

# Effect of heat stress on performance of layers and its mitigation: A review

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## Abstract

This review article mainly focusses on the effect of heat stress on growth performance, egg production, egg quality and potential mitigation of layer chicken. Reduced feed intake is probably the primary cause of heat stress's detrimental effects on production, as it reduces body weight, feed efficiency, egg output, and egg quality. Egg quality and production performance were adversely impacted by the reduction in feed intake and nutrient digestibility. Heat stress reduces egg production and has a negative impact on the behavior, welfare, and immunity of poultry, which causes farmers to suffer significant financial losses. Higher ambient temperatures can lead to poorer egg quality (soft shells or shell-less eggs), reduced hen skeletal integrity, and reproductive failure (fewer eggs). Poor hatchability rates result from the lower feed intake brought on by high temperatures, which also has an adverse influence on semen fertility and quality. The laying hens' eggs produced under extreme heat stress had lower Haugh units, egg yolk color, and eggshell thickness and strength. High stocking density, or overcrowding, has detrimental impacts on animals' health by lowering the quality of the environment overall and making it more competitive for resources like feed, which can finally result in feather pecking and cannibalism. The number of birds that can be grown in a particular home or farm may be decreased if stocking density is decreased to lessen heat stress. The development of heat-tolerant breed lines, in addition to appropriate management and dietary practices, should be taken into consideration in order to address the issue of heat stress.

**Keywords:** Layer chicken; Egg production; Egg quality; Heat stress; Mitigation.

## Introduction

Due to increasing meteorological conditions that raise ambient temperatures and humidity, climate change has become a major concern for the livestock business globally (Nawab et al., 2018). According to a number of studies, heat stress lowers laying hens' body weight, feed intake, egg production, fertility, and survivorship (Mashaly et al., 2004, Quinteiro-Filho et al., 2010, Barrett et al., 2019). The body weight, feed intake, egg production rate, and egg weight of 31-week-old laying hens exposed to heat stress for five weeks were all drastically reduced, according to Mashaly et al. (2004). Furthermore, heat-stressed laying hens produce lower-quality eggs (Allahverdi et al., 2013, Mashaly et al. 2004).

In both tropical and temperate nations, one of the most significant elements influencing laying hens' production performance is high environmental temperature. Reproductive failure (fewer eggs), poor egg quality (soft shells or shell-less eggs), and compromised hen skeletal integrity are the three main causes of these losses (Sahin et al., 2007).

When animals experience heat stress (HS), their body temperature rises because they are unable to release extra heat into the surrounding air (Sugiharto, 2020). There are two types of high temperatures in chicken production: acute, which are brief, abrupt bursts of extremely high temperatures, and chronic, which are prolonged bursts of elevated environmental temperatures. Serious physiological issues, immunological suppression, and an imbalance in gut microbes can result from either form of HS (Attia et al., 2018; Chang et al., 2020; Lara & Rostagno, 2013). According to Charles (2002), the ideal temperature range for the thermoneutral zone and performance is between 19 and 22 degrees Celsius for laying hens and 18 and 22 degrees Celsius for broiler growth. Because their body temperature is maintained at a steady level and they dissipate heat through regular activities, poultry birds in the "thermoneutral zone" do not experience heat stress (Charles, 2002).

Chickens under heat stress are unable to balance the generation of body heat with the loss of heat. A number of variables, including high ambient temperature, humidity, radiant heat, and airspeed, interact to produce heat stress; high ambient temperature is a major contributing component (Lara & Rostagno, 2013). The ideal thermoneutral temperature for chickens is between 18 and 21 degrees Celsius, but their usual body temperature is between 41 and 42 degrees Celsius. Poultry perform poorly when temperatures rise beyond 32°C because they reduce feed intake. Heat stress has deleterious effect on immune response in broilers (Taleb et al., 2025). Furthermore, as the temperature rises, there are more etiologically hazardous germs in the animals' immediate surroundings. Climate change affects the emergence and spread of disease because of an increase in parasites and bacteria. Acute or chronic heat stress may cause a decline in egg production (Deng et al. 2012; Ebeid et al. 2012), which in turn may lead to a rise in mortality and morbidity (Quinteiro-Filho et al. 2012) and significant financial losses (Abo Ghanima et al. 2020b).

Owing to the detrimental effects of heat stress on the health, welfare, and laying performance of laying hens, certain feeding techniques have become more significant and are used in commercial settings (Daghir, 2008). (Attia et al. 2016; Cramer et al. 2018; Saleh et al. 2018, 2020) These strategies include a variety of treatments such as feed additives supplementation into feed or water, such as natural antioxidants, organic acids, vitamins, minerals, electrolytes, prebiotics, probiotics, phytobiotics, feeding rationing, feed restriction, dietary changes, and drinking cold. Resolving global food security issues will need an understanding of the fundamentals of heat stress's sources, effects, and strategies for reducing or controlling this pervasive menace. There aren't many research that discuss how humidity and heat stress affect growth, production, and quality metrics. Thus, the purpose of this review was to assess how heat stress affects growth performance, egg output, egg quality, and possible mitigation.

### Effect of heat stress on growth performance

The decrease in feed intake may be due to the hens' attempt to maintain homeostasis by reducing their heat output (Etches et al., 2008). Barrett et al. (2019) found that heat stress decreased feed consumption. Reduced feed intake is probably the main cause of heat stress's detrimental effects on production, as it reduces body weight, feed efficiency, egg output, and egg quality (Barrett et al., 2019). After a 12-day heat stress phase, a daily feed intake drops of 28.58 g/bird resulted in a 28.8% decrease in egg production. Heat stress reduced feed conversion by 31.6%, egg production by 36.4%, and egg weight by 3.41% in laying hens (Star et al., 2009).

In a 12-day study, heat stress reduced laying hens' daily feed intake by 28.58g and their egg production by 28.8% (Zhang et al., 2017). In contrast to the control group, which gained 1.528 kg of body weight, the weight growth of layer hens exposed to 5 weeks of chronic heat stress (35°C) decreased to 1.233 kg. Heat-stressed chickens consumed less feed than the control group, which may have contributed to the considerable weight loss (Mashaly et al., 2004). The length of time the birds were under heat stress, the intensity of the heat, their age, or the genetic and physiological condition of the chickens could all be contributing factors to the variations (Nawab et al., 2018).

Heat stress causes poor growth rates in poultry raised in hot settings by lowering meat and egg production, reproductive performance, feed intake, and feed conversion efficiency (Shame et al., 2023). Meat quality, growth, and egg yield all suffer when feed intake is decreased. Poor growth performance in hot settings is mostly caused by a decrease in feed utilization efficiency (Shame et al., 2023).

High ambient temperatures are known to reduce the development rate and meat yield of commercial broilers (Zhang et al., 2017). High temperatures have an adverse effect on intestine development, resulting in decreased feed consumption, a higher death rate, and inferior weight increase (Rostagno, 2020). High temperatures can also cause respiratory alkalosis in broilers by upsetting their acid-base balance and increasing their respiratory rate (Scanes, 2015).

One of the main elements that adversely affects poultry output is heat stress, also known as hyperthermia, which is a consequence of global warming. Overheating reduces development, meat and egg production, feed intake, feed conversion efficiency, and reproductive function (Alverdy and Luo, 2017; Quinteiro-Filho et al., 2017; Rostagno, 2020). Poor hatchability rates result from the decreased feed intake brought on by high temperatures, which also has an adverse influence on semen fertility and quality (Nawab et al., 2018; Nyoni et al., 2019).

Poultry perform poorly in hot weather because they use more water and less feed (Saeed et al., 2019; Rahman and Hidayat, 2020). Due to a lack of calcium, laying hens produce fewer eggs, watery eggs, eggs with thin shells, or even eggs without shells at high temperatures. They also grow more slowly and are more prone to illness because of their weakened nutritional needs, as protein digestibility can drop by up to 9.7% (Habashy et al., 2017; Nawaz et al., 2021). High ambient temperatures have been shown to reduce the growth rates, feed efficiency, immunity, and carcass quality of broiler chickens (Dayyani and Bakhtiyari, 2013).

### **Effect of heat stress on egg production**

The number of eggs produced by hens kept in a hot chamber differed significantly from that of hens kept in regulated chambers (Mashaly et al., 2004). This implies that the production of eggs and the surrounding temperature are inversely related. Hens exposed to high temperatures produced 83.6 to 83.8 percent of their eggs, while chickens in the control group produced 93 to 93.2% of their eggs (Star et al., 2008).

Deng et al. (2012) found that during a 12-day heat stress phase, egg production decreased by 28.8%. In four genetically different strains of Egypt, it was also discovered that acute heat stress, which is defined as exposure to  $35 \pm 1^\circ\text{C}$  heat stress and  $55 \pm 5\%$  relative humidity for six hours, had a detrimental effect on egg quality and production. Egg production declined in Lohman Brown, Golden Sabathia (23.21%), Fayoumi (15.15%), and White Leghorn (28.57%) (Ghoname et al., 2022). Star et al. (2009) reported that laying hens under heat stress saw a 3.41% drop in egg weight and a 36.4% decrease in egg output. Moreover, heat stress has been shown to dramatically reduce eggshell weight (9.93%), thickness (1.2%), percentage (0.66%), and weight (3.24%) (Ebeid et al., 2012).

Heat stress led to thinner eggshells, more broken eggs, and poorer production performance (Lin et al., 2013). Additionally, heat stress has been shown to drastically reduce eggshell weight (9.93%), eggshell thickness (1.2%), eggshell weight (3.24%), and eggshell percent (0.66%).

According to Kirunda et al. (2001), White Leghorns' ability to produce eggs declined when exposed to high ambient temperatures. Production performance and egg quality were adversely influenced by the reduction in feed intake and nutrient digestibility (Song & King, 2015; Song et al., 2022; Zaboliet al., 2019). The reduction in feed consumption, which decreased the amount of nutrients available for egg production, was probably the cause of the decline in chicken egg output. According to Daniel and Balnave (1981), feed intake is decreased before egg production declines. In comparison to hens subjected to thermoneutral circumstances ( $21^\circ\text{C}$ , 68% Relative humidity), those exposed to severe heat stress ( $33^\circ\text{C}$ , 66% Relative humidity) showed a significant drop in laying performance markers, such as feed intake (-30%) and egg production rate (-11%) (Kim et al., 2024). Furthermore, the laying hens' eggs produced under extreme heat stress had lower Haugh units, egg yolk color, and eggshell thickness and strength. Additionally, hens exposed to extreme heat stress showed significantly higher serum  $\text{K}^+$  and lower  $\text{Na}^+$  levels than hens kept in thermoneutral conditions (Kim et al., 2024).

Heat stress lowers laying hens' feed intake, body weight, egg production, fertility, and survivorship, according to several research (Kim et al., 2012). The body weight, feed intake, egg production rate, and egg weight of 31-week-old laying hens exposed to heat stress for five weeks were all drastically reduced, according to Mashaly et al. (2004). Furthermore, heat-stressed laying hens produce lower-quality eggs (Mahmoud et al., 1996). According to Ebeid et al. (2012), heat stress has been shown to impair layer production performance by reducing eggshell thickness, increasing egg breakage, and increasing egg weight and percentage.

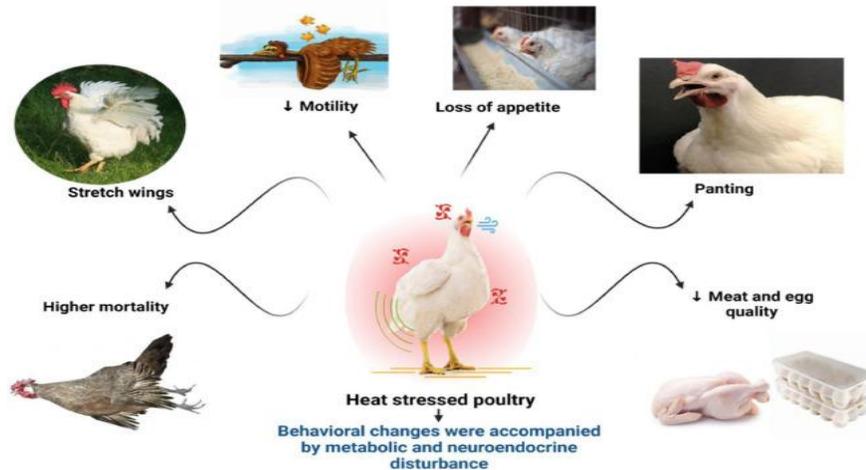
### Effect of heat stress on egg quality

Eggshell production is a complicated process that is influenced by nutrition, hormones, disease, management, and inheritance, according to a study by Kamanli et al., (2010). It is only feasible to produce high-quality eggshells when chickens are grown under optimal circumstances and all required elements are present and operating in harmony. Eggs from hens housed at higher temperatures had higher calcium content in their shells. This finding is consistent with that of Kamanli et al., (2010) who explained this by showing that calcium carbonate precipitation occurs more quickly at higher temperatures. Additionally, it's possible that the higher calcium deposition rate at the higher temperature led to the formation of larger crystals, which decreased the strength of the egg shell.

Heat stress, not a decrease in feed intake, is the primary cause of a drop in egg weight. The weight loss of egg albumen and yolk is also largely caused by high temperatures (Smith, A.J., 2005). These results are supported by the findings of Ugurlu et al. (2001) who hypothesized that one effect of heat exposure on chickens was decreased egg weights. Mashaly et al. (2004) found that high temperatures might greatly reduce the shell thickness and specific gravity in addition to the weights of the egg yolk, egg albumen, and shell.

Low feed intake can be partially explained by the distinctively poor eggshell quality of birds exposed to heat stress. According to reports from a number of studies, a drop in feed intake during high ambient temperatures compromises the quality of the egg shell. According to Elijah and Adedapo (2006), chickens' incapacity to consume enough feed required to produce egg shells at high ambient temperatures is the cause of small egg size, low egg production, and crack occurrence. An estimated 61.4 million dollars are lost annually in the US layer business as a result of heat stress (St-Pierre et al., 2003). These losses happen as a result of laying hens' egg weight, shell thickness, and production rate being significantly reduced by heat stress (Wolfenson et al., 2000).

Due to a lack of calcium, laying hens produce fewer eggs, watery eggs, eggs with thin shells, or even eggs without shells at high temperatures. They also grow more slowly and are more prone to illness because of their weakened nutritional needs, as protein digestibility can drop by up to 9.7% (Habashy et al., 2017; Nawaz et al., 2021). According to Dayyani and Bakhtiyari (2013), a heat-stressed chicken would pant, spread its wings, hold them slightly apart from its body, stand or lie down, and close its eyes.



**Figure 1:** Effect of heat stress on production performance of poultry (Lin et al., 2006).

### Sign of heat stress in poultry

According to Nardone et al. (2010), heat stress in poultry can cause the following symptoms: open-mouthed panting, squatting near the ground, elevated wings, drooping, slow and lethargic behavior, closed eyes, lying down, increased water intake, decreased appetite, decreased egg production, smaller eggs, poorer egg shell quality, decreased body weight, and increased cannibalism. Like dogs, chicks and adult chickens pant to stay cool. This is the first sign that they require shade and water. They squat close to the ground, spread their wings, and pant freely when they are stressed by heat (Nardone et al., 2010). Chickens that lay are susceptible to heat exhaustion. Water is the main ingredient in an egg. Because laying eggs requires a lot of fluids, it's important to keep your chickens comfortable and hydrated.

A sharp decline in egg production and smaller eggs, shell thinning, a decreased growth rate in broilers, increased thirst and the bird actively seeking water, decreased appetite, open-mouthed breathing, a sort of rapid, short breathing (panting), and a characteristic posture of standing with wings outstretched and then prostrating, which



Figure 2: Sign of heat stress in poultry



Figure 3: Poultry response to heat stress (Bhawaet al., 2023).

ultimately leads to death, are the main symptoms. The mortality rate might be as high as 100%, but it could also be between 5% and 50%. The temperature of the affected bird may rise to 42°C.

**Poultry response to heat stress**

Birds will try to rebalance the heat in their environment by changing their usual activities. Birds may decide to rest to dissipate heat from activity, eat less feed, drink more water, lift their wings away from their bodies to reveal any patches of skin without feathers, move into moving air streams or against cooler surfaces like brick walls, and move away from other birds. and begin to breathe rapidly.

**Heat stress mitigation strategy**

The layout and design of the housing are important factors in reducing heat stress in hens during hot weather. Thus, it's imperative to make sure that air enters and exits the poultry house with ease. Ensuring that air flows easily into and out of the house could lessen the negative effects of HS (Nawab et al., 2018). Effective strategies to counteract heat stress include wet feeding, self-selection, diurnal feeding patterns, and coarser meals. Additional feeders should be provided, and the feed should be thoroughly prepared into mash, crumb, or pellets to increase appetite on hot days.

In hot and humid areas, open-style dwellings with sufficient water input, ventilation, and shade are crucial. It is advised that the house be oriented east-west (Oloyo & Ojerinde, 2020).

Feed supplements like vegetable oils help to mitigate heat stress in broilers (Rafiei-Tari et al 2018).

To control their body temperature, poultry in warmer climates should eat less feed and more water (Sahin et al., 2009; Sohail et al., 2012). Because heat stress causes the body to excrete more minerals and lowers vitamin and mineral concentrations in the serum and liver, it has been demonstrated that supplementing with vitamins and minerals can reduce mortality and improve growth performance in poultry birds under heat stress (Sahin, K., et al., 2009). Because panting is linked to increased water loss in hot, dry conditions, birds must consume more water to prevent dehydration (Sohail et al., 2012). Because it will absorb body heat, the bird will cool down if it drinks water that is colder than its body temperature. Blood pH levels can be balanced by adding an electrolyte to drinking water to restore vital minerals.

Feeding timing is a critical component in reducing the effects of heat stress on feed intake and utilization (Sahin, K., et al., 2009). As a result, the hens should be fed a lot of the feed in the early morning and late evening when it's cold outside, and the rest can be provided whenever they choose. Since feed-starved chickens produce less heat than fed ones, removing feed on hot days can improve performance to some extent (Daghir, 2009). As a result of fasting, feed withdrawal alters intestinal architecture and depletes intestinal mucosa, which can damage intestinal cells.

Because it aids in the removal of ammonia, carbon dioxide, and moisture that have accumulated in the poultry barns, adequate ventilation is essential (Nawab et al., 2018). Technology for ventilation can lessen stress-related health problems (Nawab et al., 2018). Overcrowding, or excessive stocking density, has a detrimental effect on animal welfare because it degrades habitat quality overall and intensifies competition among birds for resources like feed, which can ultimately lead to feather pecking and cannibalism (Nawab et al., 2018). High stocking density typically has detrimental impacts on production performance, health, and moisture of litter feed efficiency and may ultimately lead to low economic return (Nawab et al., 2018). However, reducing stocking density to reduce heat stress may also restrict the number of birds that may be raised in a given farm or residence. Therefore, it is necessary to look at other strategies for lowering heat stress that maintain stocking density without compromising the birds' performance and well-being.

### **Conclusion**

Heat stress has become a serious issue that is costing the poultry business a lot of money because of the rising global temperatures and the decreased heat tolerance of contemporary chicken genotypes. Heat stress is a major problem for poultry production in the tropics and has a detrimental effect on the productivity and health of the birds. As global temperatures rise and modern chicken genotypes lose their ability to withstand heat, heat stress has become a significant problem that is costing the poultry industry a lot of money. The productivity and health of the birds are negatively impacted by heat stress, which is a significant issue for poultry production in the tropics. The choice of rearing systems with improved ventilation, appropriate housing conditions, and suggested right stocking densities, all essential for improving performance at high temperature are some of the strategies employed globally to counteract the detrimental effects of heat stress. A number of measures will help to lessen heat stress because there isn't just one. It is necessary to conduct more study on novel approaches that use heat tolerance genes and genetic markers to identify genotypes with greater heat tolerance.

### **Ethical consideration**

The authors declare and confirm that the manuscript is original, has no misconduct, has never been published in another journal and is confirmed to be published in this journal.

### **Conflict of interest**

The authors declare no conflict of interest.

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