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Review Article

Alternative Systems for Laying Hens in Brazil: Technical Requirements and Challenges

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Abstract

Market and society demands have encouraged significant changes in the animal production systems. Specifically, laying hen producers around the world have experienced pressure from consumers, retailers, restaurants, non-governmental organizations and governments to implement cage-free, free-range, organic, and "colonial" systems, ensuring better welfare conditions for animals. At present, conventional production of laying hens in cages predominate in Brazil, with no specific regulations or directives that deal with the transition to alternative systems. But the government and the egg laying chain have already make a short-term commitment to partially or completely transitioning to alternative systems. The present work was carried out with the objective of reviewing the protocols, norms, and directives currently used in Brazil, which promote welfare for the hens during the laying phase. Based on this information, the main recommendations for planning and sizing alternative laying hen systems are presented, as well as the challenges of building new facilities and adapting the existing ones according to the climatic conditions of Brazil are discussed.

Keywords: Alternative laying hen systems; Animal welfare; Egg farming; Egg production.

Introduction

Concepts associated with animal welfare have been reported since the 1960s, when animal production rapidly intensified [1]. However, interest of society in the origin of animal products and new market demands have only recently encouraging more significant changes in these production systems [2]. Specifically, poultry egg producers around the world have experienced pressure from consumers, retailers, restaurants, non-governmental organizations and governments to eradicate conventional production, where laying hens are housed in cages. This production system greatly affects the animal welfare, restricting the natural behavior of the hens, when compared to the systems that use litter area, perches, and nests [3]. The transition from the conventional to alternative systems is limited by the financial constraints, since improving the welfare of laying hens increases the egg production cost [4,5].

In 1999, the European Union (EU) announced that commercial systems for laying hens in conventional cages would be banned from January 2012 [6]. Other countries that also no longer authorize the raising of laying hens in conventional cages are New Zealand and Canada [7,8]. Netherlands successful invests in alternative laying hen production since 2004, Bhutan banned battery cages since 2012, while India prohibited construction of new battery cage facilities in 2018 [2]. However, some countries, such as Australia and United States, are still in the transition phase to the alternative production systems [1,8]. Although Brazil so far does not have regulations or directives that lay down the transition from conventional to alternative systems, the Brazilian government and the egg laying chain have also been influenced by international demands [9,10], especially considering egg exporting. As a result, the percentage of laying hens in alternative systems increased from 4% in 2010 to 28% in 2020 [11]. Furthermore, one of the strategies widely adopted by retail companies and large Brazilian producers has been to make a short-term commitment to partially or completely transitioning to alternative systems [12].

In the alternative systems (cage-free, free-range, organic, and "colonial"), the environment of all stage production must be designed to protect the hens from thermal discomfort, fear, and distress, in addition to allowing the hens to express their natural behavior [13,14]. Therefore, studies for building and adapting alternative laying hen systems are essential and strategic. The present work was carried out with the aim of reviewing the protocols, regulations, and directives currently used in Brazil, which deal with welfare in laying hen production. Based on this information, the main recommendations for the planning and sizing alternative systems are presented, as well as the challenges inherent in the new facilities and the adaptation of existing ones, considering the Brazilian climatic conditions.

Animal Welfare and Laying Facilities

Animal welfare is a subjective expression, which depends on different points of view of the people and cultures that make up society. There is a broad discussion in the scientific community about the concept of animal welfare and its applicability in the science and the production sector [14,15]. According to the Terrestrial Animal Health Code of the World Organization for Animal Health [16], the expression welfare means the mental and physical state of an animal considering the conditions in which it lives and dies.

In 1965, the British Parliament created the Brambell Commission to determine which is essential for guaranteeing animal welfare in livestock species. This commission released a report indicating codes of practice for animal agriculture in the United Kingdom in response to public concerns over the conditions under which animals were kept in intensive systems. The document presented a diagnosis of breeding conditions, as well as a definition of the minimum standards that should be met for the welfare of the animals, known as the "five freedoms of Brambell" [17]. The five freedoms indicate that the animal must experience its state of welfare by being healthy, well nourished, in adequate environmental conditions, free from suffering (distress, fear, and pain), in addition to being able to express its natural behavior. Currently, the five freedoms have influenced the design of facilities and animal management practices in intensive production systems, domestic animals, and those raised in zoos or laboratories [18].

The laying hens maintain their internal body temperature at a

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relatively constant level through organic control mechanisms, represented by physiological compensations. If thermal comfort is not achieved and laying hens are exposed to heat stress, there may be a reduction in feed consumption and weight gain, as well as an increment in mortality [19]. Considering the tropical climatic conditions in Brazil, this aspect needs to be well evaluated during the sizing and management of poultry buildings. Regarding nutrition, several factors can change the needs of a laying hen, such as breed, genetics, sex, feed consumption, energy levels, nutrient availability, air temperature, air humidity, gas concentration (ammonia and CO_2), among others [20]. Generally, the provision of feed and water should prevent competition between laying hens, with the chemical composition and physical form of feed significantly contributing to prevent and treat both welfare and health conditions [21]. Furthermore, understanding the most common diseases that affect laying hens is important for the adoption of health management programs. Many diseases, especially viruses, have no specific cure. Other have a cure, but can make activities inside the facilities unfeasible. Therefore, the best approach is prevention, which includes disinfection, vaccination, and biosecurity. These practices must be applied to both conventional and alternative laying hen systems for the minimum disease risk [22].

The laying hen systems are classified as conventional (in cages) or alternative (cage-free, free-range, organic, and "colonial"), with the major difference between them being the management adopted and the facilities design.

In the conventional system, laying hens live under a high degree of seclusion and population density (average of 18 hens / m^2), interfering with their natural behavior [13]. They are unable to move freely, extend their wings or stand up completely inside the cage [15]. This occurs because in most designs, the cages are small and inclined so that eggs roll down onto the collection belt [12]. It is common the laying hens try to practice natural habits such as scratching and bathing in sand. However, there is no space or litter material for these activities, causing frustration and stress [23]. There are ways to improve the welfare of laying hens in cages, increasing their areas and including objects for environmental enrichment, such as perches, nests, litter, and claw-shortening devices [6,24]. However, even enriched, and larger cages are not capable of fully achieving hen welfare objectives [25], as there will always be some type of limitation in the natural behavior of the hens.

In the cage-free system, laying hens are enclosed in a facility, without access to external pastures, but provided with perches, nest boxes, and foraging substrates [5]. All requirements of the cage-free system apply to the free-range one, but in addition the laying hens have daily access to an uncovered outdoor area, also called external pasture or paddock [15]. In the free-range systems, the facility is a refuge for the laying hens, protecting them from the severe weather and predators, mainly at night [26]. The differences between free-range, organic, and "colonial" systems are related to management and feeding, as well as densities of hens in the paddock. In Brazil, egg laying systems can be called organic only when they have been designed and managed according to additional legislation [27,28]. Other countries also provide specific regulations when organic eggs are produced [29]. The Brazilian legislation also recognizes the "colonial" system, in which rustic hen breeds are free to pasture and feed comes exclusively from plant sources, without any synthetic additive or growth hormone [30]. The produced eggs in this system are called "caipira" or "capoeira", generally associated with an unsophisticated production process but praised by consumers for their taste and egg yolk color [31]. In Brazil, the building and management of the alternative laying hen systems are subjected to the standards established by Humane Farm Animal Care [26], as well as normative instructions and other legislation [6,9,30,32,33]. However, there are no specific regulations or directives that deal with the transition from conventional to alternative systems.

Technical Requirements for Laying Hen Systems in Brazil

The operational procedures for raising laying hens in Brazil, as well as the technical standards for registration, inspection, and control of poultry facilities, are included in the National Poultry Health Program of the Ministry of Agriculture, Livestock, and Supply. These procedures are complemented by documents published by other governmental and non-governmental institutions with specific recommendations, including technical aspects about the facilities and management of laying hen systems. For situations where there is no national regulation, international legislation is used. Following these documents is important, since they ensure consistency, quality, and compliance within the Brazilian laying hen sector, which is quite heterogeneous, including large fully automated and rustic small-scale systems.

The Directive 74 [6] lay down the minimum standards for the protection of laying hens in the European Union, and are followed in Brazil for establishing parameters applicable both to enriched cages and alternative systems.

The Normative Instruction 56/2008 [9] recommends good practices for production animals, taking into account several principles to ensure the animal welfare in the different phases of breeding, from birth to rearing, and transportation. It also includes recommendations regarding appropriate management and nutrition for the different life stages of the animals. The main objectives are to reduce stress, avoiding unnecessary pain during transport and management, as well as ensuring a hygienic and safe breeding environment. The Normative Instruction 36/2012 [33] adds to Normative Instruction 56/2008 procedures relating to the registration, inspection, and health control of breeding by commercial, teaching, and research poultry establishments.

The Circular 004/2009 [32] deals with control standards based on the egg production process and egg products. It is an application guideline, listing all factors that can affect the quality of the products from a hygiene standpoint. The Normative Instructions 46/2011 and 17/2014 [27,28] are specific to the organic eggs, establishing the substances and practices allowed for their production. The Brazilian Regulatory Standard 16437/2016 [30] specifies the requirements for the production, classification, and identification of "colonial" eggs, but the recommendations are also applied to cage-free and free-range systems. Since 2017, the Humane Farm Animal Care program [26] has certified eggs produced in alternative systems in accordance with Brazilian Technical Standards Association. Thus, after completing a satisfactory annual inspection, producers and their properties can use the Certified Humane Raised and Handled label.

Tables 1 and 2 presents the main design parameters for the alternative laying hen systems, in accordance with the revised documents, as well as the procedures recommended by specialized institutions. The values presented refer to the laying phase (18 to 110 weeks of age). In the cage-free system, hens can be raised with or without litter [12].

The pasture is defined as any uncovered external area adjacent to the building for access by the laying hens, enclosed by a fence with a mesh or other material capable of keeping terrestrial predators out, also avoiding that hens escape [12]. Additionally, it shall consist mainly of living vegetation, with coarse grit available to help hen digestion [30]. Wire mesh and bamboo, wood, masonry, or prefabricated posts can be used as pasture fencing materials [13]. Ground coverings such as gravel, mulch, sand, and straw can be used when vegetation is not possible [26]. The pasture area must be designed and managed to minimize the risk of become degraded, contaminated, or waterlogged. To meet this purpose, it is possible to adopt rotational management of the pasture, delimiting smaller areas within the range area and alternating occupation by the hens, so that some areas are under grazing and others are in recovery [12]. Cover, like trees, shrubs, or artificial structures are required

throughout the pasture to reduce the fear of hens to overhead predators, also encouraging the use of this area by the hens [26,27,28]. It is also recommended to install shelters from severe weather and predators, as well as, if necessary, appropriate water drinking troughs [6]. If afforestation is used, non-fruit species should be chosen, keeping them pruned in order to minimize their use by other bird species [36].

Table 1: Design parameters for laying hen systems.

Requisites	Cage-free	Free-range "Colonial" Organic	Reference
Pasture density	Not applicable	0.17 m^2 / hen (free-range) 0.50 m^2 / hen ("colonial") 3.00 m^2 / hen (organic)	[27,30]
Individual nest boxes	5 hens / nest 0.30 x 0.30 x 0.35 m	7 hens / nest 0.30 x 0.30 x 0.35 m	[12,34,35]
Community nest	0.80 m^2 / 100 hens		[26]
Stocking density	7 hens / m^2 (cage-free, free-range, "colonial") 6 hens / m^2 (organic)		[28,30]
Double sided feeder	0.05 m linear / hen		[13,26]
Single sided feeder	0.10 m linear / hen		[13,26]
Circular feeder	Perimeter space of 0.04 m / hen		[13,26]
Bell drinker	1 / 100 hens		[13,26]
Nipple drinker	1 / 12 hens		[13,26]
Troughs	0.013 m linear / hen		[13,26]
Perches	Linear perch space of 0.15 m / hen Diameter of 0.025 to 0.075 m Minimal distance between perches of 0.30 m Minimal distance between perch and wall of 0.20 m Lower perch height of 0.40 m		[6,13,26]

The house (facility) is the building in which the laying hens are enclosed, with the same productive purpose and with the same sanitary conditions [30]. It must be positioned longitudinally in an East-West direction, aiming to minimize the direct incidence of solar radiation inside [13]. The recommended house width is related to the climate of the region where it will be located, varying from 3 to 10 m for hot and humid climates, and from 10 to 14 m for hot and dry climates [37]. The most common widths found in practice are between 10 and 12 m [34]. The facility must also have doors at its gables, with dimensions of 1.50 x 2.10 m, to facilitate the installation and maintenance of feeders, drinkers, and nests, in addition to management practices [34,38]. In the case of houses for alternative laying hen raising, there are single and multi-tier floor systems, the latter being incipient in Brazil [12]. Therefore, Table 1 includes the design parameters considering single-floor facilities. Concrete floors are preferable inside the building as they can be cleaned and disinfected more effectively [26]. It is also recommended making available a usable area within the house, where hens can engage in a variety of natural behaviors, such as perching, scratching, exploring, and socializing [6,36]. Nesting areas and elevated perches must not be considered as usable areas [6,26].

Table 2: Constructive aspects for laying hen systems.

Requisites	Cage-free	Free-range "Colonial" Organic	Reference
Pasture fence	Not applicable	1.00 m of height and 5.00 m from the building	[13,30]
House lateral exit areas	Not applicable	One every 15.00 m Height of 0.46 m Width of 0.53 m	[12,26]
Minimum house ceiling height	3.00 m		[13,36]
House eaves	1.00 m		[40]
House sidewall height	0.30 to 0.50 m		[38,39]
House sidewall closing	1.00-inch mesh screen (2.54 cm^2)		[30,33]
Single level floor	Minimal thickness from 0.10 to 0.15 m		[13,26]
Usable area	Width of 0.30 m Maximum floor slope of 14% Minimum headroom of 0.45 m		[6,13]
Litter area	Minimal thickness from 0.10 to 0.15 m Minimum of 15% available floor space		[12,26]

Providing dark and secluded nesting boxes within the facility is the most common practice to encourage hens to lay their eggs in the alternative systems, which also reduces the risk of cannibalism [35]. The individual nests must contain substrate (hay, straw, rice husks, wood shavings, plastic astroturf net pads) that encourages laying behavior [12], and be closed at night, as a way of preventing hens from accessing them to sleep [36]. It is important to periodically replenish, replace, and clean the nest substrate, aiming at maintaining a healthy environment for the hens [26].

The litter area must be composed by a friable material that enables the hens to satisfy their ethological needs [6]. Wood shavings, pine powder, or rice husks are suitable as litter materials [13]. A well-designed litter area must have a sufficient depth for dilution of feces, minimizing contamination and allowing hens to express their natural behavior [26]. Additionally, litter shall be replaced or topped up, in order to not become wet, contaminated by insects, mites, or other agent harmful to the hens [36].

Brazilian normative indicates that feeders and drinkers must only be installed inside the house [27,28], while European Union mentions the possibility of placing drinkers also in the pasture, provided they are suitable to avoid water contamination or access by other birds [6]. When bell or nipple drinkers are installed in the facility, adjustment is required to avoid wet litter conditions [26]. Additionally, drinkers and feeders must be placed at an optimum height for the size and age of the hens. Bell and nipple drinkers must be located 0.05 m above the hen back, while the edge of the circular feeder must be adjusted at the level of the hen back [41]. It is recommended that feeders and drinkers are distributed no more than 7 m from each other, so that hens do not walk more than this distance to access feed and water [13]. It is also indicated to install abrasive strips attached to the front feeders, if hen claws are not properly

worn. Long claws can lead to physical damages, reducing the welfare of the hens. Lower water intake reduces feed intake, affecting the hen nutrition [26]. The hens consume small amounts of water (approximately 150 to 280 mL day^{-1}) and feed (approximately 104 to 152 g day^{-1}), with this consumption being related to laying period, stress, among other factors [42,43]. However, the frequency of consumption is high, with hens drinking approximately 8 times per hour during the daylight period [44].

The facility roof materials must protect against the weather and provide thermal efficiency, with the use of plastic ceiling inside the installation being recommended [13]. Different types of tiles can be used as roof material such as ceramic, metal, fiber cement or combinations of insulating materials (sandwich tiles). The current trend is to use aluzinc tiles (composition of aluminum, zinc, and silicon), which require a simpler support structure and present greater protection against corrosion, also meeting the thermal comfort criteria [36,45]. A roof slope between of 20° to 30° is indicated, with the installation of a ridge opening improving ventilation in the poultry house. The ridge opening must be equipped with a system that allows easy opening (manual or automatic), and with wire mesh to prevent predators or other birds from entering. The minimum horizontal opening shall be equal to 10% of the width of the facility, with overlapping roofs spaced at a distance of 5% of the width of the house or 0.4 m at least [38].

The house sidewalls must be made of 1-inch metallic mesh screen (2.54 cm^2), supported by reinforced concrete pillars and secured close to the floor in a masonry half wall (0.30 to 0.50 m). It is recommended to leave a 45º slope on the upper half wall edge (from outside to within the house) to avoid the hens perching and the deposition of waste [40]. On the outside of the sidewalls, adjustable curtains must be installed that are opened or closed to control the air flow that enters the house (natural ventilation), improving the thermal comfort of the hens and reducing the concentration of gases (ammonia and CO_2). Low density polyethylene film or equivalent curtain are generally used, and may be transparent, blue, or yellow, depending on its use in managing intermittent lighting scheme [13,39]. Thus, sidewalls must prevent the house from solar radiation, water seepage, and predators [38]. The sidewall openings shall be built with tilting or sliding doors [40].

Perches cannot have sharp edges and their ends must be covered if made of hollow material. Ideally, they should be made of non-slip material and be reasonably clean and dry [26]. Also, they must be located to minimize dirtying of any hens below, being over a dropping pit or manure belt [13]. Furthermore, at least 20% of perches need be between 0.4 and 1.0 m above the adjacent floor, allowing hens to jump at a maximum angle of 45° [26]. Square perches are most advantageous with relation to the contact area of hen keel bones, while oval perches are more suitable for hen foot pads. The newly soft perches can reduce both keel bone and foot pad pressure peaks, but the round steel perch, most used in laying hen systems, was least favorable due to the smallest keel bone and foot pad contact areas [46].

The facilities must also have a footbath at the entrance to the house, with quicklime or an appropriate liquid solution for disinfecting shoes. The footbath must be accessible exclusively to employees and isolated from hens [30]. It is important that the footbath exceeds the width of the doors by 0.4 m on each side, with a width of 1 m and a depth of 0.05 m [38], preferably covered by the roof. Laying systems with more than 1000 hens require another sanitary barrier to sanitize vehicles that occasionally access the production area, called wheel dip [13]. Like the footbath, the wheel dip is a shallow tank or trough which contains a sanitizing solution, but with ample dimensions for the passage of vehicles.

A warehouse must be built nearby the facilities for storing equipment and feed [36]. This building must be of masonry construction, with a specific space to also store control documents. Feed storage can also be done in metal silos with a conical bottom that are connected to the automated feeder system. All electrical installations must be inaccessible to the hens, isolated, protected against rodents and adequately grounded [13].

Challenges of Alternative Laying Hen Systems in Brazil

Brazil is a continental country with diverse tropical climate, and regions experiencing varying air temperatures and humidity levels [10]. This can pose challenges for maintaining optimal conditions within alternative laying hen facilities. For this, following the design parameters, constructive aspects, and management recommendations for these systems are essential [36]. Despite the advances associated with the various standards and directives established for alternative laying hen production in Brazil, more regulation, incentives, and dissemination of information about these systems are required. Furthermore, more specific protocols that enable to ensure the welfare of laying hens are necessary, especially those related to the design and building of the facilities, as well as elements that compose them (nests, perches, litter area, among others), and which are directly related to the natural behavior of the hens. Additionally, the current standards are recommendations to be followed, but they do not correspond to laws capable of regulating the design and management of these facilities, also imposing sanctions in case of non-compliance. Thus, the need for more specific legislation for this topic, as it already exists in other countries, is an important demand in Brazil.

Globally, installing new alternative laying hen systems or converting existing conventional systems to alternative ones requires significant investment in infrastructure and buildings, as well as training due to the different management practices [4,5]. Operating costs are around 41% more expensive in cage-free, free-range, “colonial”, and organic production. Furthermore, alternative systems generally require more space per hen compared to conventional ones [8]. These costs and training requirement can be a barrier for many Brazilian producers. However, agricultural credit lines with low interest rates can incentive the investment or the migration from conventional to alternative systems. Also, to overcome the demand for specialized labor, more studies on the technical and economic feasibility of these systems can help the training procedures, in addition to raise awareness among producers regarding the adoption of alternative systems.

The scientific community has reporting and discussing many management challenges in alternative laying hen systems, which are also applied to Brazilian conditions. This discussion has created a bias in the literature where the alternative system problems are evidenced, but successful examples are less well documented, leading to exploitation to slow policy changes [2]. Special attention must be paid to cannibalism problems, fowl mite infestation, significant feather loss, bone fractures, and keel bone deformation [26]. Pasture access benefits the hens, improving plumage condition and reducing footpad dermatitis. However, this practice increases susceptibility to disease, predation, and parasites in comparison to conventional systems. The solutions for this include identifying the best management procedures for each specific condition, performing an adequate genetic selection, and redesigning pasture spaces to be attractive and protective to the hens [47]. Better parasite control and lower stocking densities tend to improve hen welfare in the alternative systems, potentially enhancing profitability [5]. Breeding and genetics also reduce the incidence of skeletal hen damages in alternative systems, such as bone fractures and keel bone deformations. The perch shape and type highly affect the keel bones and foot pads in laying hens, requiring a proper design and placement [46]. Generally, a key observation is that most of the challenge solutions are already available, requiring a better dissemination of existing information and guidance [2].

Final Considerations

Alternative laying hen systems have become increasingly widespread, and are considered successful on different scales from developing countries to those with high human development index. Ongoing research and regulation are required for spreading these alternative systems in

Brazil, encouraging their implementation, and facilitating migration from the conventional system. Addressing the challenges and better disseminating the information already available requires collaboration among producers, retailers, government, researchers, and education institutions, as well as consumers, to promote sustainable egg production practices in Brazil.

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