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ANIMAL WELFARE IN LAYING BIRDS: HISTORICAL, SCIENTIFIC AND LEGAL APPROACHES IN THE CONTEXT OF ANIMAL PRODUCTION

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Abstract: This article reviews the evolution of the concept of animal welfare, with an emphasis on the scientific, historical and legal changes that have shaped management practices in animal production. It highlights the importance of the "Five Freedoms", which have guided the development of guidelines to ensure adequate conditions for farm animals. The challenges faced in intensive production systems, such as confinement and overcrowding, are discussed, and management strategies aimed at mitigating negative impacts on the welfare of laying birds are presented, including nutritional management, environmental control, biosecurity and adequate lighting. The study also discusses national and international legislation that influences animal welfare and suggests recommendations for promoting more sustainable and ethical practices in laying poultry farming.
Keywords: Animal welfare, laying poultry management, five freedoms, biosecurity and animal welfare legislation.

INTRODUCTION

Historically, concerns about animal welfare have taken shape over the last sixty years. Scientific evidence indicated that animals suffered from unmet behavioral needs and animals' emotions and feelings began to be considered (DAWKINS, 1978). The focus of the study of animal welfare science aims to meet the basic needs of animals such as biological functioning and the physical characteristics of the environment (YEATES; MAIN, 2008).

Most animal welfare research over the last 40 years has focused on avoiding negative states. However, there is growing interest and research in studies of positive welfare states in animals (HEMSWORTH et al., 2015). This shift in welfare science has led to the realization that animal welfare cannot be achieved without positive affective states, such as feelings of comfort and pleasure (MELLOR and BEAUSOLEIL, 2015).

Given this evidence, animal sentience has been proven, which means that animals have the ability to feel both positive and negative feelings (ABREU; MAZUCO; SILVA, 2017).

As society begins to recognize animal suffering as a relevant factor, animal welfare can be inferred to have an economic value. The conflict between scarce financial resources and the need for investment to ensure the quality of life of animals directly affects attitudes towards the welfare of farm animals in Brazil (MOLENTO, 2005).

This study aims to evaluate and discuss the historical, scientific and legal approaches to animal welfare in laying poultry production systems, highlighting the practices that impact on the quality of life of the birds and proposing recommendations to improve management and sustainability in laying poultry farming.

HISTORY AND ORIGIN OF THE SCIENCE OF ANIMAL WELFARE IN FARM ANIMALS

Man possibly started working with animals for production around ten thousand years ago (ZEDER and HESSE, 2000).

According to FRASER and BROOM (2002), the interaction between farmers and their animals has undergone an intense and marked process of change throughout history. At the beginning of the 20th century, the use of animals for production increased in association with the expansion of human needs. A system of keeping animals at high stocking densities began, which is still rooted in commercial pressures today. In the 1970s, intensive animal husbandry led to the intensive confinement of cattle, pigs and poultry in many countries.

Over the last few decades, some societies have become less willing to accept low-cost animal products, to the detriment of animal suffering. Animal welfare has a strong presence in the moral codes and ethical pillars of several countries, and proper treatment of animals has been taken very much into consideration and is no longer seen as something that can be left to the free choice of individual livestock farmers (SINGER, 2002).

According to MOLNÁR (2022), there were major changes in animal production at the end of the Second World War, when Europe suffered from food shortages and began using intensive breeding systems for large-scale production.

In the last 50 years, there has been a substantial increase in animal products due to advances in animal genetics, facilities, nutrition and health. However, animals are housed in smaller and smaller spaces and their welfare is therefore being questioned (HÖTZEL; NOGUEIRA; MACHADO FILHO, 2010).

The book "Animal Machines", written by journalist Ruth Harrison and released in 1964, was a milestone in the debates on the ethics of animal production in agriculture. The book reported on the practices involved in production systems and the mistreatment of animals in confinement. The publication had a major impact, prompting the English Parliament to set up a committee to investigate the accusations reported in the book. In 1965, this committee, chaired by veterinarian Rogers Brambell, was charged with technically reporting on the existing reality. He acknowledged that he did not have sufficient knowledge to measure the items requested, however, he formulated a report known as the "Brambell Report" which determined that each animal, regardless of species, should have the freedom to turn around; perform body care; stand up; lie down and stretch its limbs. This culminated in the drafting of the "Five Freedoms of Brambell", which contained a number of recommendations for keeping farm animals in order to ensure minimum welfare conditions, thus avoiding animal suffering (HÖTZEL; MACHADO FILHO, 2004).

In 1979, the Farm Animal Welfare Council (FAWC) improved and reformulated the "five Brambell freedoms", which became known as the "Five freedoms of animal welfare" (FARM ANIMAL WELFARE COUNCIL, 2009). These freedoms became widely disseminated and discussed, becoming a reference in the field. The five freedoms can be expressed as: nutritional freedom, which includes the availability of water and food of adequate quality and quantity; sanitary freedom, which covers the absence of health problems such as injuries and diseases; environmental freedom, which includes the adequacy of the facilities in which the animals live; behavioral freedom, which refers to the environment similar to the natural one compared to the natural behavior of the species and psychological freedom, which represents the absence of fear and stress (MOLENTO, 2006).

CONSIDERATIONS AND DEFINITIONS OF ANIMAL WELFARE (AW):

The literature is full of references on the subject and on definitions and concepts, with the purpose of informative clarification.

The term animal welfare is considered complex and has many points of view, involving scientific, ethical, economic, cultural, religious and political issues (CEBALLOS; SANT'ANNA, 2018). In addition to these factors, it involves numerous areas of knowledge, such as ethology, physiology, psychology, health, reproduction, among others (VEISSIER; MIELE, 2014).

A widely used definition is that cited by BROOM (1991), who describes welfare as the animal's ability to interact and live well in its environment and MOLENTO (2005) agreed, stating that this can be measured and it must be taken into account that farm animals have specific behavioral needs and are capable of altering their behavior to adapt to the environment in which they live.

According to MOLENTO (2007), well-being is a term that has been in common use in human societies for a long time. Also omnipresent in human history is the connection with animals and the idea on the part of segments of society that animals feel and their suffering should be avoided.

Animal welfare has been defined by the absence of negative experiences such as illness, hunger, thirst, stress or reduced physical fitness (BRACKE AND HOPSTER, 2006).

According to FRASER *et.al.* (1997), an animal's welfare should involve attending to its physical state, mental state and natural state related to its natural behavior.

According to the World Organization for Animal Health (OIE), in chapter 7.1.1, "animal welfare" means the physical and mental state of an animal in relation to the conditions in which it lives and dies. The OIE mentions that an animal experiences good welfare if it is healthy, comfortable, well-nourished, safe, is not suffering unpleasant states such as pain, fear and distress, and is able to express behaviors that are important to its physical state and mental state. It requires disease prevention and appropriate veterinary care, shelter, management and nutrition, a stimulating and safe environment, proper handling and humane killing or slaughter (INTRODUCTION TO THE RECOMMENDATIONS FOR ANIMAL WELFARE, 2018).

LEGISLATION AND RECOMMENDATIONS ON ANIMAL WELFARE

International bodies that deal with issues related to animal health and food safety, such as the FAO (Food and Agriculture Organization of the United Nations), EFSA (European Food Safety Authority) and OMSA (World Organization for Animal Health), have prioritized animal welfare, establishing international standards and recommendations aimed at ensuring adequate welfare conditions for animals

(INTRODUCTION TO THE RECOMMENDATIONS FOR ANIMAL WELFARE, 2018).

Council Directive 1999/74/EC, of July 19, 1999, lays down minimum standards for the protection of laying hens. As of January 1, 2012, European Union (EU) countries have required that laying hens be reared in enriched cages. This space should be 750 cm², of which 600 cm² is usable space, since the remaining 150 cm² is for placing utensils, such as the perch and the nest (MATUR *et al*., 2015).

In the United States, California was the first to pass a law requiring all eggs produced or sold in the state to come from cage-free systems, as recommended by the Health and Safety Code of the State of California, which came into force in 2015, followed by Ohio, Utah, Colorado, Massachusetts and Nevada. For Oregon and Washington, this law came into force at the end of 2023, and Michigan and Rhode Island for 2025 and 2026, respectively (HSC, 2023).

Decree No. 24.645, of July 10, 1934 (repealed by Decree No. 11, of January 18, 1991), was the first official document in Brazil to establish animal protection measures and define that all animals in the country would be protected by the state and those who mistreated animals would be penalized by fines or imprisonment. It also established that the following are considered ill-treatment: abuse and cruelty against animals, keeping animals in unhygienic places, without light, where they are unable to move or rest, forcing animals to do excessive work that results in suffering, abandoning them, injuring them, among other situations (BRASIL, 1934).

Article 225 of the Brazilian Federal Constitution of 1988 gives the government the power to protect fauna and flora, prohibiting practices that subject animals to cruelty (BRASIL, 1988).

The Federal Council of Veterinary Medicine (CFMV) in Resolution No. 1236 of October 26, 2018, considers veterinarians and zootechnicians to be the professionals trained to identify cases of cruelty, mistreatment and abuse against animals, where cruelty is defined according to Article 2 as "any intentional act that causes unnecessary pain or suffering to animals, as well as intentionally inflicting continuous mistreatment on animals". In addition, Article 4 states that it is the duty of veterinarians and zootechnicians to recommend management procedures, production systems, breeding and maintenance in line with the physiological, behavioral, psychological and environmental needs of the species (BRASIL, 2018).

Normative Instruction No. 56, of November 6, 2008, in its 1st Article, establishes the general procedures for the Recommendations of Good Welfare Practices for Production Animals and Animals of Economic Interest - REBEM, covering production systems and transportation (BRASIL, 2008).

However, in Brazil, national or state legislation on animal welfare has not yet been published specifically for laying poultry, but we can find manuals and protocols from governmental and non-governmental entities such as the Brazilian Agricultural Research Corporation (EMBRAPA), the Brazilian Animal Protein Association (ABPA) and the Brazilian Poultry Union (UBA) that aim to respect the minimum conditions for poultry health, nutrition, management and welfare.

MANAGEMENT PRACTICES FOR LAYING BIRDS

AMBIENCE

The environment in poultry farms refers to the integrated management of environmental factors that directly affect the welfare, health and productivity of the birds. The use of advanced technologies has been explored to optimize the environmental management of poultry houses. MAHFUJUL *et al.* (2021) points out that the use of sensors and real-time monitoring systems can control temperature, humidity and air quality parameters, providing an ideal environment for the birds. These systems not only increase thermal comfort, but also make it possible to identify anomalies early on, minimizing health risks and increasing production efficiency.

Sustainable production in poultry systems is another important dimension of the concept of ambience. RAJKUMAR *et al.* (2021) describes sustainable practices as the efficient use of resources and the minimization of chemical applications that can be incorporated into poultry farms. He emphasizes that sustainability must be aligned with ways in which poultry can adapt to climate change. Climate adaptation, according to LIVERPOOL-TASIE (2019), occurs through genetic selection and specific management to resist extreme variability in temperature and humidity. Therefore, the concept of ambience in poultry breeding encompasses not only immediate control of the environment, but also long-term strategies to ensure the health and sustainability of production systems.

Environmental management is of fundamental importance, especially in hot regions, where heat stress can severely damage the well-being and productive efficiency of laying hens. According to RENAUDEAU *et al.* (2012), heat stress is one of the most important problems encountered in poultry farming, resulting in loss of performance, egg quality and harmful physiological responses. This type of stress is caused by exposing birds to an environment with high temperatures, exceeding their thermal comfort zone, causing changes in their metabolism and behavior that directly affect production efficiency.

According to ABREU and ABREU (2011), in order to improve the environment for poultry, four points should be prioritized: knowledge of the bird's physiology, a bioclimatic diagnosis of the production micro-region, application of the basic concepts of environment and detailed typification of the systems. These points will help assess the situation and point out the adjustments that need to be made, promoting lighter environments in terms of temperature, humidity, gases, dust, saving electricity and water, as well as improving the workforce, which must be highly specialized.

Studies by LIN *et al.* (2006) show that environmental management can directly influence the physiological response, reducing body temperature, respiratory rate and improving the birds' feed efficiency. These tactics not only guarantee the birds' well-being, but also maintain productivity under conditions of heat stress. Therefore, environmental control, through cooling technologies and improvements in nutritional management, are fundamental to guaranteeing good performance from layers, emphasizing the need for integrated management adapted to local climatic conditions.

HEAT STRESS AND THERMAL COMFORT

Heat stress is one of the main antagonisms to the productive performance, egg quality and health of laying hens. Recent research has shown that heat stress has the ability to reduce feed intake and egg production, as well as compromising the integrity of the hen's intestinal barrier, causing increased susceptibility to infections and reduced nutrient absorption.

Therefore, nutritional management, such as supplementation with antioxidant additives and minerals, has been studied with the aim of reducing the negative impacts of heat stress.

Adequate environmental conditions are essential for poultry health and immunity. SOLIMAN and SAFWAT (2020) argue that heat stress and poor ventilation potentially depress the birds' immune system, resulting in greater ease of disease onset and reduced egg production agility. They emphasize that maintaining a controlled microclimate in the houses is essential to repel oscillations that negatively impact zootechnical performance. Therefore, environmental management should focus on thermal stability and air quality, factors that affect the birds' homeostasis and, consequently, their productive capacity.

The thermal comfort zone is a critical aspect of poultry farming, as it directly affects the welfare, production and health of the animals. VANDANA *et al.* (2021) point out that heat stress occurs when the ambient temperature exceeds the birds' ability to dissipate heat, resulting in reduced egg production, lower weight gain and higher mortality. The authors present the ideal temperature range for laying birds between 18°C and 24°C, at which the birds can maintain homeostasis without needing additional thermoregulation mechanisms, providing the highest productive performance and reducing physiological stress.

Climate change and its extreme temperature variations have a major impact on poultry immunity and productivity. SOLIMAN and SAFWAT (2020), emphasize that temperatures outside the comfort zone, both high and low, affect the immune response of birds, predisposing them to susceptibility to disease. They report that temperatures above 28°C induce heat stress, resulting in lower quality poultry products such as meat and eggs. The study proposes that management and environmental control strategies, such as adequate ventilation and the use of foggers, are necessary to mitigate the adverse effects of thermal variations.

ARSAD *et al.* (2023) carried out a systematic review, which found that within the temperature range of 18° C to 22° C, birds showed normal behaviors, such as normal feeding and normal social interaction. Thus, maintaining an adequate thermal comfort zone is essential not only for the birds' physical health, but also for their behavior and general well-being.

For example, the study by CORNESCU *et al.* (2023) showed that the inclusion of zinc-enriched yeast and parsley in the diet of layers could improve production performance and egg quality under heat stress. These nutritional interventions reduced lipid peroxidation levels, improved egg weight and maintained egg quality during storage. The combination of these additives also provided a favorable antioxidant response to the birds' heat stress.

In order to prevent the effects of heat stress, environmental management methods such as adequate ventilation systems, evaporative cooling systems and nutritional supplementation have been widely studied. BUSTAMANTE *et al.* (2013) point out that the practices adopted, such as: misting systems and improvements in the ventilation of sheds to reduce the ambient temperature, can reduce the ambient temperature and improve the thermal efficiency of the birds. Nutritional supplementation with additives such as vitamins and electrolytes can also help minimize the harmful effects of heat on bird performance, increasing their resistance and egg quality.

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POPULATION DENSITY

Cage rearing raises questions about animal welfare due to the reduced space in which the animals live, as it is not compatible with the birds' physiological needs, making them more susceptible to stress. High densities, i.e. a reduction in cage area per bird, can have consequences such as physiological changes, leading to an increase in body temperature, generated by high environmental temperatures and relative humidity, which lead to heat stress (CASTILHO *et al*., 2015).

According to MENEZES *et al.* (2009), the density of poultry housing in Brazil is between 350 and 450 cm^2 /bird, and areas smaller than 350 cm^2 /bird can be found.

Stocking density is one of the critical factors in the rearing of laying birds, as it has a direct influence on their well-being, health and productive performance. Increasing stocking density in houses and cages can lead to various problems, such as injuries, stress and compromised environmental conditions. Research such as that by GUO *et al.* (2012), who studied the effects of feeding method and cage density on the productivity and stress of layers, or the studies carried out by GHOLAMI *et al.* (2020), who looked at the effect of density on plantar pad dermatitis and bird welfare, show that stocking density not only affects productive performance, but also animal welfare.

These investigations show that high stocking densities affect the behavior and performance of birds, generating chronic stress which results in physiological and behavioral changes. The research by GUO *et al.* (2012) clearly showed that the performance of laying birds is impaired in high-density environments, with a reduction in laying rate and an increase in feed consumption per unit of production. This negative effect becomes even greater when combined with inappropriate feeding methods, showing that feed management needs to be considered alongside density in order to optimize bird health and productivity.

In addition to production performance, stocking density also affects the birds' physical well-being. The study by GHOLAMI *et al.* (2020) showed that high stocking densities are directly involved in several unhealthy manifestations, such as dermatitis on the plantar pads, a painful pathological condition that can impair the birds' locomotion and well-being. These conditions are often favored by inadequate floors and the absence of substrates that enable the natural behavior of scarification, revealing that proper density management must be associated with improvements in environmental conditions, thus allowing negative impacts to be minimized.

Density directly influences aggression between birds, reflecting social and physical stress. These conditions can also lead to increased mortality. When overcrowded, birds tend to express more aggressive behavior, such as feather pecking, which not only harms their well-being, but can also cause significant physical damage and increased mortality. The results of GUO *et al.* (2012) reinforce the need for adjustments in stocking density and appropriate management with the aim of reducing stress and improving the social behavior of laying birds.

Therefore, proper stocking density management plays an essential role in the welfare and productive efficiency of laying birds. Implementing practices that include adequate stocking density, along with improving the environment and feed, is of the utmost importance to minimize the impact of stress and harmful physical conditions.

FORCED MOULTING

Feather moulting is a natural process in birds, where their production cycle ceases and leads to internal and external physiological changes, resulting in a renewal of the plumage and preparing the reproductive system for its next laying cycle. Under natural conditions, moulting takes around four months, however, with the use of forced moulting, the process can take around eight weeks or less (ARAÚJO *et al.*, 2007).

Forced moulting is a common practice in the management of laying hens, with the aim of renewing the laying cycle and increasing productivity and egg quality. Forced moulting is traditionally carried out by fasting, but other alternatives such as non-fasting moulting have been studied due to concerns about animal welfare and bird health. According to LEI *et al*. (2023), forced moulting without fasting, through specific and controlled diets, is capable of increasing productive performance and reducing oxidative stress in hens, as well as maintaining intestinal and liver health, mitigating the harmful effects of prolonged fasting and promoting a smooth transition during the moulting period.

Comparisons between different moulting methods, as shown by MISHRA *et al.* (2022), show that the choice of method can directly affect the productive performance, egg quality and immune response of the birds. The study compared forced moulting methods, including total fasting and low-density diets, and showed that moulting without fasting leads to faster recovery of the birds, with less effect on egg production and immune response. Birds subjected to less aggressive methods showed better egg quality, including stronger shells and better uniformity after the moulting period, which could benefit commercial production.

In addition to the productive aspects, forced moulting without fasting also has a positive effect on the general health of chickens, reducing physiological stress and promoting better intestinal morphology. LEI *et al.* (2023) state that alternative moulting strategies improve the integrity of the intestinal villi, favoring the absorption of nutrients and reducing the risk of liver disease, which is common in fasted birds. These adaptations to forced moulting not only improve hen welfare, but also productivity and egg quality, highlighting the importance of management strategies that prioritize the health and productivity of laying hens.

THRESHING

Pecking is a practice widely used in laying poultry farming in order to control aggressive behaviors such as cannibalism, which can result in feather and cloacal injuries and high mortality in stressed laying hens reared in confined systems with high density and poor welfare (MAZZUCO, 2008).

Many objections to the practice of pecking have been described in the literature, since although it reduces aggression, it can be a painful and stressful method, due to the pain and discomfort associated with cutting the beak, which goes against animal welfare. Authors report that the trigeminal nerve that innervates the beak of birds is damaged during pecking, and neuromas are formed and, if pecking is not carried out properly, the neuroma can persist and cause pain to the animal. This pain can vary greatly between birds, depending on their age and the amount of tissue removed (ROCHA; LARA; BAIÃO, 2008).

According to BIST *et al.* (2023), pecking associated with the provision of fiber-rich diets can mitigate some negative effects on the welfare of birds, promoting a reduction in stress and improving feeding behavior.

However, alternatives to pecking are being studied with a view to improving bird welfare without affecting production performance. A study carried out by GUINEBRETIÈRE *et al.* (2020) evaluated management strategies for non-pecked hens, including improvements to the rearing environment and environmental enrichment. The results showed that managing the environment appropriately, providing more space, substrates for scarification and enrichments such as hay and pecking blocks, could reduce the incidence of aggressive behavior, without the need for pecking. These practices offer a more natural and stimulating environment in which birds can safely express their innate behaviors.

The studies show that integrated management, which considers both environmental modification and nutritional adjustments, can be a viable alternative to conventional pecking. BIST *et al.* (2023) point out that the use of fiber-rich diets, combined with improvements in the environment, could not only improve bird welfare, but also maintain productivity and egg quality at adequate levels. Strategies that avoid pecking, or minimize its negative impacts, reflect a management approach that emphasizes animal health and welfare, corroborating the relevance of more humane practices in the rearing of laying hens.

NUTRITIONAL MANAGEMENT

Nutrition is one of the pillars of successful laying production, affecting health, production performance and egg quality. The use of alternative and sustainable ingredients in the diet of laying hens has been a growing strategy to improve feed and reduce production costs. MAISTO *et al.* (2022) mention the use of *Moringa oleifera* leaf meal as a promising dietary supplement, due to its high content of antioxidants, vitamins and minerals, and that the inclusion of *Moringa* in the birds' diet improves the lipid profile of the eggs, reducing their cholesterol content; and also provides a higher feed efficiency rate and general health of the hens, especially in stressful situations.

Another innovative nutritional management strategy for laying hens has been the use of recycled feed, such as processed food waste (agro-industrial waste), to make up their diet. According to KIM *et al.* (2024), the inclusion of recycled feed waste in the diet of layers improved feed efficiency, reducing dependence on conventional ingredients such as corn and soy, which have a high cost and environmental impact. The research concludes that the use of recycled feed does not compromise egg production and quality, and is a viable and sustainable alternative that contributes to the circular economy and the use of food waste.

These innovative nutritional strategies demonstrate that sustainability and productivity can go hand in hand in the management of laying hens. In this sense, MAISTO *et al.* (2022) and KIM *et al.* (2024) indicate that the use of alternative ingredients such as Moringa oleifera and recycled feed waste improves bird performance and enables more sustainable production practices. The diversification of food sources makes a significant contribution to the resilience of the poultry sector in the face of volatile prices for traditional ingredients and highlights the importance of adaptive nutritional management, seeking a balance between poultry health, egg quality and the economic and environmental sustainability of production.

A feed formulation for laying birds must be precise, i.e. meet the nutritional requirements in order to provide efficiency in production and bird health. According to WENLIANG *et al.* (2021), in their work on poultry nutrition, feed must be balanced in terms of protein, energy, amino acids and minerals in order to be efficient for laying performance. According to the authors, a nutritional disorder, such as a lack of essential amino acids, can damage egg quality and production. They suggest that nutritional models be based on the production phases of the birds, adjusting the formulations to meet the requirements of the birds during the different phases of the production cycle.

HUANG *et al.* (2019) also discuss the need for proper feed formulation. The authors mention that additives such as enzymes and probiotics can improve the digestibility of nutrients and the intestinal health of birds, improving feed efficiency and egg quality. They state that calcium and phosphorus are critical requirements in the diet of layers, as they are essential for eggshell formation. In addition, adequate vitamin and mineral supplementation contributes to the productive longevity of the birds and to avoiding problems such as osteoporosis and reduced laying rates.

In the research by ABU HAFSA *et al.* (2022), on nutrition strategies for laying birds, it is shown that continuous monitoring of diets is fundamental for adjusting the composition of the feed to the environmental conditions and the characteristics of the flocks. The authors argue that individualizing diets according to the strain of birds, production stage and rearing environment is essential to maximize the genetic potential of layers. They emphasize the importance of continuous monitoring of the diets in order to adjust the composition of the feed according to the environmental conditions and the specific characteristics of the flocks. They also argue that customizing diets, taking into account factors such as the strain of birds, the stage of production and the rearing environment, is crucial to maximizing the genetic potential of layers. They suggest that the use of alternative ingredients, such as agricultural by-products and non-conventional protein sources, can be a sustainable strategy for meeting nutritional requirements, reducing costs without compromising feed quality and productive performance. Therefore, formulating feed for laying birds should be a dynamic and adaptive practice, focused on animal health and productivity.

Water quality and temperature are crucial factors for the well-being and productivity of laying birds. GUANG LI *et al.* (2023), take a moment to emphasize that water is probably the most important nutrient for birds, because it directly affects their physiological functions and productive performance. The authors indicate that water should not contain contaminants such as bacteria, heavy metals and chemical residues, as these can cause disease, reducing feed intake and, consequently, egg production. In addition, water quality affects feed efficiency, since poor quality water can affect the digestibility of nutrients and the absorption of essential minerals.

Water temperature is also a concern for the health of laying birds. GUANG LI *et al.* (2023) indicate that the ideal water temperature for layers should be between 10°C and 14°C, as very low or high temperatures can cause heat stress, resulting in reduced consumption and productivity. When the water is too cold, the birds tend to consume less, which can cause dehydration and electrolyte imbalance in the body. On the other hand, water that is too hot can increase the birds' body temperature, potentiating the effects of heat stress, especially in hot climates. Therefore, the water temperature must be controlled to keep the birds in their thermal comfort zone, thus guaranteeing an adequate supply of water, both for consumption and for proper functioning and productive performance.

In addition, the work of GUANG LI *et al.* (2023) emphasizes the need for regular monitoring and maintenance practices of the water supply systems in poultry houses. The implementation of filtration systems and the use of additives to improve water quality, such as chlorine and organic acids, are also effective strategies to ensure that the water supplied to the birds meets the necessary sanitary standards. In this way, ensuring adequate water quality and temperature not only preserves the health of laying birds, but also contributes to the sustainability and efficiency of poultry production.

LIGHTING PROGRAMS

Light is perceived by birds through hypothalamic photoreceptors that secrete gonadotropin-releasing hormone (GnRH), which acts on the pituitary gland to produce the gonadotropins luteinizing hormone (LH) and follicle stimulating hormone (FSH). LH and FSH bind to receptors on the granulosa cells of the ovarian follicle, stimulating the production of estrogens and androgens in the small follicles and progesterone in the larger (pre-ovulatory) follicles. On short days, there is no adequate secretion of gonadotropins as the photosensitive phase is not illuminated, unlike long days, when LH is produced. This hormonal mechanism will control reproductive functions, behavior and secondary sexual characteristics (MACARI; FURLAN; GONZALES, 1994).

According to NUNES *et al.* (2013) Brazil has a favorable climate for the use of open sheds, with the use of natural light, but artificial light is not ruled out. Lighting programs consist of a combination of hours of artificial light and hours of natural light, and incandescent bulbs have been replaced in industrial poultry farming due to their higher energy consumption and shorter lifespan. An alternative that has been adopted is the light-emitting diode, which has a longer lifespan and lower electricity consumption.

One of the main factors in the process of rearing laying hens is lighting, which has a direct impact on their reproductive performance, health and well-being. Intermittent light programs and lighting with variable intensities have been explored in order to maximize egg production by adjusting light stimuli according to the birds' physiological needs. According to FARGHLY *et al.* (2023), the adoption of intermittent light programs can optimize the reproductive performance of hens, reducing stress and favoring a more natural environment for the birds' behavior, since this management format allows for visual rest intervals that help the birds recover, for egg production and their health.

In addition to the effects on reproductive performance, the intensity and duration of light are also essential for the birds' well-being. KANG *et al.* (2023) studied the effect of a variable intensity lighting program and found that adjustments in light intensity throughout the day reduced aggressive behavior and stress among laying hens. In this way, varying the light intensity provides a closer simulation of the natural cycle of light and dark, allowing for an atmosphere that is more in line with the birds' circadian rhythms, stimulating natural behaviors due to resting and feeding.

Studies show that the introduction of well-planned light programs not only promotes bird welfare, but also maximizes productive efficiency. FARGHLY *et al.* (2023) state that the use of intermittent light could reduce mortality and increase feed conversion, while KANG *et al.* (2023) show that the oscillation of light intensity favors the preservation of egg quality and bird health in the long term. Therefore, light programs that are carefully designed and adapted to the specific circumstances of the farm are essential for optimizing the productivity and well-being of laying hens, highlighting the importance of innovations in management systems in the modern poultry sector.

Adequate lighting in poultry farms plays a fundamental role in their well-being and productivity. According to ZHONG-YING *et al.* (2023), defining the ideal light intensity and spectrum for each phase of the birds' development is fundamental to optimizing the feeding, resting and production cycles. The authors state that the use of multispectral lamps, which adjust to the intensity of the day's lighting through color composition, significantly improves bird behavior, leading to better feed conversion and higher egg production. The study points out that blue and green light during the initial growth phase favors development, while red light during the laying period stimulates activity and egg production. The authors also stress the importance of the lighting environment, in order to minimize the birds' stress, suggesting that an adjustable lighting regime could be used, simulating a more natural day and night cycle, which could contribute to reducing anxiety and aggressive behaviour. To this end, the implementation of a programmable lighting system, which could vary the intensity and color of the light throughout the day, would make it possible to adapt the environment to the needs of the birds at different times, increasing comfort and productive efficiency. Thus, controlled lighting is considered a crucial factor in improving animal welfare and the sustainability of poultry production.

In addition to behavior, ZHONG-YING *et al.*(2023) point out that optimizing the light environment also affects the physiological events of birds. They note that controlled exposure to different light spectra can regulate biological processes such as circadian rhythm and hormone secretion, which are determinants of poultry health and reproductive performance. The research concludes that the use of multispectral lamps customized for each life stage of the birds not only maximizes production, but also promotes a more comfortable and healthy environment, which is essential for the sustainability and efficiency of poultry production.

FACILITIES AND EQUIPMENT

The correct management of facilities and equipment is vital for the efficient and sustainable production of laying hens, as it directly affects the welfare of the birds and the quality of the eggs. According to SANTOS *et al.* (2023), rearing systems have adapted to the demands of productivity, animal health and product quality, with an increasing focus on improving the rearing environment. These modern facilities, such as enriched cages in rearing systems, offer an environment that favors the birds' natural behavior, allowing the expression of innate behaviors, such as perching, pecking and scarifying, factors that reduce stress and increase production efficiency.

The facilities and equipment in poultry houses are crucial factors for the health, well-being and productivity of the birds. ONBAŞILAR *et al.* (2020), says that enriched cages, which provide more space and environmental stimuli for the birds, thus promoting their natural behaviors, such as scratching and perching, are of paramount importance. The authors report that these cages have an impact on the birds' health, reducing bone diseases and stress conditions, as well as increasing egg quality. The use of perches, nests and sand-bathing areas are essential components of these facilities, providing an environment in which their well-being is safeguarded and which complies with the welfare standards established by international treaties.

For the construction and decoration of poultry houses, the selection of appropriate materials is essential to ensure the long life, functionality and well-being of the birds. ONBAŞILAR *et al.* (2020) suggest that enriched cage systems should be made from galvanized steel, due to its resistance to corrosion and ease of cleaning, factors which help to maintain the hygiene and durability of the facilities. Regarding the structural design of the sheds, they suggest the use of concrete and thermal materials that help maintain internal temperature stability, and easy-to-clean materials such as epoxy resins for floors and walls.

The advancement of modern environmental control technologies in facilities is also fundamental for the management of laying hens. According to LI *et al.* (2020), China has made significant progress in the area of environmental control, using technologies to regulate temperature, ventilation and lighting in laying houses. These innovations have made it possible to precisely control environmental conditions, reducing the effect of heat stress and improving air quality, which is vital for maintaining the birds' respiratory health. The automation systems with feeding and egg collection have also been effective in increasing operational efficiency, since they have reduced manual labor and the risk of contamination.

The integration of state-of-the-art equipment and optimized facilities represents management that tends to maximize productivity without harming animal welfare. As highlighted by SANTOS *et al.* (2023), new facilities and equipment have the common characteristic of being able to meet both the physiological needs of the birds and the economic requirements of producers, leading to the production of better quality eggs with less impact on the environment. The research by LI *et al.* (2020) shows that adapting technologies and improving facilities play a fundamental role in meeting the challenges brought about by modern production, contributing to a safe and comfortable environment for hens, resulting in better production results and greater sustainability in laying poultry farming.

Poultry houses must be carefully designed to ensure that the environment is conducive to the welfare, health and productivity of the birds. YUQUN *et al.* (2018) state that intelligent environmental control technologies are needed to monitor and adjust the control of parameters such as temperature, humidity and ventilation. This system guarantees automated, real-time management of internal conditions in the houses, ensuring that the birds are always in an optimal environment. Precise control reduces heat stress and improves air quality, which are decisive factors for the productive performance and health of the animals.

In addition to technological factors, the physical design of the sheds must be considered. According to ISTIAK and KHALIDUZZAMAN (2022), sheds should have adequate ventilation, controlled lighting and spaces that allow the birds to move naturally. Population density must be properly balanced to avoid overcrowding, which causes stress and a higher incidence of disease. The authors also state that good architectural planning, combined with building materials that favor thermal insulation, is essential for maintaining a stable internal temperature, regardless of external climatic conditions.

Finally, the implementation of efficient monitoring systems is essential to maintain a controlled environment. As demonstrated by YUQUN *et al.* (2018), the integration of sensors and data analysis platforms allows for the early detection of anomalies and rapid decision-making to correct environmental problems. The authors point out that continuous monitoring not only improves animal welfare, but also contributes to operational efficiency, reducing energy costs and avoiding production losses. As such, barns should be designed as dynamic structures, equipped with advanced technologies and designed to provide an ideal environment for rearing laying birds.

BIOSECURITY

Biosecurity is a central element in the management of laying birds and is of fundamental importance in preventing diseases and controlling the health of flocks. The adoption of stable and effective biosecurity practices is vital to protect birds against infection by pathogens and to reduce the occurrence of disease outbreaks, with drastic consequences for production. TILLI *et al.* (2022) who analyzed biosecurity in seven European countries pointed out that compliance with biosecurity guidelines is extremely variable between farms, reflecting the very different practices and awareness of farmers. The research showed that a permanent monitoring approach and education on standardized practices are needed as elements to increase adherence to biosecurity standards, especially in regions with greater variability.

Research carried out by ISMAEL *et al.* (2021) on small and medium-sized farms in Ethiopia indicated that most of these operations lack the appropriate infrastructure and knowledge to apply basic health control practices. The shortcomings lie in poor visitor control, failures in waste management and inadequate disinfection of equipment, increasing the susceptibility of birds to infectious diseases. These shortcomings are made more acute by the lack of awareness of biosecurity protocols and limited financial resources, indicating that training programs and practical experience are fundamental to improving the biosecurity conditions of these farms.

In Ashanti, Ghana, the research carried out by ADOMAKO *et al.* (2024) on poultry farms highlights the need for biosecurity as a preventive strategy to avoid disease outbreaks in laying poultry farms. The data obtained indicates that poultry farmers recognize the importance of biosecurity, however, failures often occur due to the lack of necessary infrastructure, such as physical barriers and strict control of the entry and exit of people and vehicles from farms. The study suggests that improvements in infrastructure and worker training, together with biosecurity monitoring, are essential to improve defenses against pathogens and guarantee the sustainability of poultry production.

Biosecurity is considered a constant challenge due to variations in management practices and compliance with health guidelines. ADOMAKO *et al.* (2024) state that failure to adhere to basic biosecurity protocols, such as visitor control and vehicle disinfection, increases the risks of spreading infectious diseases. The study identified that, despite knowledge of biosecurity measures, many local producers do not have the appropriate infrastructure or financial resources to carry out all the recommended practices. It is clear that there is a need to implement government policies and educational programs with a focus on technical and financial support for small producers. The definition of biosecurity is not limited to the simple execution of preventive measures, but encompasses an integrated approach that unites the awareness and continuous training of all those involved in the poultry production chain.

POULTRY FARMING SYSTEMS

CONVENTIONAL CAGE REARING SYSTEM

The system of rearing laying hens in conventional cages has become established in poultry production, since its economic efficiency and the maximization of production in a reduced area make it extremely advantageous. However, this system has been the subject of considerable criticism regarding bird welfare, since it drastically reduces space and the birds' ability to express natural behaviors. The intensive system can cause extreme stress to the animals, generating behavioral and physiological changes, which can lead to the animal developing health problems as a result of welfare failures (SILVA *et al.*, 2006).

Hens live under a high degree of confinement, i.e. a high population density, which interferes with their natural behavior because it prevents them from moving freely, not being able to stretch their wings or stand up completely at the bottom of the cage, since in most farms the cages are tilted so that the egg rolls when it is laid towards the collecting trough (SILVA *et al.*, 2006).

The space required to raise birds in conventional cages is between 350 cm² and 450 cm² per bird and barns can contain sets of up to seven overlapping cages called "cage batteries" (SILVA; MIRANDA, 2009).

According to WIDOWSKI *et al.* (2016), confinement in conventional cages limits basic movements, such as perching, scratching and fully opening the wings on a continuous basis, resulting in a variety of negative effects on the birds' health and behavior. Such limitations not only affect the hens' physical well-being, but can also result in high levels of stress and aggression.

In comparison, recent studies show that birds reared in conventional cage systems have a greater number of problems related to bird health, such as osteoporosis, due to the lack of exercise and restricted mobility. FRASER *et al.* (2013) point out that, despite the protection provided against predators and adverse environmental conditions, conventional cages do not create an environment that allows birds to enjoy their full well-being. Hens are prone to developing stereotyped behaviors and physical injuries, such as sores on the foot pads, due to contact with wire surfaces, contributing to the issue of poor animal welfare in this type of system.

Although welfare concerns exist, conventional cages are, to date, common in various parts of the world, including Brazil, due to their economic benefits, such as lower production costs, effective disease control and ease of management. WIDOWSKI *et al.* (2016) emphasize that the continued development of improvements in the conditions of conventional cages or the possibility of transitioning to alternative systems is necessary to make production efficiency compatible with the growing demand for welfare standards. Implementing changes such as nests, perches and nail-wearing devices can reduce some of the negative effects on welfare by creating an environment that is more favorable for the hens, as well as being beneficial to health, as it can increase bone strength without compromising the economic viability of the system.

***CAGE FREE* SYSTEM**

The cage-free system has been highlighted as an alternative to confinement in cages, seeking to improve the welfare of laying birds. For ONBAŞILAR *et al.* (2020), the cage-free system provides greater freedom of movement, enabling natural behaviors such as scratching and perching. The authors point out that the cage-free system contributes to bird health by reducing the incidence of skeletal problems and skin lesions, as it improves the quality of life of layers and meets the growing consumer demand for more ethical production practices.

In addition to the animal welfare benefits, the *cage-free* system also has an impact on egg production and quality. PHILIPPE *et al.* (2020) compared egg production in three different systems and found that birds reared in cage-free systems had higher egg quality, with thicker shells and lower breakage rates compared to the traditional cage system.

The impact of the *cage-free* system on the intestinal microbiota of birds was addressed by SHI *et al.* (2019) and the results indicate that birds raised in the *cage-free* system have a greater microbial diversity in the cecum, which is associated with better intestinal health and digestive efficiency. This microbial diversity can contribute to resistance to disease and better utilization of nutrients, positively reflecting on the health and productivity of the birds. In this way, the *cage-free* system not only promotes animal welfare, but can also bring benefits to product quality and the sustainability of poultry production.

FREE RANGE SYSTEM

The so-called "*free range*" production system is an outdoor rearing system that is becoming increasingly important due to the growing demand for more humane and sustainable production practices with regard to animal welfare. In this system, laying hens have the possibility of direct access to nests and perches at different heights, to outdoor areas to express natural behavior such as sand bathing, and to explore the environment to access pasture for the consumption of insects and forage. The free range system has significantly increased bird welfare compared to confinement systems by providing freedom of movement and opportunities for natural behaviors, leading to less stressed and healthier chickens, says HARTCHER *et al.* (2016).

However, the *free range* system also brings challenges that can compromise the birds' welfare if not managed properly. Studies by RANA *et al.* (2022) show that free-range chickens are exposed to additional risks from predators, exposure to the weather and a higher incidence of parasites. In addition, the behavior of chickens outdoors varies greatly according to the quality and type of vegetation, shelter and protection provided. Unsatisfactory outdoor environments, without cover or shade, can lead to avoidance behavior, in which hens avoid using the outdoor space altogether, compromising the beneficial effects of the system.

To maximize the potential of the free range system and minimize welfare problems, careful management and planning of outdoor areas is required. HARTCHER *et al.* (2016) propose that the inclusion of structures such as shrubs, shelters and shaded areas, as well as regular soil management, can encourage the use of outdoor areas by birds, promoting their well-being and general health. Predator control strategies and disease monitoring are also important to ensure that the benefits of the outdoor system are fully realized. Therefore, although the *free range* system provides great opportunities when it comes to chicken welfare, its effectiveness depends on management that considers the complex interactions between the birds' behavior, environment and health.

FINAL CONSIDERATIONS

Society's growing concern for animal welfare has had economic, cultural, legal and scientific implications. The science of animal welfare is gaining more and more attention, as consumers are more concerned about the origin of the products they consume and demand that companies adapt and improve their animal welfare standards, demanding that birds be raised in more extensive systems that allow them to express their natural behavior and thus reduce stress.

Proper management plays an essential role in the welfare and productive efficiency of laying birds. Implementing practices that include adequate density, along with improving the environment and feed, is of the utmost importance to minimize the impact of stress and harmful physical conditions. Scientific evidence shows that integrated management must consider the space, environment and natural behaviour of birds as a solution to optimize health and productivity in mass production systems.

Research in developing regions has shown specific challenges for effective biosecurity practices, adjusted to local realities and based on continuous monitoring and education of producers, which is essential for sustainable and safe management in laying farms.

The adaptation and transition to animal welfare systems will require efforts from veterinarians, zootechnicians, producers and all those involved in laying poultry in a short period of time. Therefore, investing in animal welfare will be an essential tool for adding value to products and boosting the laying poultry chain, aiming for greater sustainability and production efficiency.

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