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Review on Effect of Different Housing System on Production and Health Performance of Chickens

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Abstract

By generating revenue and ensuring food security for households, poultry production plays a significant part in reducing poverty. A key factor which determine optimum health, growth and productive performance of the birds is poultry housing system. A review was conducted with the aim of bringing summarized information to the beneficiaries about various poultry housing systems and their impact on chicken health and productivity. The review integrates both global and regional perspectives on poultry housing with a strong emphasis on African and Ethiopian contexts. In terms of production, there are findings showing that animals raised in intensive housing systems outperform than those raised in semi-intensive and free-range systems, with respect to egg weight, egg size, egg production percentage, and carcass percentage. Conversely, compared to cage systems that produce high-quality eggs and meat, birds housed in alternative systems exhibit greater levels of comfort and behavioral activity. On the other hand, organic (free range) housing systems have greater rates of disease incidence, cannibalism, and feather pecking. Ethiopian has diverse agroecological zones that ranges from hot, arid lowlands to cooler highland zones which poses several challenges to poultry health and productivity. High ambient temperatures and varying humidity levels caused by climate change can cause heat stress in birds which exacerbated within enclosed poultry housing systems. Therefore, suitable housing systems that focus not only on production but also on the animals' well-being and better behavioral activities are recommended for both quality and efficient productive performance.

Keywords: Egg; Health; Housing System; Meat; Organic; Productive Performance

Introduction

In recent years, poultry production has taken the lead in the global agriculture sector [1]. Poultry production increased at the fastest rate in Asia, South America, and Africa due to their fast urbanization, poverty, and hot environment [2]. For both small--scale and commercial chicken farming, housing system is very essential. The housing system is an external factors that affects the chickens' performance as well as the qualities of their eggs and meats. It is apparent that every system has pros and cons in relation to animal/bird health, welfare and performance [3].

The internal climatic conditions of a poultry house is crucial for maintaining the health, growth, and productivity of the birds, and this is determined by the design of the housing. Thus, the kind of chicken housing system that the suggested poultry farm uses depends on the local climate in the area where the farm is situated [4]. While the controlled housing system is most prevalent in temperate regions of the world, the open poultry house system has been deemed a good method of housing in tropical countries due to its ease of construction, ease of heat management, and minimal management cost [5].

The extreme temperatures and humidity of the tropical region might be dangerous to poultry birds if improperly handled. Heat stress and, in severe situations, even mortality can be resulted from high temperatures and humidity [6]. It is true that heat stress has been shown to reduce feed intake, feed efficiency, egg quality and quantity, and flock activity, which in turn increases pulse and respiration rates, water intake and mortality ([7].

Ethiopia's poultry industry can be divided into three main production systems according to a few chosen criteria, including breed, flock size, housing, feed, health, technology, and biosecurity. These poultry production systems are village or backyard, large commercial and small scale commercial. Certain chicken breeds, inputs, and production characteristics are unique to these production systems. Each can production system contributes to solve the socio-economic problems of different target societies [8].

Low input, low output, and the recurring loss of a large proportion of the flock due to disease outbreaks are the hallmarks of the backyard (traditional) poultry production system [8]. Since the 1950s, Ethiopia has imported several exotic chicken breeds, including Rhode Island Red, Australorp, New Hampshire, and White Leghorns, with the goal of increasing poultry productivity. Since then, numerous unusual chicken breeds have been distributed to rural farmers and small-scale poultry producers in metropolitan areas by higher education institutions, research organizations, the Ministry of Agriculture, and non-governmental organizations (NGOs) [9].

Ethiopian has diverse agroecological zones that ranges from hot, arid lowlands to cooler highland zones paired with a huge number of plant and animal species, for a long, which poses several challenges to poultry health and productivity [10]. Chickens are predominantly vulnerable to climate change because they can only tolerate narrow ranges of temperatures beyond which reproduction and growth are negatively affected. Further, increases in temperature caused by climate change cause heat stress in birds which exacerbated within enclosed poultry housing systems [11].

To inhance poultry production and health, compiled information about the role of different housing system on production and health performance of chickens very essential. Therefore, the objective of this review paper is to provide a comprehensive overview on poultry housing system and its possible effect on egg and meat production and health performance of chickens.

Methodology

A comprehensive search was conducted using combinations of the terms chicken, housing, layer, health, effect, performance, and broiler to find studies that looked into the impact of various housing systems on the productivity and health performance

of chickens as well as some related issues in Scopus, PubMed, Google Scholar, Google, and AGORA (Access to Global Online Research in Agriculture). literature review was conducted with a focus on English-language studies (2000–2024) that discuss poultry housing systems, production, and management, with preference for African and Ethiopian data. The review primarily relied on published, peer-reviewed sources, potentially excluding unpublished reports, theses, or local agricultural data, which might offer more context-specific insights. The references from each of these searches were carefully examined in order to comprehend and contrast their results. To ensure that the material reported in these references was accurate and comprehensive, they underwent another revision. For the review, thorough pertinent data were gathered, collated, illustrated, and cited.

Poultry Housing System

Housing is essential for keeping environmental conditions within the operator's control when raising chicken for eggs or meat. It facilitates the most efficient use of feed energy for productive uses as opposed to mitigating the consequences of adverse weather. According to researches, the housing system has an impact on a variety of chicken's products, including live weight gains, mortality, feed efficiency, egg size, egg shell thickness, and blood spots in the egg [12].

Types of Poultry Housing Systems

There are four housing schemes that chicken keepers often adhere to. The amount of land and the available funds heavily influence the sort of housing that is chosen.

Free range system

Backyard farming is another name for the free-range approach. Scavenging provides nearly all of the diet in this system, which is low in input. Other characteristics include low veterinary service, low biosecurity, high offtake rates, and high mortality. Here, the inputs for shelter, food, and healthcare are either minimal or nonexistent. Therefore, it doesn't require any additional investments beyond the price of the foundation stock, a few handfuls of local grains, and maybe some basic night shades mostly for the family's nighttime residence. The human population is housed near to the chickens. The majority of chickens kept under this method are native breeds, while some hybrid and foreign breed may also be kept [13].

Figure 1: Free Range System

Semi-intensive system

As the name suggests, birds are raised partially on ranges or in houses; that is, they are kept inside during the night and are allowed access to runs when necessary. While runs are only fields, houses have solid floors. The upkeep of run conditions to lower contamination is essential for success of rearing. For adults, the stocking density rate is 750 birds per hectare on average. Additionally, there is very little control over the birds here, making it impossible to use scientific management techniques. The approach is used for duck rearing to some extent. Houses provide facilities for watering and feeding animals [15].

Folding unit System

Folding unit system is more recent innovation. Daily rotation of moveable folding unit provide birds with fresh ground. Not insignificantly, the herbage provides a healthy and durable source of food for the birds as well. For the farmer, there is an additional advantage to plowing and fertilizing. The drawbacks of this housing system includes extra labor which is needed for the frequent movement of the fold units and to provide food, drink, and eggs to the birds [16].

Figure 2: Folding unit System

Intensive system

Intensive system completely confines the birds indoors, denying them access to the outdoors; it is usually employed in places with limited or expensive land. This system mostly relies on imported exotic breeds, which have high input needs for things like nutrition, housing, healthcare, and an advanced management system. Higher productivity is a defining feature of this system, wherein poultry production is fully focused on the market to satisfy the substantial demand for poultry in major cities. Chick mortality rates have been brought down to just 5% because of the implementation of improved biosecurity measures [17]. There are three intensive poultry production system namely: Wire floor, deep litter and battery (cage system).

Wire floor: In this system, the control of internal parasites and bacterial diseases is improved. Nevertheless, the house typically has high humidity, the birds seem anxious, the rate of egg breaking is high, and the feather peaking is high [18].

Battery cage system: Battery cages are a type of housing used for several animal production techniques, but primarily for egg-laying hens. As in an artillery battery, the name refers to the configuration of connected identical cages arranged in rows and columns. For various animals, comparable cage systems are employed, despite the fact that the term is primarily associated with chicken husbandry. Those who support animal welfare and industrial companies have disagreed over battery cages [19]. According to [20] the majority of laying hens in the globe are housed in robotic cages. Although the system lessen aggression and cannibalism in chicken, it prohibit many natural behaviors, limit movement and raise the risk of osteoporosis

Figure 3: Battery cage system

Deep litter system: Under this approach, a minimum of one-third of the floor space is covered with litter, such as wood shavings, sand, turf, or straw, and the hens have access to a sizable enough portion of the floor space to gather bird droppings. No more than seven birds per square meter of usable floor space should be stocked [21].

Figure 4: Deep litter system

Effect of Housing system on Layer Chicken`s Productivity

According to [22], hens kept in the intensive system performed better in terms of productivity (greater egg weight, egg mass, and egg production%) and were heavier in weeks 26 and 46 than chickens raised in the semi-intensive and free-range systems. The most plausible reason for the chickens' reduced body weight is because they spend more time moving about and being more active in a free-range environment, which burns more calories. These variations in productive capacity align with the results of [23], who discovered that Indigenous Aseel chicken raised in confined and semi-intensive systems performed more productively. Additionally, [24] found that genotypes of Botswana chickens raised in intensive housing systems had superior semen quality features, which in turn led to better fertility. On the other hand, [22]research revealed that hens kept in intensive and semi-intensive systems had lower rates of hatchability and fertility than free-range hens. This is consistent with research by [25], which showed that raising guinea hens on the free range enhanced their physiological and reproductive abilities.

The findings of [3] indicate that eggs produced by birds raised in cage housing had significantly ($P<0.05$) higher egg quality traits such as albumen index, yolk index, and Haugh unit score than eggs raised in deep litter housing. The study also found

that there was a lower feed consumption and body weight at sexual maturity, as well as better feed conversion, and economic returns in cages as opposed to deep litter housing.

During the laying phase, which lasted from 18 to 76 weeks, an industrial experiment using ISA-Brown commercial layers revealed that the egg productivity of layers raised in barns was 1.67 percent lower and 2.56% lower than that of layers kept in conventional and enriched cages respectively. Generally the study conclude that, cages are the most economical way to produce eggs and the best system for disease prevention [26]. According to the report of [27] even among birds with untrimmed beaks, cannibalism is unusual in battery cages. However, it should be emphasized that beak cutting is common for pullets that will eventually be housed in cages, in part to prevent feather pecking.

As indicated by [28] and [29] discovered that furnished cages have more fractured eggs than traditional cages. Comparably, furnished cages had a higher percentage of cracked eggs ($P \leq 0.01$) than an alternate production technique (4.1%), according to [30]. Because the nest area in furnished cages is small, there is a chance that eggs will collide. Comparing furnished cages to traditional cages, [31] found a decreased percentage of shattered eggs. Eggshell damage in cage, free-range, and organic systems did not differ much, according to [32]. The study of [33] found no correlation between the housing arrangement of White Leghorn W-36 layers raised in conventional and furnished cages starting at 19 weeks of age and shell thickness. The aforementioned data indicates that the quantity of soiled and fractured eggs is not significantly impacted by the housing system, but alternative systems tend to have higher levels of bacterial contamination on the eggshells.

A number of investigations and comparisons between laying hens raised in conventional and organic systems have been conducted to examine and compare many aspects of egg quality, such as egg, albumen, yolk, shell weight, albumen height, eggshell breaking strength and thickness, yolk color, and whipping capability. According to a study by [34], the hen rearing technique had no effect on the percentage of eggshell, but the eggs produced in the conventional system had a higher egg shell strength. Compared to conventional yolks, organic yolks were paler. The protein and lipid concentrations of organic eggs were considerably greater. The weights of the yolk, albumen, and eggshell were statistically lower in the eggs produced using the organic method than in the conventional one, making the eggs derived from it lighter. In the organic eggs, the yolk/albumen ratio was lower (0.38 vs. 0.39). Conversely, [32] found that compared to conventional eggs, organic eggs were heavier and had superior breaking strength. According to [32] and [34], eggs from conventional systems had higher values of yolk color.

Effect of Housing System on Broiler Chicken`s Productivity

Study carried out to determine how housing systems affected the production of Arbor acres and Hubbard broiler breeder strains showed that breeder farms with controlled housing systems produced more eggs overall and at their peak production average than those with open housing systems. In spite of the initial increased expense, it concludes that breeding farm owners should use an environmentally controlled housing system [35]. According to the study done to compare the percentage of carcass and production performance of broilers raised in cage systems versus those raised on the floor, raising broilers in cages result in higher production efficiency than raising them on the ground [36].

There is one common belief that organic hens are safer and healthier than conventional ones, thus they're prepared to spend more for free-range or certified organic chicken meat[37][38].There is debate about whether alternative rearing methods provide chicken meat with higher quality and flavor than traditional methods when it comes to qualitative aspects. Prior research indicated that elements of meat quality qualities are significantly influenced by the strain of the bird and the type of rearing method [39][37][40][41].

Because they are encouraged to forage and profit from the flora, broilers raised in alternative production methods increase their choice of environment and what to eat [42][39]. The quality of chicken meat should therefore improve as a result of out-

door access and feeding on organic diets. Meat quality from conventional, free-range, and organic broiler production methods has been examined in an increasing number of studies [42][43]. However, not many research have examined the characteristics of meat quality in slow-growing broiler genotypes that are not allowed access to the outdoors [41].

According to [39], because of the superior welfare conditions, high quality of the carcass and meat, appears to be a good in the organic production system. Conversely, [44] found no evidence that the fatty acid profile of meat from free-range hens was healthier than that of chickens raised intensively; in fact, in several ways, the opposite was true. According to [45] aside from yellowness, the organic rearing method had no additional positive effects on the quality of chicken meat when compared to conventional methods.

A free-range housing system dramatically reduced the broiler chicks' overall feed consumption and body weight, according to research by [46]. This study found that although the fatty acid makeup of breast meat is similar, the housing systems had an impact on the meat's color, specifically its redness and yellowness. In birds raised on free range, the color of the breast meat exhibits a decrease in redness and an increase in yellowness. The birds raised conventionally had significantly greater levels of plasma triglycerides and very low density lipoprotein (VLDL) than birds raised free-range. In general, these results indicate that a longer growing period was required.

The study of [47] aimed at assessing the effects of different housing conditions on both feed conversion ratio and mortality of male broiler flocks indicates that feed conversion rate was significantly increased by concrete floors, negative ventilation, blue curtains, fluorescent lighting, owner management, tap water, and well water.

About 80% of consumers globally favor chicken products derived from free-range (organic) systems with increased welfare standards that are perceived higher quality. The bulk (about 70%) of intensive production systems currently in use do not typically fulfill the natural behavioral needs of chickens, according to published literature. In outdoor production systems, the productive performance is not efficient because of cannibalism and disease incidence which causes mortality that can exceed 10%. Based on the studies of [48] it has been concluded that floor housing performed better and had higher-quality carcasses during the analyzed time.

Effect of Housing Systems on Health of Chickens

Chickens are housed in cage systems or alternative systems under commercial housing conditions. Housing types primarily vary in terms of environment complexity, mobility freedom, and group size [49]. Alternative housing options include loose housing outside (such as organic systems and free range (FR)) and indoors (such as single- and multi-tier floor pens (FP)). Compared to cage systems, birds housed in alternative systems are able to exhibit a greater degree of comfort and activity as well as their entire natural behavioral repertoire. However, [50] found that birds housed in alternate systems exhibit higher levels of aggression, feather pecking, cannibalism, and disease incidence.

Bacteria such as *Streptococcus faecalis, Salmonella spp., Enterobacter aerogenes,* and *Seratia marcesces* were shown to be considerably influenced by the housing systems, according to a study that looked into the health status of broiler chickens under various housing conditions by [51]. This study showed highest total bacterial load count ($10^8 \times 10^6$CFU) in the bird raised in a colony cage system due to the fact that the cages were stationary during the experimental period, which was followed by a bird raised in a fold unit housing system with $10^2 \times 10^6$CFU and a bird raised in a conventional deep litter housing system with 98×10^6CFU.

But according to [52], compared to a cage system, a deep litter housing environment dramatically increased the numbers of aerobic bacteria and *Staphylococcus spp*. This study also shows that the types of housing had a substantial impact on the overall

fungus count in eggshells. In general, the study demonstrated that compared to eggshells produced from battery cage housing systems, the mean microbial counts of eggshells produced from deep litter housing systems were much higher. Similarly [53] also reported that eggs from residences that kept laying hens away from shaving and manure had reduced bacterial levels.

Eggshells from furnished cages had considerably fewer bacteria on them than those from the alternative method, according to [30]. The same investigators did not discover any statistically significant variations in the percentage of enterobacteria on eggshells between the alternate systems and the cage. In contrary, Enterobacteria counts on eggshells varied statistically significantly between conventional and furnished cages, according to [28]. (12.3% in furnished cages vs. 5.8% in conventional cages). According to [54], compared to eggs from traditional cages, free-range eggs had a roughly 1-log increase in aerobic bacterial contamination. However, [55] did not find any differences in gram-negative bacteria counts on eggshells between conventional cages, furnished cages and aviaries. Generally, this study concluded that, that bacterial contamination of eggs is determined by the production system but farm organization and management also play important roles.

According to research by [56], broilers maintained in cages had lower isolation rates of Campylobacter than broilers raised on the ground, suggesting that birds housed in cages have better sanitary conditions than those produced on the floor. Furthermore, it was discovered that the immune systems of the birds grown in cages outperformed than those raised on the ground in a few specific areas. Additionally, compared to broilers kept in cages, [57] found that broilers grown on the floor absorbed unpleasant fumes and litter particles, which hampered pulmonary gas exchange and raised the arterial partial pressure of CO2.

According to [58], broilers maintained in cages have better wing bones than those bred on the ground, and their humerus's proliferative zone, hypertrophic zone, and overall growth plate are all larger. These data collectively suggest that rearing broilers in cages may result in the production of higher-quality, healthier birds.

Using White Leghorn hens as stress indicators, the study looked at how housing arrangements affected the birds' physiological responses, indicates that compared to hens kept in regular cages, those kept in floor pens had far more telomeric DNA in their kidney, spleen, and lymphocytes. Moreover, it shows that hens grown on floor pens suffered less damage to their DNA than chickens raised in traditional cages. According to [48], the study's overall conclusion was that hens kept in floor pens experience less stress than those kept in traditional cages.

The finding of [59] found that compared to floor housing, cage housing had a greater incidence of wing fractures, wing and breast bruise cases. The study demonstrates that the frequency and severity of food pad lesions, as well as cases of shank and drumstick bruising, rose in floor housing.

Discussion

Housing system of poultry for egg or meat production is important as a means of keeping environmental conditions under the control of the operator. Research has shown that egg production rate, egg size, egg shell thickness, blood spot in the egg, feed efficiency, live weight gains and mortality are affected by housing system [60][61][62]. The studies regarding production performance parameters revealed the superiority of caged systems over uncaged systems. However, the welfare level of the free-range was higher, even though the production performance was lower than the other systems[61].

Based on various selected factors like breed, flock size, housing, feeding, health, technology, and bio-security, Ethiopia's poultry sector can be divided into three primary production systems. Large-scale commercial poultry production systems, small-scale commercial poultry production systems, and village or backyard poultry production systems are the three types of poultry production systems [17]. Chickens are raised in free-range systems in most villages, with the majority of their diet coming from scavenging: insects, maggots, seeds, and plant materials, with very tiny amounts of grain crop and table waste supplements

from the home. It covers 95-98 percent of the country's chicken production system and is not profitable due to its lack of market orientation. The housing mainly provides night shelter and protection from predators, but does not adequately safeguard chickens against environmental stressors or disease agents [63].

According to [64] one ot the key management difficulty of backyard poultry production systems is housing. Poor input, low output, and the recurring destruction of a major proportion of the flock due to disease outbreaks characterize this system of poultry production [65]. Backyard-reared chickens are generally low in productivity, producing (annually) around 40-60 small-sized eggs and varying degrees of hatchability, with low chick survival rate[66][67].

The study by [68] found that deep litter housing is the most common kind of commercial poultry farms housing in centeral Ethiopia. It was found that a negligible portion of farms grew chicken in cage systems. commercial poultry farms in Ethiopia primarily employ intensive housing systems characterized by indoor confinement of large numbers of birds, usually greater or equal to 10,000 per farm. These intensive systems support higher biosecurity, controlled feeding, and environmental management practices essential for commercial-scale production and higher productivity [17].

The study by [69] on *Salmonella* and *Escherichia coli* associated morbidity and mortality in layer chickens in Hawassa city, Southern Ethiopia was indicated that higher morbidity and mortality rates in chickens reared on deep litter systems than those reared on cage systems. In addition to that, this study indicated the higher morbidity and mortality in chickens kept in poorly maintained buildings due to the access of rodents to the poultry house. Rodents can transmit pathogens to chickens and contaminate feed and water. In addition, poorly constructed buildings also stress chickens due to the direct effects of temperature and sun light, which increase the susceptibility of chickens to diseases. This finding was supported by [70] which showed that environmental controlled sealed buildings positively influenced egg production percentages and reduced mortality in a hot humid tropical climate than open houses.

Conclusion and Recommendations

In intensive poultry housing systems, performance exceeds that of semi-intensive and free-range systems. However, many consumers prefer free-range products, believing they offer better quality and welfare. Research shows that better welfare in organic systems can lead to higher-quality carcasses, meat, and eggs. Despite the benefits of reduced stress and increased comfort for birds, issues like feather pecking, cannibalism, and higher disease prevalence remain significant concerns. In Ethiopia, traditional free-range systems characterize poultry production in many villages, while deep litter housing is the most common commercial poultry production. A key factor in the low productivity of the poultry sector is the inadequate protection of chickens from environmental stressors and diseases. Integration of improved semi-intensive systems could enhance both productivity and welfare of backyard poultry production in Ethiopian.

Based on the above conclusion the following recommendations are forwarded.

- Suitable housing systems that focus not only production but also on the animals' well-being and better behavioral activities are recommended for both quality and efficient productive performance
- Cage housing systems should constructed the way by which birds can express their full natural behaviour and more comfort as much as possible
- Alternative housing systems should built to provide suitable environments which reduces the bird's aggression, feather pecking, cannibalism and incidence of diseases.

- Simple devices that improve both production and chicken survival should be used for construction of poultry house by farmers.

- More detailed and comprehensive studies are needed to establish the impact of housing systems on egg and meat quality as well as health aspects.

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