make up the table as shown in Figure 1 below.

Figure 1 - Flowchart with eligibility criteria for selected papers



Sousfrce: Authors (2024).

Table 1 shows the papers selected to compose this work, as explained above. In the presented structure, one can observe the delimited papers with information on their titles: repositories, countries of origin, references to the authors and the year of publication. From this perspective, the following were selected: eight papers from the CAPES periodic; six from SCIELO; two from Google Scholar and two from ScienceDirect.

Table 1 – Compilation of papers retrieved to construct the systematic review.

ID	Paper title	Repository	Country of origin	Reference
Q1	Application of Visual Radiographic Analysis of Quality Grade of Table Eggs	CAPES Periodicals	Taiwan	Hsiao *et al.* (2021).
Q2	Assessment of Egg Quality in Native and Foreign Laying Hybrids Reared in Different Cage Densities	Scielo	Türkiye	Ozenturk and Yildiz (2020).
Q3	Determinação de *Salmonella* spp. e quantificação de alterações de casca e de conteúdo interno de ovos comercializados em Natal e Mossoró, Rio Grande do Norte	Google Scholar	Brazil	Rebouças *et al.* (2020).
Q4	Determination of Colistin B in Chicken Muscle and Egg Using Ultra-High-Performance Liquid Chromatography-Tandem Mass Spectrometry	CAPES Periodicals	India	Kumar *et al.* (2021).
Q5	Effect of laying hens age and housing system on physicochemical characteristics of eggs	CAPES Periodicals	Poland	Nowaczews *et al.* (2021).
Q6	Effects of dietary chromium propionate on laying performance, egg quality, serum biochemical parameters and antioxidant status of laying ducks under heat stress	Science Direct	China	Chen *et al.* (2021).
Q7	Egg Quality from Nera Atriana, a Local Poultry Breed of the Abruzzo Region (Italy), and ISA Brown Hens Reared under Free Range Conditions	CAPES Periodicals	Italy	Ianni *et al.* (2021).
Q8	Inactivation of *Salmonella enterica Serovar Enteritidis* on Chicken Eggshells Using Blue Light	CAPES Periodicals	China	Hu *et al.* (2021).
Q9	Nondestructive detection for egg freshness grade based on hyperspectral imaging technology	CAPES Periodicals	China	Yao *et al.* (2020).
Q10	Organic copper, iron, manganese and zinc: digestibility, production parameters and egg quality of layers	Scielo	Brazil	Crosara *et al.* (2021).
Q11	Qualidade dos ovos e prevalência de endoparasitas na criação de galinhas caipiras em Apodi e Mossoró, Rio Grande do Norte, Brasil	Google Scholar	Brazil	Silva *et al.* (2020).

Table 1 – Compilation of papers retrieved to construct the systematic review.

Q12	Spray and Aerosolised pH-Neutral Electrochemically Activated Solution Reduces *Salmonella Enteritidis* and Total Bacterial Load on Egg Surface	CAPES Periodicals	Australia	Tenzin *et al.* (2021).
Q13	Egg Quality Parameters, Production Performance and Immunity of Laying Hens Supplemented with Plant Extracts	CAPES Periodicals	South Korea	Dilawar *et al.* (2021).
Q14	Performance of brown layers fed reduced dietary protein levels in two rearing systems	Scielo	Brazil	Viana *et al.* (2020).
Q15	Physical quality of eggs of four strains of poultry	Scielo	Brazil	Almeida *et al.* (2021).
Q16	Production Performance and Egg Quality of Laying Hens as Influenced by Genotype and Rearing System	Scielo	Serbia	Rakonjac *et al.* (2021).
Q17	Production, egg quality, and intestinal morphometry of laying hens fed marine microalga	Scielo	Brazil	Fernandes *et al.* (2020).
Q18	Valorization of postextraction residues analysis of the influence of new feed additives with micronutrients on eggs quality parameters	ScienceDirect	Poland	Ligas *et al.* (2021).

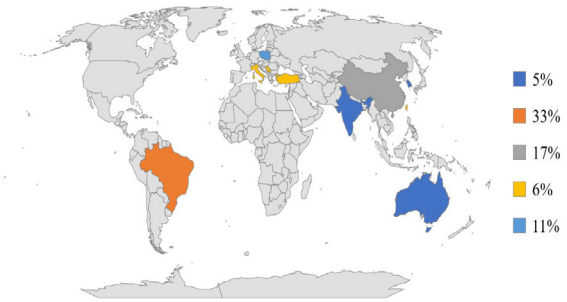
Source: Authors (2024).

According to table 2, the essential results of each study used to compose this review are highlighted.

Countries with the greatest prominence in the research, production, consumption, export, and import of eggs

Eighteen papers were selected for this research; among the countries of origin of the selected studies, Brazil stood out with the largest number of publications at 33%, with China in second place representing 17% of the works, Poland comprising 11% of the productions. Another 24% of the papers chosen presented contributions from Italy, Taiwan, Turkey and Serbia, each country providing 6% each, while Australia, South Korea, and India represented 15% of the studies, each nationality constituting 5%, according to Figure 2.

Figure 2 - Location of selected publications on egg quality parameters.



Source: Authors (2024).

According to the Organization for Economic Co-operation and Development/Food and Agriculture Organization of the United Nations (OECD/FAO) (2022), despite Brazil leading in the number of publications between 2020 and 2021, in the last few years China led the egg production and consumption sector with approximately thirty-four million tons for production and consumption. The European Union stood

Table 2 – Main results of the studies covered.

REFERENCE	TYPE OF ANALYSIS	EXPERIMENTAL GROUPS	MAIN FINDINGS
HSIAO, W. T.; *et al.* Application of Visual Radiographic Analysis of Quality Grade of Table Eggs. Applied Sciences, v. 11, n. 6, p. 1-15, 2021.	The study utilized a non-destructive X-ray method to analyze eggs, obtaining digital grayscale images to assess gas content.	Evaluations were conducted on whole eggs, including shell and internal portions. Two classes of organic eggs and one conventional egg from different commercial brands were selected for the study.	Initial photometric interpretation of grayscale images yielded negative results, hindering identification of egg components such as yolk and egg white. However, gas presence and calcium carbonate content in eggshells were discernible. Statistical analysis revealed no significant difference in freshness between the two classes of organic eggs, while commercial samples exhibited better freshness results compared to conventional eggs.
OZENTURK, U.; *et al.* Assessment of Egg Quality in Native and Foreign Laying Hybrids Reared in Different Cage Densities. Brazilian Journal of Poultry Science. v. 22, n. 4, p. 1-10, 2020.	Comparison of egg quality between layers of Turkish origin (Atak-S - AS) and commercial genotype ISA Brown (IB). Assessment conducted on various egg parameters including weight, shape index, shell strength, thickness, white and yolk index, and Haugh Unit.	Evaluation included layers raised in two different cage housing densities. A total of 648 eggs were assessed across the experimental groups.	No significant effects observed for cage housing densities on internal and external egg quality parameters. Genotype (IB vs. AS) and age of birds significantly impacted egg weight, shape index, shell strength, shell thickness, white and yolk index, and Haugh Unit. IB breed exhibited higher egg weight, shape index, shell strength, albumen index, yolk index, and Haugh Unit compared to AS species.
REBOUÇAS, G. G.; *et al.* Determination of Salmonella spp. and quantification of shell changes and internal content of eggs sold in Natal and Mossoró, Rio Grande do Norte. Research, Society and Development, [S. l.], v. 9, n. 10, p. e399108302, 2020.	Evaluation of the presence of Salmonella spp. in eggs collected from commercial points in Mossoró and Natal, Rio Grande do Norte. Assessment included changes in both shell and internal content of the eggs.	Analysis conducted on 360 eggs obtained from 20 commercial points. Included 18 white-shelled eggs from laying hens sold within expiration date and stored at room temperature.	Alterations observed in shell integrity, with percentages indicating broken shells (10%), cracked shells (40%), and dirt on shells (90%). Presence of blood stains detected in 15% of egg whites, 33% of yolks, and lack of integrity in 28.3% of egg yolks. Approximately 13.33% and 76.6% of eggs were found to be in violation of legislation based on type and chamber height, respectively. Salmonella spp. isolated in 4.17% of samples, with 2.5% found in the shell and 1.67% in the yolk, exceeding regulatory standards for absence of this microorganism.
KUMAR, H.; *et al.* Determination of Colistin B in Chicken	Evaluation of a new method for detecting Colistin B in egg and	Analysis conducted on samples obtained from 30 eggs and 20 poultry	Validation of the method achieved high linearity of the solvent

REFERENCE	TYPE OF ANALYSIS	EXPERIMENTAL GROUPS	MAIN FINDINGS
Muscle and Egg Using Ultra-High-Performance Liquid Chromatography-Tandem Mass Spectrometry. International Journal of Environmental Research and Public Health, v. 18, n. 5, p. 1-12, 2021.	poultry muscle samples. Method involved high-performance liquid chromatography coupled to mass spectrometry.	muscles. Egg samples underwent extraction with acidified methanol and water, followed by centrifugation, filtration, and evaporation processes without solid phase extraction.	standard for the egg matrix, with a calibration curve range of 5-25 µg/L and a coefficient of determination of 0.994. Limit of quantification was determined to be 5 µg/kg-1, indicating the smallest amount of analyte that can be quantified. Chromatogram results showed an average recovery between 88-107%. Colistin B presence was observed in 3 out of 20 chicken muscle samples, ranging from 50–560 µg/kg−1, while egg samples did not contain this substance.
NOWACZEWSKI, S.; *et al.* Effect of laying hens age and housing system on physicochemical characteristics of eggs. Annals of Animal Science, v. 21, n. 1, p. 291-309, 2021.	Investigation of the effect of age and rearing systems on eggs produced by Hy-line brown hens. Analysis focused on comparing eggs from two different rearing systems: cage farming (C1) and cage-free (C2).	C1: New cage farming system with 48 hens, utilizing 3.6 m2/bird and a housing density of 750 cm2. C2: Cage-free system with 7,000 birds. Birds in both systems received the same feed containing 11,000 IU/kg of vitamin A. Birds aged between 40 and 60 weeks were included in the study .	Yolks of eggs from cage-free hens were observed to be darker (12 points) compared to those from cage-raised birds (11 points), with significant differentiation ($p<0001$). Eggs from older hens (60 weeks) exhibited thin shells and increased susceptibility to rupture (from 9.4 N) compared to eggs from younger hens (44 weeks).
CHEN, X. L.; *et al.* Effects of dietary chromium propionate on laying performance, egg quality, serum biochemical parameters and antioxidant status of laying ducks under heat stress. Animal, v. 15, n. 2, p. 100081, 2021.	Investigation into the use of chromium propionate in feeding ducks under heat stress and its influence on egg quality.	Treatment groups included varying levels of chromium propionate in duck feed: 200, 400, 600, and 800 µg/kg, along with a control group without this component. Ducks were subjected to heat stress conditions at 32°C during the study.	Introduction of chromium propionate supplement led to a significant increase in duck laying rate ($p<0.05$). Concentration of 400 µg/kg resulted in a 5.4% reduction in feed/egg ratio compared to the control group. Ducks under heat stress exhibited significant differences in yolk color with chromium propionate treatments, scoring around 11 points compared to the control's 10 points ($p < 0.05$). Haugh Unit increased in duck eggs with chromium propionate supplementation ($p<0.001$), ranging from 73 to 76 Haugh units for supplemented samples compared to 72 Haugh units for the control. Albumen height increased with increasing concentrations of chromium propionate, with the 800 µg/kg concentration resulting in a height of 6.12 mm compared to

REFERENCE	TYPE OF ANALYSIS	EXPERIMENTAL GROUPS	MAIN FINDINGS
			5.78 mm for the 200 µg/k concentration. Chromium propionate addition t duck feed, especially at highe concentrations, promoted th production of eggs with highe albumen heights and helpe maintain egg quality, particularl at the 400 µg/kg and 800 µg/k concentrations.
IANNI, A.; *et al.* Egg Quality from Nera Atriana, a Local Poultry Breed of the Abruzzo Region (Italy), and ISA Brown Hens Reared under Free Range Conditions. Animals, v. 11, n. 2, 2021.	Comparison of egg aspects between native poultry breeds (Nera Atriana - NA) and commercial genotype ISA Brown (IB).	NA birds raised in restricted areas of the Abruzzo region, Italy, with access to open areas and supplemented with 25.98 µg/g of β-carotene in the feed. IB birds also raised cage-free but with different genetic characteristics.	NA species exhibited higher tota fatty acid composition compared t IB, with significantly highe palmitic acid content (C16:0) a 28.58%. Significant differences observed i oleic acid (C:18) concentration with NA genotype lower at 9.46% compared to IB at 44.53% No discrepancies found betwee poultry groups regardin polyunsaturated fatty acids Yolk color parameters showed higher incidence of red in NA genotype samples compared to IE with statistically significan differences in the a* coordinate.
HU, X.; *et al.* Inactivation of Salmonella enterica Serovar Enteritidis on Chicken Eggshells Using Blue Light. Agriculture, v. 11, n. 8, p. 762, 2021.	Investigation of the reduction of S. enteritidis on egg surfaces through blue light antimicrobial action.	Samples obtained from markets were divided into control (C) and blue light irradiation (LA) treatments. Inoculation process involved washing eggs with sterilized water, drying them, and subjecting them to artificial contamination with Salmonella Enteritidis. LA irradiation conducted at a wavelength of 415 nm under aseptic conditions in a biosafety cabinet.	Control treatment initially had S enteritidis count of 6.42 log1 CFU/egg, reducing over time t 4.0 log10 CFU/egg LA treatment showed initia decrease to 2.70 log10 CFU/egg with no significant changes unti the end of the evaluation period Mass loss over storage period wa lower for LA eggs (3.09% compared to control (3.88%), wit significant difference Yolk index at the end of evaluatio indicated greater egg freshness fo LA treatment compared to contro After 4 weeks, considerabl reduction in Haugh Unit value observed, with greater intensity i control samples decreasing fror 86.27UH to 33.54UH, while LA eggs reduced from 86.27UH t 49.28UH at the end.
YAO, K.; *et al.* Nondestructive detection for egg freshness grade based on hyperspectral imaging technology. Journal of Food Process	Utilization of hyperspectral imaging system (SIH) and diffuse reflectance spectroscopy in the Visible and Infrared region (VIS-NIR) to analyze 188 egg	188 egg samples were analyzed using the SIH technology and diffuse reflectance spectroscopy. Samples were assessed	Spectra were obtained in the rang of 400-1000 nm by defining a area of interest of 32x32 pixels i the central region of each eg sample. Average spectrum was calculate

REFERENCE	TYPE OF ANALYSIS	EXPERIMENTAL GROUPS	MAIN FINDINGS
Engineering, v. 43, n. 7, 2020.	samples at three different stages of freshness.	at three different stages of freshness.	for each sample. Interactive Retention of Informative Variables (RIVI) technique was highlighted, determining variations through a binary matrix and a filter aided by a standard algorithm. Calibration achieved 99.29%, and prediction reached 97.87% using the RIVI technique.
CROSARA, F. S. G.; *et al.* Organic copper, iron, manganese and zinc: digestibility, production parameters and egg quality of layers. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, v. 73, n. 3, p. 733-741, 2021.	Examination of the replacement of inorganic minerals Cu, Fe, Mn, and Zn with their organic form (MO) at different levels in the diet of Dekalb White laying hens aged 67 weeks. Comparison of production rates, digestibility, and egg quality.	Evaluation conducted on 240 Dekalb White laying hens. Birds subjected to diets with varying levels (100, 65, 45, and 35%) of organic minerals (MO) replacing inorganic minerals. Treatment groups compared based on production rates, egg-laying capability, viability, weight, and egg mass.	Birds fed diets with organic mineral supplementation exhibited lower production rates but higher egg weights. Sources or levels of inclusions of organic minerals did not influence digestibility and egg quality. Economically relevant zootechnical indices, such as viability, weight, and egg mass, were achieved with supplementation of 2.8 mg Cu, 17.5 mg Fe, 24.5 mg Mn, and 17.5 mg Zinc per kg of feed (MO35) in white layers during the last third of the laying cycle.
ILVA, N. L. .; *et al.* Egg quality and endoparasite prevalence in free range chicken farming in Apodi and Mossoró, Rio Grande do Norte, Brazil . Research, Society and Development, [S. l.], v. 9, n. 9, p. e6673997875, 2020.	Microbiological analysis of egg quality Physical-chemical analysis of egg quality Parasitological analysis of bird excreta	Birds raised in cage-free systems Locations: Apodi and Mossoró, Rio Grande do Norte Egg samples: 108 eggs for microbiological analysis, 135 eggs for physical-chemical analysis Bird excreta samples collected monthly for parasitological analysis over five months	Microbiological analysis: 100% of egg samples negative for total and thermotolerant coliforms, mesophilic bacteria, Staphylococcus aureus, and Salmonella sp. Physical-chemical analysis: Eggs exhibited good yolk pigmentation, internal and external quality, with pH, yolk index, Haugh unit, and shell thickness meeting legislative standards. Parasitological analysis: Incidence of Eimeria and Heterakis during months with high rainfall; prevalence of ascarids during months with relative humidity over 80%.
TENZIN, S.; *et al.* Spray and Aerosolised pH-Neutral Electrochemically Activated Solution Reduces Salmonella Enteritidis and Total Bacterial Load on Egg Surface. Applied	Evaluation of electrochemically active (SEA) neutral pH solution with free chlorine against total bacteria and artificially inoculated Salmonella Enteritidis on egg surfaces	Brown Hy-line chickens Treatments applied to selected eggs: Control (unwashed eggs) Sprayed water (45s) Aerosolized water (60s and 120s)	Reduction in total bacteria with sprayed SEA treatment, resulting in 0 log10 CFU/egg, significantly different from aerosolized SEA which had 1.4 log10 CFU/egg; both SEA treatments differed from the control, which had 2.2 log10UFC/egg.

REFERENCE	TYPE OF ANALYSIS	EXPERIMENTAL GROUPS	MAIN FINDINGS
Sciences, v. 11, n. 2, 2021.		Sprayed SEA solution (45s) Aerosolized SEA (60 - 120s)	Lower count of S. enteritidis with sprayed SEA solution (0 log10 CFU/egg) compared to aerosolized SEA treatment for 60s and 120s (2.6 log10 CFU/egg and 1.2 log10 CFU/egg respectively), and significantly lower than the control (5.4 log10 CFU/egg). Superior reduction in S. enteritidis amount with sprayed SEA treatment (45s) compared to sprayed water, similar to the behavior observed with aerosolized SEA for 60s and 120s compared to water aerosolized.
DILAWAR, M. A.; *et al.* Egg Quality Parameters, Production Performance and Immunity of Laying Hens Supplemented with Plant Extracts. Animals, v. 11, n. 9. P. 975, 2021.	Evaluation of the effects of supplementation with plant extracts on chicken egg quality	Brown Hy-line hens Treatments added to birds' water: TC (control) T1 (0.01% of extracts from both Mentha arvensis and Geranium thunbergii) T2 (0.05% of Mentha arvensis and Geranium thunbergii) T3 (0.1% of Mentha arvensis and Geranium thunbergii)	Significant increase in egg weight in T2 samples compared to control, with 62.06g versus 60.45g. Considerable increase of 89.49% in daily production of T2 eggs, with a greater mass of 54.91 g/bird/d; similar effect observed in T3. Lower cholesterol levels in T2 and T3 compared to TC, with reductions of 144.89% and 159.77% respectively, differing significantly. Better Haugh Unit results in T3 samples, with a value of 76.96 Haugh units, similar to egg shape index (79.22%).
VIANA, E. D. F.; *et al.* Performance of brown layers fed reduced dietary protein levels in two rearing systems. Revista Brasileira de Zootecnia, v. 49, 2020.	Evaluation of eggs from brown laying hens (Hisex Brown breed) raised in cages and cage-free systems Assessment of different levels of crude protein (140, 150, 160, and 180 g/kg−1) in the diet	Evaluation of eggs from brown laying hens (Hisex Brown breed) raised in cages and cage-free systems Assessment of different levels of crude protein (140, 150, 160, and 180 g/kg−1) in the diet	No interaction observed between protein levels and rearing system for body weight gain, feed consumption, egg production, egg weight, and feed conversion. Birds raised on the ground (cage-free) showed higher feed consumption. Egg production influenced by farming system, with cage-free birds showing higher production. Feed conversion rate (kg/dz) improved in cage-raised birds, but they had higher rates of cracked and broken eggs. Protein levels in the diet did not affect feed conversion. Cage-free birds had higher egg production and a higher percentage of dirty eggs compared to cage-raised birds.

REFERENCE	TYPE OF ANALYSIS	EXPERIMENTAL GROUPS	MAIN FINDINGS
ALMEIDA, G. R. de; *et al.* Physical quality of eggs of four strains of poultry. Acta Scientiarum. Animal Sciences, v. 43, 2021.	Evaluation of the physical quality of eggs from four bird lines: Hisex Brown (HB), Hy-Line Brown (HL), Isa Label (IL), and Lohmann Brown (LB)	Bird lines evaluated: HB, HL, IL, LB Parameters assessed: Weight Specific gravity Albumen height Percentage of yolk and albumen Haugh Unit Total of 864 eggs collected over 63 days from farms in the Rio Pomba and Viçosa Region, Minas Gerais	Significant effect ($p<0.005$) observed on weight, specific gravity, albumen height, percentage of yolk and shell, and Haugh units across all four bird lines. Weight of eggs varied for HB (62.05g), HL (63.63g), IL (57.10g), and LB (50.62g). Specific gravity measured as 1.087, 1.079, 1.070, and 1.074 g/cm-3 for HB, HL, IL, and LB respectively. Albumen height observed as 6.15mm, 5.68mm, 4.91mm, and 4.51mm for HB, HL, IL, and LB respectively. Percentage of yolk ranged from 27.28% to 30.14%, while albumen content varied from 8.49% to 9.67%. Haugh Unit values were 74.45, 70.78, 66.56, and 66.24 for HB, HL, IL, and LB respectively.
RAKONJAC, S.; *et al.* Production Performance and Egg Quality of Laying Hens as Influenced by Genotype and Rearing System. Brazilian Journal of Poultry Sci ence, v. 23, n. 2, p. 1-7, 2021.	Evaluation of the effect of cage-free and organic farming systems, as well as ISA Brown (IB) and New Hampshire (NW) genotypes, on productive performance and egg quality	Genotypes: ISA Brown (IB) New Hampshire (NW) Farming systems: Cage-free Organic Parameters analyzed: Egg production Daily egg mass Internal and external factors Amount of layer albumen Yolk content	Significant differences observed in egg production between breeds raised cage-free, with IB birds showing higher production rates compared to NW birds in both cage-free and organic systems. Statistical effects noted for daily egg mass of the IB genotype, with consistent mass across both rearing conditions, whereas NW genotype showed variability. Higher amount of layer albumen in IB birds raised in cage-free system compared to NW birds; for organic farming, similar albumen content observed for both breeds. Consistent yolk content around 27% for IB breed regardless of breeding method; NW breed showed greater yolk quantity in cage-free system compared to organic farming.
FERNANDES, R. T. V.; *et al.* Production, egg quality, and intestinal morphometry of laying hens fed marine microalga. Revista Brasileira de Zootecnia, v. 49, 2020.	Evaluation of egg production and quality of laying hens fed diets supplemented with biomass of marine microalgae Dunaliella salina at levels of 0.25, 0.50, 0.75, and 1%.	Laying hens of Bankiva line Supplemented diets with Dunaliella salina biomass at different levels: 0.25%, 0.50%, 0.75%, and 1%	Inclusion levels of Dunaliella salina biomass had a proportional effect on egg performance, with increased egg weight and mass observed as biomass proportions increased. Linear effect observed for feed

REFERENCE	TYPE OF ANALYSIS	EXPERIMENTAL GROUPS	MAIN FINDINGS
			conversion ratio, with a reduction from 1.93 to 1.66. Biomass addition was not linearly significant for egg production and feed consumption. Significant increase noted in yolk index and yolk coloration, with corresponding increase in yolk weight. High levels of total carotenoids observed, with an increase from 246.6 to 430.1 mg/L. Reduction in lipid oxidation, assessed by thiobarbituric acid reactive substances, from 0.91 to 0.64.
LIGAS, B.; *et al.* Valorização de resíduos pós-extração - análise da influência de novos aditivos alimentares com micronutrientes nos parâmetros de qualidade dos ovos. Poultry Science, v. 100, n. 11, 2021.	Investigation of the influence of chicken supplementation using new additives in bird feed, enriched with copper, manganese, and zinc ions, on egg quality parameters Evaluation of physical parameters including weight, resistance, shell thickness, Haugh Unit, layer performance, and biofortification level Assessment of transfer of microelements to individual egg fractions and organoleptic properties of eggs.	Chickens fed with: Alfalfa biomass enriched with copper, manganese, and zinc ions Goldenrod biomass enriched with copper, manganese, and zinc ions Control group (without supplementation)	Greatest transfer of microelement content to albumen occurred in hens fed with goldenrod enriched with 100% dose of microelements, compared to those fed with alfalfa and the control group. Highest transfer rate to yolk observed in chickens fed with goldenrod enriched at a dose of 50%. Mechanical properties evaluated showed no significant variation among the groups of birds. Better organoleptic parameters found in birds fed with fortified biomass compared to those fed with conventional premixes.

Source: Authors (2024).

out in exports with four hundred million, whilethe United Kingdom ranked first in imports with one hundred and thirty-eight million.

It was observed that the main criteria for evaluating the quality of eggs addressed by the studies involve the effects of breeding and feeding the birds. However, research is also focused on physical, physicochemical, microbiological analyses, and contamination control, in addition to innovative, alternative, and non-destructive methods, which were also explored.

Influence of birds on egg quality

Among the 18 studies found, the papers of Q2, Q5, Q7, Q15, and Q16 focused on aspects such as the age of the birds, different forms of breeding, and the influence of these variables on the quality of the eggs produced.

Influence of the bird species

From the results of the work by Nowaczewski et al. (2021), the internal color parameters, expressed by score, showed a darker color in the yolk of eggs produced by C2 hens compared to C1. The color parameter of the yolk is a quality indicator, being a determining factor for consumer's choice, with more intense color of the yolk being associated with higher vitamin levels (SANCHES et al., 2021). Therefore, the best result for yolk color occurred in group C2, since high pigmentation values are indicative of egg quality.

The results also showed by Nowaczews *et al.* (2021) explain that young C2 chickens (cage-free) contained better quality compared to those of advanced age, as eggs from older birds (60 weeks) had thin shells and were susceptible to rupture compared to those of younger birds (44 weeks). The results obtained indicated superiority for the group of young chickens raised cage-free, due to their morphological characteristics.

Influence on birds feed

The nutritional composition of bird feed, management, and age are factors related to egg resistance, as well as mineral content, as birds lose their ability to absorb calcium over time (Oliveira et al., 2020). These factors help understanding the data obtained in the Nowaczews *et al.* (2021) study, since there were differences in the results found between the two forms of breeding and ages of the layers, demonstrating that these parameters are decisive for obtaining eggs with better morphological and physical-chemical quality.

The article by Ianni *et al.* (2021) revealed that the composition of saturated fatty acids in egg yolk between two special types evaluated, native laying hens and commercial poultry class, suggests that eggs from NA are superior, with lower susceptibility to oxidation during heat treatments, resulting in greater oxidative stability for cooking and other applications. The study also highlighted those eggs from chickens not traditionally sold, such as the Nera Atriana species, have a fatty acid profile that increases consumers' nutritional options. It was also noticed that the internal choir of the eggs showed a higher incidence of red color in the yolks of samples of the native Abruzzo genotype compared to commercial birds.

It is seen that the quality parameters related to the yolk are also relevant due to the lipid composition and carotenoid content. The color of the yolk is related to the birds' diet and, in general, the more intense the color, the better the quality; it may vary in color from yellow to orange depending on the levels of pigments in the feed, changing with availability to dyes and access to vegetation (Oak et al., 2020).

In the research results from Nowaczews *et al.* (2021) and Ianni et al. (2021), the production of eggs with intensely colored yolks was observed. These studies had the cage-free aspect or having access to free areas in common, but presented other influencing factors associated with the color intensity, such as the increase of β-carotene in the chickens' feed and the age of the birds.

The paper of Ozenturk and Yildiz (2020) reflected on the potential of the native poultry breed, comparable with the commercial poultry class due to the ideal shape of its eggs for commercialization. Data on the albumin index were considered within the acceptable average for intake, although the desired yolk index, above forty-six, was not increased by the specific genotypes. A significant effect was observed between the genotype, the age of the birds and the increase in egg weight. According to Poletti *et al.* (2021), bird laying, and egg quality are influenced by age, housing and feeding, with egg weight increasing proportionally to the age of the hens, corroborating the findings of Ozenturk and Yildiz (2020).

Egg quality is defined as high when it reaches the range of 60-72 Haugh units and is considered excellent when it reaches a value of 72 or more (Natividade et al., 2022). Thus, it was verified that the eggs produced were well evaluated, due to their values above 80 Haugh units. The native genotype (AS) studied obtained high quality eggs, being able to compete commercially with the traditional class (IB).

The study by Almeida *et al.* (2021), revealed that the Hisex Brown breed presented eggs with superior quality parameters, evidenced by greater weight, specific gravity, height, and album quantity, in addition to a higher yolk content. Only this strain obtained results above 72 Haugh units, leaving greater freshness and internal quality of the eggs compared to the other genotypes. The resistance of eggs from this strain, associated with greater specific gravity, suggests better shell quality, which, according to the authors, increases the commercialization potential.

The research by Rakonjac *et al.* (2021), found that the different lineages of layers influenced the eggs evaluated, and the best production performance was observed for the IB breed, in addition there was an interaction between the cage-free and organic farming systems in relation to the genotypes. The results helped to understand that when choosing a form of breeding, one of the factors to be taken into consideration is the genotype of the birds, as the breed most adaptable to the chosen system must be selected to produce eggs with better quality.

Influence of bird feeding and supplementation on egg quality

With the results obtained, it was noted that papers Q6, Q10, Q13, Q14, Q17 and Q18, in their approach, sought to observe changes in traditional food or liquid intake through the addition of supplements for birds, evaluating the effect of this modification on egg quality.

Based on the results of Chen et al. (2020), associated that the levels of chromium propionate in the diet of birds subjected to stress, positively influenced the laying and quality of eggs. With the evaluation of the yolk color, a better score was noted for eggs from birds fed with chromium propionate. This parameter is important since thermal stress conditions cause degradation of pigmentation. This phenomenon harms the laying, production, external and internal aspects of eggs (oliveira*et al.*, 2020).

The height of the white increase is directly proportional to the amount of chromium propionate in the feed, namely the addition of the substance produced better quality in the eggs. In the general context, the addition of the compound helped to reduce changes in egg quality, helped to improve the color of the yolk and maintain the quality of the albumen.

A paper by Dilawar *et al.* (2021) showed positive results when dealing with poultry supplementation on egg quality, providing an increase in weight and a reduction of cholesterol in treated samples. According to the authors, cholesterol reduction is associated with changes in the production or coordination of endogenous lipoproteins and in the metabolic process of cholesterol synthesis, manipulation, and distribution. Furthermore, one of the best quality treatments presented, with Haugh Unit values above 72 and shape index around 79%, making them commercially viable.

With the work of Crosara *et al.* (2020), it can be observed that the replacement of inorganic minerals with organic ones at an inclusion level of 35% (MO35) met the dietary requirements for laying hens, in addition, there was an increase in egg mass with addition of these substances.

The addition of components with beneficial potential that can be consumed by birds is an extremely important factor, as they help maintain egg quality. Therefore, in the studies covered in Q6 and Q13, improvements in egg quality were found with the increase of substances in poultry feed or water, in the Q10 study, these effects were not significantly observed, although the replacement of inorganic minerals contributed to an increase in egg weight, an attractive feature for the consumer. According to Heryandi *et al.* (2020), who added fermented pineapple residues to poultry feed, obtained a significantly positive effect ($p<0.01$) on egg yolk color, corroborating study Q6, while Abreu *et al.* (2018), with the addition of an enzyme complex to chicken feed, an increase in egg productivity and weight was achieved, corroborating the findings in papers Q10 and Q13.

In the study by Viana *et al.* (2020), it was observed that although the variation in protein levels does not significantly affect the parameters evaluated for the quality of eggs produced, changing the method of creation can promote greater productivity, which consists of a satisfactory result. According to the same authors, raising layers cage-free contributed to greater production due to the well-being and comfort of the birds, which compared to rearing in cages have more circulation space and can act naturally, another factor mentioned.

The research by Fernandes *et al.* (2020), showed that microalgae biomass has high levels of carotenoids. The authors also indicated that Dunaliella salina has the capacity to partially replace protein levels and provides energy for layers hens. Thus, the results were positive with the increase of different concentrations of D. salina biomass, consolidating it as a potential viable alternative for addition to bird feed.

Ligas *et al.* (2021), showed that the food additives produced have potential for food biofortification, and supplementing bird feed with goldenrod biomass promoted greater bioavailability in the edible parts of the eggs, which is relevant data as the consumption of enriched eggs with micronutrients is associated with functional properties, improving the quality of eggs in relation to conventional eggs sold on the market.

Alternative techniques for determining egg quality

It was observed that three of the selected studies (Q1, Q4 and Q9) addressed the use of alternative methods for analyzing egg quality, with two studies (Q1 and Q9) focused on non-destructive sample methodologies.

In the research by Kumar *et al*. (2021), a methodology for detecting Colistin was implemented, and resulted in chromatograms with averages between 88%

ethod for detecting dangerous compounds in food, relevant to human health.

It is understood that colistin is an antibiotic synthesized non-ribosomally by Bacillus polymyxa subspecies colistinus, effective against several Gram-negative bacteria such as Acinetobacter baumannii, Enterobacter cloacae, Salmonella, Klebsiella pneumoniae and Pseudomonas aeruginosa. Inappropriate use in humans or food-producing animals may compromise the effectiveness of colistin in the treatment of human infections caused by Enterobacteriaceae, making them multidrug-resistant or highly resistant to this medication (kumar *et al.*, 2020).

The work of Yao et al. (2020), combined spectroscopy with a non-destructive hyperspectral imaging system, which represents the chemical composition of the sample by processing pixels obtained from spectral sources (VIS-NIR), obtaining promising results in detecting the level of freshness of eggs, since the results presented a prediction above 95%, which is ideal for reliability.

The study by Hsiao *et al.* (2021) investigated the use of visual radiographic analysis for examining agricultural products indicating a promising method for determining egg quality.

Non-destructive methods present advantages for egg producing industries due to their practicality, speed, cost reduction and contribute to reducing losses (reis et al., 2021). These procedures can be seen in studies presented by Yao *et al.* (2020), with a new and non-destructive methodology for analyzing eggs that showed positive results and good prediction.

Microbiological and physical quality of eggs

From the results obtained, it was observed that 2 studies (Q3 and Q11) applied physical evaluations and carried out microbiological analysis to verify the quality of the eggs sold.

The study by Rebouças *et al.* (2020), investigating the inspection of eggs sold in two municipalities in Rio Grande do Norte, found physical-chemical and microbiological changes, pointing out potential problems, especially due to the high percentage of dirty eggs, which increases the risk of microbiological contamination and affecting consumer selection criteria at the time of purchase. The authors highlight that the presence of dirt on eggshells and the conditioning storage conditions can contribute to interference in the sanitary quality of the product. Thus, the urgency of improving hygiene practices and implementing sanitary control measures to prevent product losses and ensure food safety is highlighted.

Silva*et al.* (2020), found that eggs from birds raised in cage-free conditions on six commercial properties comply with the safety standards for consumption provided for by Brazilian legislation, both in physical and microbiological terms, indicating that raising free--range birds is promising. The authors observed that, to combat the incidence of endoparasites, especially during periods of high occurrence or high relative humidity, it is necessary to use antiparasitic medications. The use of these medications can contribute to safe production, avoiding losses during egg processing.

Techniques for controlling contamination in eggs

It was found that the studies of Tenzin *et al.* (2021) and Hu *et al.* (2021) presented different techniques involving physical or physical-chemical methods for microbial control.

The work of Tenzin *et al.* (2021), when researching the use of sprayed and aerosolized pH neutral Electrochemically Activated Solutions (ECAS), showed promising results on the reduction of total bacteria, reducing the microbial load. This same effect was observed for the reduction of Salmonella Enteritidis indicating effectiveness of treatments with ECAS. The use of these solutions, in addition to being effective, can be used at an industrial level and become a viable alternative to commonly used biocides.

Hu *et al.* (2021) investigated the inactivation of S. Enteritidis with blue light (BL) irradiation, verifying that was effective in reducing the microbial load. Furthermore, they observed loss of mass in the eggs, as an effect caused by the evaporation of water and carbon dioxide from the egg protein through the pores of the shell, an event that occurred less intensely in the BL treatment. This result highlights the positive effects of blue light. With the loss of the yolk structure in the control treatment, which was dispersed in the white, the result indicated greater freshness of the eggs for the BL treatment. As for the Haugh Unit, the data obtained showed higher quality in samples irradiated with blue light. The controlled sample showed a total of 86.27% in the first week and in the fifth week it was not possible to detect Haugh Unit values due the degradation,

while the sample concentrated with blue light showed values of 86.27% and 45.66%, respectively.

In general, among the papers covered in relation to reducing contamination in eggs, the approaches presented in research of Tenzin *et al.* (2021) and Hu *et al.* (2021) showed efficiency in significantly reducing Salmonella Enteritidis.

CONCLUSION

It was found that the most used conventional parameters in evaluating egg quality include the Haugh Unit, the yolk color index, the percentage of yolk and white, as well as the thickness and resistance of the shell. In the microbiological aspect, studies focused mainly on the detection of Salmonella spp. There is a predominance of Brazilian publications, highlighting the frequent use of dietary modifications or supplementation of birds to evaluate their effects on egg quality, as well as the investigation of the influence of bird genotypes. Other countries have adopted different approaches, including alternative and innovative analysis techniques in addition to traditional methods. Adapting a methodology that uses images to assess egg quality is a promising trend internationally. International studies highlight opportunities for advances in Brazil, highlighting the need to develop new techniques to assess egg quality on a national scale.

This study points to the possibility of future reviews that explore non-destructive and innovative methodologies for evaluating egg quality, offering practical alternatives for the food industry.

REFERENCES

ABPA. Relatório Anual (2022) da Associação Brasileira de Proteína Animal (ABPA). São Paulo, 2022. 144 p. Disponível em: https://abpa-br.org/wp-content/uploads/2023/01/abpa-relatorio-anual-2022.pdf. Acesso em: 19 mar. 2023.

ABREU, M. T.; FASSANI, E. J.; SILVEIRA, M. M. B. M.; VIVEIROS, M. P. Complexo Enzimático à Base de Xilanase, β-glucanase e Fitase em Rações para Poedeiras Comerciais Leves em Pico de Produção. Boletim de Indústria Animal, v. 75, n. 1, p.17-24, 2018. DOI: https://doi.org/10.17523/bia.v75n1p17.

ALMEIDA, G. R. de; MENDONÇA, M. de. O.; WEITZEL, L. C. de. C.; BITTENCOURT, T. M.; MATOS, A. S. de; VALENTIM, J. K.; ARAÚJO, M. L. de; OLIVEIRA, A. Q. C. de. Physical quality of eggs of four strains of poultry. Acta Scientiarum. Animal Sciences, v. 43, 2021. DOI: https://doi.org/10.4025/actascianimsci.v43i1.52738.

BRASIL. Resolução nº 899, de 29 de maio de 2003. Aprova o Guia para a Validação de Métodos Analíticos e Bioanalíticos. Diário Oficial da União: Agência Nacional de Vigilância Sanitária, Brasília, DF, 29 maio 2003.

CARVALHO, D. A. de; SARMENTO, J. L. R.; ALMEIDA, M. J. de. O. Conservação, uso e melhoramento de galinhas caipiras. Ponta Grossa, PR: Atena. Embrapa Meio-Norte-Livro científico (ALICE), 2020. 115 p. DOI: 10.22533/at.ed.032202704.

CHEN, X. L.; ZENG, Y. B.; LIU, L. X.; SONG, Q. L.; ZOU, Z. H.; WEI, Q. P.; SONG, W. J. Effects of dietary chromium propionate on laying performance, egg quality, serum biochemical parameters and antioxidant status of laying ducks under heat stress. Animal, v. 15, n. 2, p. 100081, 2021. DOI: https://doi.org/10.1016/j.animal.2020.100081.

CORRÊA NETTO, L. B. C.; SILVA, L. M. da; XAVIER, M. M. B. B. S. Qualidade e rotulagem de ovos comercializados no município de Valença-RJ. Pubvet, v. 12, n. 9, p. 1-9, 2018. DOI: https://doi.org/10.31533/pubvet.v12n9a173.1-9.

CROSARA, F. S. G.; SANTOS, S. K. A.; SILVA, L. S. S.; CARVALHO, G. L.; LITZ, F. H.; FERNANDES, E. A. Organic copper, iron, manganese and zinc: digestibility, production parameters and egg quality of layers. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, v. 73, n. 3, p. 733-741, 2021. DOI: https://doi.org/10.1590/1678-4162-12195.

DILAWAR, M. A.; MUN, H. S.; RATHNAYAKE, D.; YANG, E. J.; SEO, Y.S.; PARK, H. S.; YANG, C. J. Egg Quality Parameters, Production Performance and Immunity of Laying Hens Supplemented with Plant

Extracts. Animals, v. 11, n. 9. P. 975, 2021. DOI: https://doi.org/10.3390/ani11040975.

FERNANDES, R. T. V.; GONÇALVES, A. A.; ARRUDA, A. M. V. D. Production, egg quality, and intestinal morphometry of laying hens fed marine microalga. Revista Brasileira de Zootecnia, v. 49, 2020. DOI: https://doi.org/10.37496/rbz4920200011.

FERREIRA, J. A.; VALENTIM, J. K.; MACHADO, L. C.; OLIVEIRA, H. F. Elaboração de etograma para poedeiras criadas em gaiolas. Revista de Ciências Agroveterinárias. v. 21, n. 2, p. 135-147. DOI: https://doi.org/10.5965/223811712122022137.

GALVÃO, T. F.; PEREIRA, M. G. Revisões sistemáticas da literatura: passos para sua elaboração. Epidemiologia e Serviços de Saúde, v.23, n. 1, p. 183-184, 2014. DOI: http://dx.doi.org/10.5123/S1679-49742014000100018.

HELMAN, E. A. C.; LEMOS, M. J.; GALINDO, E. L. O.; MARQUEZINE, P. C. C. R.; SANTOS, J. C.; SILVA, J. B. A importância do tempo, temperatura e embalagem durante o armazenamento de ovos comercializados em estabelecimentos varejistas do bairro do Recreio dos Bandeirantes no município do Rio de Janeiro – RJ. Brazilian Journal of Animal and Environmental Research, v.3, n.44, p.4365-4375, 2020. DOI: DOI: https://doi.org/10.34188/bjaerv3n4-138.

HERYANDI, Y.; YANTI NOVA, P.; ADRIZAL, A.; MAHATA, M. E. The response of laying hens fed fermented pineapple peel waste by indigenous microorganism from bamboo sprout. Revista Brasileira de Saúde e Produção Animal, v.21, p. 1-8, 2020. DOI: https://doi.org/10.1590/S1519-99402121372020.

HSIAO, W. T.; LIN, H. H.; LAI, L. H. Application of Visual Radiographic Analysis of Quality Grade of Table Eggs. Applied Sciences, v. 11, n. 6, p. 1-15, 2021. DOI: https://doi.org/10.3390/app11062815.

HU, X.; SUN, X.; LUO, S.; WU, S.; CHU, Z.; ZHANG, X.; Liu, Z.; WU, J.; WANG, X.; LIU, C.; WANG, X. Inactivation of Salmonella enterica Serovar Enteritidis on Chicken Eggshells Using Blue Light. Agriculture, v. 11, n. 8, p. 762, 2021. DOI: https://doi.org/10.3390/agriculture11080762.

IANNI, A.; BARTOLINI, D.; BENNATO, F.; MARTINO, G. Egg Quality from Nera Atriana, a Local Poultry Breed of the Abruzzo Region (Italy), and ISA Brown Hens Reared under Free Range Conditions. Animals, v. 11, n. 2, 2021. DOI: https://doi.org/10.3390/ani11020257.

KLEIN, L. R.; BISOGNIN, R. P.; FIGUEIREDO, D. M. S. Estudo do perfil epidemiológico dos surtos de doenças de transmissão hídrica e alimentar no Rio Grande do Sul: uma revisão dos registros no Estado. Hygeia: Revista Brasileira de Geografia Médica e da Saúde, v. 13, n. 25, p. 48-64, 2017. DOI: https://doi.org/10.14393/Hygeia132504.

KUMAR, H.; CHEN, B.; KUCA, K.; NEPOVIMOVA, E.; KAUSHAL, A.; NAGRAIK, R.; BHATIA, S. K.; DHANJAL, D. S.; KUMAR, V.; KUMAR, A.; UPADHYAY, N. K.; VERMA, R.; KUMAR, D. Understanding of colistin usage in food animals and available detection techniques: A review. Animals. v. 10, n. 10, p. 1–19, 2020.

KUMAR, H.; KUMAR, D.; NEPOVIMOVA, E.; OULKAR, D.; KUMAR, A.; AZAD, R. M. R.; BUDAKOTI, S. K.; UPADHYAY, N. H.; VERMA, R.; KUČA, K. Determination of Colistin B in Chicken Muscle and Egg Using Ultra-High-Performance Liquid Chromatography-Tandem Mass Spectrometry. International Journal of Environmental Research and Public Health, v. 18, n. 5, p. 1-12, 2021. DOI: https://doi.org/10.3390/ijerph18052651.

LIGAS, B.; IZYDORCZYK, G.; MIKULA, K.; SKRZYPCZAK, D.; KONKOL, D.; KORCZYŃSKI, M.; SKRZYPCZAK, D.; KONKOL, D.; KORCZYŃSKI, M.; WITEK-KROWIAK, A.; CHOJNACKA, K. Valorização de resíduos pós-extração - análise da influência de novos aditivos alimentares com micronutrientes nos parâmetros de qualidade dos ovos. Poultry Science, v. 100, n. 11, 2021. DOI: https://doi.org/10.1016/j.psj.2021.101416.

NARUSHIN, V. G.; ROMANOV, M. N.; GRIFFIN, D. K. A novel Egg Quality Index as an alternative to Haugh unit score. Journal of Food Engineering, v. 289, n. 110176, p. 1–6, 2021.

NASRI, H.; BRAND, H. V. D.; NAJJAR, T.; BOUZOUAIA, M. Egg storage and breeder age impact on egg quality and embryo development. Journal of Animal Physiology and Animal Nutrition, v. 104, n. 1, p. 257–268, 2020.

NATIVIDADE, A. C.S da; BRITO, D. A. P.; COSTA, W. F. R da; SOUZA, A. S. B de; OLIVEIRA, J. M. S.; SALGADO, G. P; LIMA, N. P.; GOMES, K.S. Qualidade de ovos brancos, vermelhos, caipiras e enriquecidos comercializados em São Luís, MA. Research, Society and Development, v. 11, n. 13. DOI: https://doi.org/10.33448/rsd-v11i13.35293.

NOWACZEWSKI, S.; LEWKO, L.; KUCHARCZYK, M.; STUPER-SZABLEWSKA, K.; RUDZIŃSKA, M.; CEGIELSKA-RADZIEJEWSKA, R.; BIADAŁA, A.; SZULC, K.; TOMCZYK, L.; KACZMAREK, S.; HEJDYSZ1, M.; SZABLEWSKI, T. Effect of laying hens age and housing system on physicochemical characteristics of eggs. Annals of Animal Science, v. 21, n. 1, p. 291-309, 2021. DOI: https://doi.org/10.2478/aoas-2020-0068.

OECD/FAO. Perspectivas Agrícolas da OECD-FAO 2022-2031. OECD Publishing. Paris, 2022. DOI: https://doi.org/10.1787/f1b0b29c-en.

OLIVEIRA, H. F. de; CARVALHO, D. P.; ISMAR, M. G.; REZENDE, P. M.; CAMARGO, S. M. P.; SOUTO, C. N.; OLIVEIRA, S. B. Fatores intrínsecos a poedeiras comerciais que afetam a qualidade físico-química dos ovos. Pubvet. v.14, n.3, p.1-11, 2020. DOI: https://doi.org/10.31533/pubvet.v14n3a529.1-11.

OZENTURK, U.; YILDIZ, A. Assessment of Egg Quality in Native and Foreign Laying Hybrids Reared in Different Cage Densities. Brazilian Journal of Poultry Science. v. 22, n. 4, p. 1-10, 2020. DOI: https://doi.org/10.1590/1806-9061-2020-1331.

POLETTI, B.; VIEIRA, M. de. M.; PINTO, A. T.; FERREIRA, J. I.; NASCIMENTO, V. P. do. Qualidade de Ovos de Produção Orgânica ao Longo de Cinquenta Semanas de Postura. Revista Brasileira De Agroecologia, v. 16, n.1, p.73-80. 2021. DOI: https://doi.org/10.33240/rba.v16i1.23170.

RAKONJAC, S.; DOSKOVIĆ, V.; BOŠKOVIĆ, S. B.; ŠKRBIĆ, Z.; LUKIĆ, M.; PETRIČEVIĆ, V.; PETROVIĆ, D. M. Production Performance and Egg Quality of Laying Hens as Influenced by Genotype and Rearing System. Brazilian Journal of Poultry Sci ence, v. 23, n. 2, p. 1-7, 2021. DOI: https://doi.org/10.1590/1806-9061-2019-1045.

REBOUÇAS, G. G.; ARAÚJO, B. V. S. de; GOMES, A. P.; ABRANTES, M. R.; REBOUÇAS, M. de. O.; SILVA, J. B. A. da. Determinação de Salmonella spp. e quantificação das alterações de casca e conteúdo interno de ovos comercializados em Natal e Mossoró, Rio Grande do Norte. Research, Society and Development, v. 9, n. 10, 2020. DOI: https://doi.org/10.33448/rsd-v9i10.8302.

REIS, T. L.; MORAES, J. E. de; CALIXTO, L. F. L.; PIZZOLANTE, C. C. Acurácia de dias de avaliação da gravidade específica como medida da qualidade de casca de ovos de galinha. Research, Society and Development, v. 10, n. 5, 2021. DOI: https://doi.org/10.33448/rsd-v10i5.15148.

RUMÃO, J. da. S.; BRITO, D. A. P.; REINEHR, C. O.; CONCEIÇÃO, A. O.; FRAZÃO, R. M. Ocorrência de Salmonella spp. e de microrganismos indicadores de qualidade em ovos comercializados na Região Metropolitana de São Luís, Maranhão. Research, Society and Development, v. 9, n. 8, 2020. DOI: http://dx.doi.org/10.33448/rsd-v9i8.6175.

SALAMEH, J.-P.; BOSSUYT, P. M.; McGRATH, T. A.; THOMBS, B. D.; HYDE, C. J.; MACASKILL, P.; DEEKS, J. J.; LEEFLANG, M.; KOREVAAR, D. A.; WHITING, P.; TAKWOINGI, Y.; REITSMA, J. B.; COHEN, J. F.; FRANK, R. A.; HUNT, H. A.; HOOFT, L.; RUTJES, A. W. S.; WILLIS, B. H.; GATSONIS, C.; LEVIS, B.; MOHER, D.; McINNES, M. D. F. Preferred reporting items for systematic review and meta-analysis of diagnostic test accuracy studies (PRISMA-DTA):

explanation, elaboration, and checklist. BMJ, v. 370, n. m2632, 2020.

SANCHES, D. S.; GARCIA, E. R. de. M.; ANDRADE, G. da. C. de; ÁVILA, L. R. de. Perfil do Consumidor de ovos de Galinha no Município de Aquidauana-MS. Veterinaria e Zootecnia, v.28, p. 1-10. DOI: https://doi.org/10.35172/rvz.2021.v28.508.

SILVA, S. da.; FORGIARINI, J.; ALVES, D. A.; KRABBE, E. L.; AVILA, V. S.; LOPES, D. C. N.; XAVIER, E. G. Performance and egg quality of Embrapa 051 laying hens subjected to different feeding programs. Medicina Veterinária (UFRPE), v. 14 n. 1, p. 64-73, 2020. DOI: https://doi.org/10.26605/medvet-v14n1-3715.

TENZIN, S.; FERRO, S.; KHAN, S.; DEO, P.; TROTT, D. J. Spray and Aerosolised pH-Neutral Electrochemically Activated Solution Reduces Salmonella Enteritidis and Total Bacterial Load on Egg Surface. Applied Sciences, v. 11, n. 2, 2021. DOI: doi:https://doi.org/10.3390/app11020732.

TOMASZEWSKI, C. A. Desenvolvimento de metodologia analítica para quantificação e avaliação de incidência de antiparasitários em ovos por cromatografia líquida acoplada à espectrometria de massas tandem. 2020. 110 p. Dissertação (mestrado) - Universidade Federal do Rio Grande do Sul, Porto Alegre.

VASCONCELOS, L. A. S. D. Avaliação da qualidade microbiológica e físico-química de ovos comercializados em Manaus, AM. 2018. 55 p. Dissertação (mestrado) - Universidade Federal do Amazonas, Manaus.

VIANA, E. D. F.; SOUZA, W. J. D.; COSTA, M. A. D.; ARNHOLD, E.; CARVALHO, F. B. D.; MELLO, H. H. D. C.; BARCELLOS CAFÉ, M.; STRINGHINI, J. H. Performance of brown layers fed reduced dietary protein levels in two rearing systems. Revista Brasileira de Zootecnia, v. 49, 2020. DOI: https://doi.org/10.37496/rbz4920200063.

YAO, K.; SUN, J.; ZHOU, X.; NIRERE, A.; TIAN, Y.; WU, X. Nondestructive detection for egg freshness grade based on hyperspectral imaging technology. Journal of Food Process Engineering, v. 43, n. 7, 2020. DOI: https://doi.org/10.1111/jfpe.13422.

.

Recebido em 29-3-2024
Aceito em 21-5-2024