THESIS

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Effect of heat stress on Poultry

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List of Abbreviations

AHS	Acute Heat Stress
AST	Aspartate Amino Transferase
ANS	Autonomic Nervous System
CHS	Chronic Heat Stress
CP	Crude Protein
DM	Dry Matter
FAO	Food and Agriculture Organisation
FCR	Feed Conversion Ratio
GIT	Gastrointestinal Tract
HT and MT	High and medium temperature
HS	Heat Stress
HSP	Heat Shock Protein
IGF	Insulin Growth Factor
KCL	Potassium Chloride
MMT	Minimum mortality Temperature
NDF	Neutral Detergent Fibre
ROS	Reactive Oxygen Species
RH	Relative Humidity
SOD	Super Oxide Dimutase
WHC	Water Holding Capacity
PSE	Pale , soft and exudative
SAM	Symphathetic adrenal medullar axis
HPA	Hypothelmic pituitary adrenal axis

1. INTRODUCTION

As the time passed, population of world is increasing day by day. The demand of food also increasing. The chicken industry is known to contribute significantly to global food and nutrition security, which aids in supplying humans with affordable protein, necessary micronutrients, and energy. According to reports, the amount of poultry meat produced increased from 120.0 million metric tonnes in 2017 to 125.8 million metric tonnes in 2018. Poultry industry is one of the fast growing livestock industry in developing countries. The poultry industry is negatively impacted by the one of the most sever climatic situation.

The recent sharp rise in global average temperature has significant effects on the world's agriculture sector, particularly in tropical and subtropical regions. An ongoing rise in temperature has an effect on all living things (Nardone et al., 2010). Temperatures over the typical range (thermo-neutral zone) in living things disrupt normal physiological processes and cause cell damage. High environmental temperatures typically cause stress-related problems such as diminished growth retardation, inefficient production, and aberrant metabolic processes (Afsal et al., 2018).

Poultry is heat stressed when the air temperature and humidity increases, because it is not possible to get rid of excessive body heat. When humidity is about 50 percent or higher and temperature is over 20℃, it causes mild heat stress for an adult poultry. When the ambient temperature goes over 30 ℃ the bird will not be able to lose heat and sever heat stress occurs.

There are two main types of heat stress: acute one (AHS) characterized by intensive heat for a short period of time, and chronic stress (CHS), when the temperature is higher than it is required for long duration. Unfortunately, both types cause large decline in productivity and is a major impediment to productive husbandry in many parts of the world (Pawar et al., 2016).

Signs of the heat stress on poultry are: hyperventilation with open mouth, elevated feather, slow activity, increased water intake and reduced feed intake. Consequently, weight gain is lower than it is normal and in case of layers number of eggs and eggshell quality will be affected.

To prevent heat stress ventilation and cooling technologies are highly important. However, we may reduce the effects of heat stress with some nutritional adjustments, as well.

2. Aim of the thesis

2.1. Aims

- To investigate the impact of heat stress on the production, growth performance, physiology and welfare of broilers
- To evaluate the impact of heat stress on layers' performance and egg quality and reproductive traits

3. LITERATURE REVIEW

3.1. Poultry production

Poultry production is an important sector in animal husbandry. Its products are egg and meat. Poultry industry has been dominated the world's agriculture industry for 8000 years. Thirty percent of the world protein requirement is supplied by the poultry sector. Global production of chicken has been increased 42 per cent from last decade from 80 million metric tonnes in 2007 to 109 million metric tonnes in 2017.

According to the surveys of the United Nations' Food and Agriculture Organization (FAO) the total number of poultry was 27.9 billion in 2019. The largest share in the sector belongs to chicken, and number of chicken has been doubled since 1990. Largest chicken producer is the Asian region, and is followed by America, then Africa and Europe (Table 1).

Table 1. Wold chicken production in 2018 and 2019 (FAOSTAT)

Number of Chickens in the World (1000 Head)		
Area	2018	2019
Asia	15.454.349	15.939.266
America	5.799.513	5.962.543
Africa	1.996.865	2.042.603
Europe	2.025.942	2.020.248
Oceania	137.766	150.658
World Total	**25.414.434**	**25.915.318**
Source: FAOSTAT		

The highest density chicken production are found in central Brazil, Eastern United States, Southern Asia and Eastern and Western Europe (i.e., more than 10,000.0 birds per km2) (Robinson et al., 2014). High chicken density is normally related to intensive commercial activities. However, in certain Asian regions, like in Indonesia or on the Island of Java even though the number of birds is high, birds are grown on small family farms for local consumption (Figure 1)(Nääs et al., 2015).

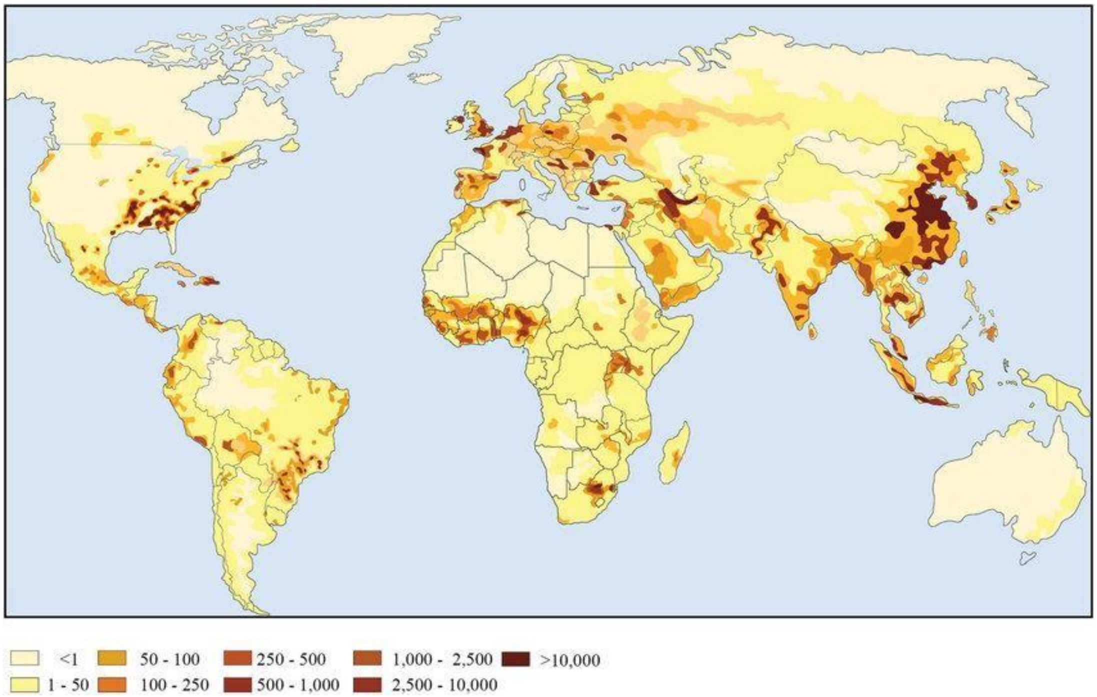

Figure 1 Global distribution of chickens (birds/km2) Source: Robinson et al., 2014.

Poultry production is widespread in rural regions and primarily consists of unremarkable local chicken breeds, according to a number of studies conducted in several resource-limited communities (Bhadauria et al., 2014).

Chicken production is one of the most profitable sector of livestock husbandry as it has several advantages over management of other species. Advantages of chicken production are:

- Only 1.5-1.8 kg feed is required for 1 kg weight gain of a modern broiler hybrid. This feed efficiency is highly beneficial compared to other species and results in relatively low price of chicken meat.
- Life cycle of the broiler chicken is short with its 5-7 weeks period. Thus a farm can have 5-7 rounds of flocks annually.
- Due to the fast and efficient growth production costs are relatively low.
- Eating chicken meat does not violates any religious and cultural values.

- It is possible to work with relatively high stock density, so high amount of meat can be produced on a small territory.
- Main waste of chicken production is the litter, which can be used for fertilizing soil.

However, there are also some challenges to face with as a chicken farmer:

- Cost of feed means approximately 60 per cent of the overall costs of production. As feed prices have increased dramatically recently, it means high risk on the cash flow of a farm.
- As environmental effects of animal husbandry becomes more and more important, emission of the nitrogen and phosphorus with the litter might cause problems for the producers.
- Animal welfare issues (like cage vs deep litter management) increases the management cost of broiler and rather of egg production.
- Using antibiotics in feed in certain regions of the world might cause animal and human health risk issues.
- Heat stress compromise birds' performance in many poultry growing regions of the world
- (Muchadeyi et al., 2004).

3.2. Heat stress

Birds are heat stressed when the body heat equilibrium is not balanced. Therefore, ambient temperature should be controlled efficiently in intensive poultry farming. However, heat stress in chicken flocks is commonly occur when the energy cost of maintenance increases (Scanes, 2015; Abbaset al., 2017; Abdelnour et al., 2018). When the temperature in the stall is not optimal for the birds, it has negative impact on the wellbeing of chickens, on the productivity, reproduction, andalso on the economic characteristics (Yousaf et al., 2019).

In thermoneutral zone (i.e. optimum temperature) normal body temperature can be adjusted easily. The normal body temperature is close to 41 °C. As the ambient temperature increases birds try to keep their physiological body temperature with panting. The higher the the body temperature is, the higher the rate of panting and it becomes hard to release heat. Due to hyperventillation birds lose increased amount of CO_2 through their lungs which causes elevation in blood pH disturbing the physiological acid-base balance of the animal. Consequently, health status and performance of chickens decline (Abbas et al., 2012). When even with panting it is not possible to reduce heat stress and body temperature increases with more than 4 °C chicken may die.

As it was mentioned at the very beginning of my thesis, there are several signs of heat stress in poultry, like panting with an open mouth, squatting close to the ground, droopy behavior, raised wings, depression, and sometimes cannibalism might develop in the flock. Main goal in this case is to cool the body temperature with releasing water by evaporation through the surface of the lungs and with shifting the feathers(Mack et al., 2013) Due to high temperature water consumption is increased and in return loss of appetite can be seen, which results in reduced body weight. Also performance is affected, so layers produce smaller eggs, the quality of egg shell declines and also laying intensity is reduced(Nardone et al., 2010; Dayyani & Bakhtiyari, 2013).

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3.3. Management of heat stress in poultry flocks

Minimizing heat stress is a major objective in order to use resources for growth, maintenance of a good physical state, reproduction, and production rather than for the maintenance of thermal neutrality in animals. In the end, this leads to increased animal output and financial success for the producer (Lin et al., 2006). The amount of heat stress experienced by chicken can be reduced by a multi-pronged approach that incorporates environmental modifications (the provision of housing designs, shaded areas, and ventilation systems), stocking density management, and nutritional control and selection for heat tolerance genes (Yu et al., 2008).

3.3.1. Farm management

Designing a chicken coop with adequate ventilation is the first step in managing heat stress (Saeed et al., 2018). In places with extended periods of high ambient temperature, this can be accomplished by installing effective air circulation systems. According to Addo et al. (2018), this helps to maintain proper air quality in terms of ammonia, humidity, carbon dioxide, and oxygen while also ensuring optimal air movement in the chicken house to provide enough air movement for convective heat loss in hot temperatures.

In rural areas where free-range management is used poultry farmers should provide shade for their flocks. This makes it possible for the scavenging chicken to find a relatively cool place to hide during the warmer months, especially in the tropics. Planting trees around the shade and surrounding the chicken barn with grass cover both help lower the heat stress on the birds (Kaewthong et al., 2019). Additionally, a sparkling roof surface might lessen solar radiation's ability to heat the house. The numerous management techniques used include providing suitable shelter, shade, sprinkler systems, and ventilation. Also it is important to place the meal close to or beneath the shades in free-range settings, when the ambient temperature is high (Bhadauria, 2017). Normal handling operations like vaccination, beak trimming, and transfers should be carried out in the evening if at all feasible, and the birds should be held softly and calmly throughout to reduce additional stress on top of the hot temperature (Sahin et al., 2017)

According to research results by Bhadauria et al. (2018), heat stress may be eliminated, or decreased by making sure that birds have the necessary amount of floor space, which prevents overstocking. For birds weighing 1.7 kg, the floor space is 0.06 m^2/bird, and for those weighing 3.5 kg, it is 0.13 m^2/bird, translating to a density of 27.8 kg/m^2 (Nascimento et al., 2018). In case of parent stock management or layer facilities there are also other aspects of heat stress. For instance it has been emphasized that hatchery eggs should be transported and stored in air-conditioned surroundings in order to keep their quality (Yosi et al., 2017). Consumer eggs must also be delivered in a way that doesn't compromise their quality, since this will affect their market value and popularity. (Mack et al., 2013).

A potential heat stress management technique is to breed (select) chicken lines having better performance in areas with high ambient temperatures (Wasti et al., 2020). This can be accomplished by taking into account genes that have been suggested to be involved in heat regulation. Examples of possible genes to generate breeds that can withstand high ambient temperatures are the frizzle gene and the naked neck gene (Sohail et al., 2012). According to additional research, thermo-tolerant genes including the dwarf gene, frizzle gene, and naked neck gene polymorphisms in the heat shock proteins' (HSP) genes can be used in marker-assisted selective breeding to create breeds with improved thermotolerance (Imik et al., 2012).

3.3.2. Dietary management

Through many mechanisms, high environmental temperature has a deleterious influence on chicken's feed intake and nutrient utilization (Gous et al., 2005). According to the research conducted by Ranjan et al. (2019), nutrient and energy concentration of the diet should be increased to make up for the lost feeding time and the lower feed intake caused by high ambient temperatures. Electrolytes, vitamins, and sodium bicarbonate, amino acids, should all be abundant in the feed to make up for the minerals lost via increased sweating. Sahin et al. (2017), revealed that nutritional manipulation and the addition of feed additives like vitamins, antioxidants, probiotics, and prebiotics have the potential to completely eliminate or significantly reduce the detrimental effects of heat stress on chicken performance. Saeed et al. (2019) found for instance have found that heat stress had a detrimental effect on the number and variety of the gut microbes. According to their results, the issue may be resolved by enhancing and stabilizing eubiotic balance of the microflore. Thus giving probiotic supplements, which have the capacity to increase the number and diversity of bacteria in the caecum and jejunum might be beneficial in heat stress. Similar results were reported by Sohail et al. (2012) using a probiotic mixture and prebiotics-(mannan-oligosaccharides), which reduced or eliminated the negative effects of elevated temperature. According to Huet al. (2019), treating laying quails with feed additives like Betane at a rate of 0.07-0.13% under heat stress enhanced feed intake, the protein and energy ratio, and improved the egg quality characteristics. It is important to highlight that adding vitamins A, E, and zinc helps increase antioxidant levels since heat-stressed birds have an unstable oxidative equilibrium.

Calefi et al. (2014) have reported that adding vitamin E to chicken diets helped to reduce many of the harmful impacts of heat stress. According to Sahin et al. (2017) research, using phytochemicals with antioxidant activity can aid hens who are experiencing heat stress. Polyphenols for instance have been discovered to increase the production of antioxidant enzymes and HSP (heat shock proteins) which can reduce the presence of reactive oxygen species in the body (Addo et al., 2018). Similarly, carotenoids, vitamin E and C, and microelements like selenium, zinc, and copper as part of the non-enzymatic antioxidant defence of birds can be beneficial under overheating conditions. A study by Yosi et al. (2016) shew the positive effects of adding minerals, such as KCl (potassium chloride) to the drinking water of birds.

Furthermore, Sahin et al (2019) research results revealed that feeding hens late at night in conditions with high ambient temperatures led to improvements in laying rates and egg quality. In order to compensate for the water lost when birds pant, wet feeding might be a feasible option to manage heat stress (Calefi et al., 2014). In addition, drinking water supply is a critical point under high temperature conditions as birds' water intake increases by 1.3% for every 2°C rise in the 22–32.0°C temperature range and by 6% for every 1°C rise in the 32–38°C temperature range, which can help them regulate their body temperature in hot situations (Gous & Morris, 2005).

4. Effects of Heat Stress on Poultry Production

Saeed et al. (2019) explained that heat stress causes major financial losses in poultry production, especially in arid and tropical regions of the world. Slowed appetite, lower growth rate, decreased laying rate, reduced feed consumption, and decreased egg and meat quality are just a few of the detrimental impacts of heat stress. Due to panting birds can become dehydrated (lose bodily fluids), which may end in heat stroke and mortality (Minka & Ayo 2007), as well. According to research results broilers seems to be more vulnerable to HS than layers (Zahoor et al., 2017). Wasti et al. (2020) explained that one of the main environmental stressors that affects the poultrybusiness and causes significant financial loss is heat stress. Various physiological changes are brought on by heat stress such as decreased body weight, feed efficiency, immune-competence reduction, oxidative stress, reduced egg production, increased mortality, and an acid-base imbalance. The quality of meat and eggs is also affected.

Studying the molecular effects of heat stress increased HSP expression, and elevated plasma corticosterone level were found (Vinoth et al., 2015, Soleimani et al., 2011). These changes might cause protein degradation in the muscle and the resulting free amino acids are used in the gluconeogenesis of the liver, which creates energy (Ma et al., 2021). Increased level of corticosterone may lead to an increase in oxidative stress, which may ultimately result in decreased fewer follicles, cell death in follicular cells and egg production (Li et al., 2020).

Zhao et al. (2021) found that high temperatures harm the granulosa cells of laying hens.

Considering oxidative stress, it is revealed that HS results in reduced superoxide dismutase (SOD) activity and in elevated level of lipid peroxidation, which causes oxidative stress and weak antioxidant status.

According to the effects of HS on the blood biochemistry parameters Gharib et al. (2005) found that pullets exposed to HS had substantially lower levels of serum red blood cell count, calcium (Ca), and plasma albumin. While aspartate aminotransferase (AST) activity is increased by cyclic HS, although total protein, uric acid, globulin, or albumin are not affected, according to Bueno et al. (2017).

According to Tsiouris et al. (2018), numerous changes in the intestinal integrity, intestinal morphology, and gut microbiota have also been associated with HS. These modifications may be harmful to the intestinal health of chickens (Song et al., 2014). As hens attempt to expel their stored body heat during HS, blood flow to the internal organs including the GIT (gastrointestinal tracts) decreases (Goo et al., 2019). Due to the consequent tight junction relaxation, intestinal permeability rises and the intestinal barrier function is compromised Figure 2 (Gupta etal., 2017). Reduced crypt depth and reduced villous height are also signs of HS, which provide evidence on small intestine mucosa damage (Shakeri et al., 2019). Similar conclusions were reached by Santos et al. (2015) and Song et al. (2013), who found that heat-stressed birds had stripping, crypt depth destruction and a drop in epithelial cell area ratio, and villus height decrease. HS also promotes the growth of harmful bacteria including *Salmonella spp*. and *Escherichia coli* in poultry (Kammon et al., 2019).

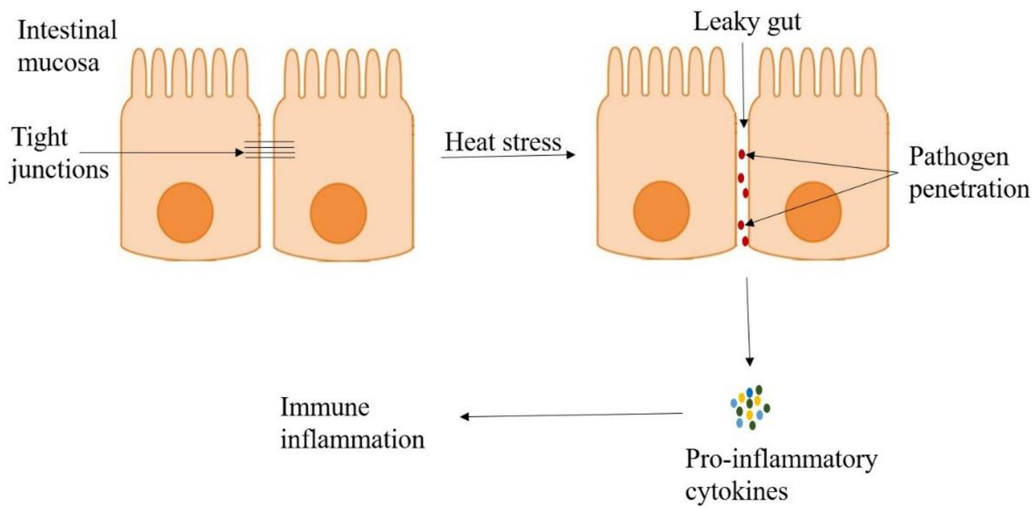

Figure 2. Effect of heat stress on intestinal integrity and immune barried activity (Goel, 2021)

4.1 The impact of heat stress on meat production

Numerous researches have examined the impact of heat stress on broiler output. Birds exposed to high ambient temperatures have behavioral, physiological, and immunological responses that reduce their ability to produce (St-Pierre et al., 2003).

In a recent study, broilers that experienced prolonged heat stress had 34.8% lower body weight at 42 days of age than in normal conditions, also their feed intake was reduced with 17.8%, thus the feed conversion ratiowas elevated with 36.8%(Mack et al., 2013).

As a summary of research results correlation between meat production and heat stress was found to be almost linear (Figure 3)(Sohail et al., 2012; Gwaza et al., 2017; Lu et al., 2007; Babinszky et al., 2011; Imik et al., 2012; Fouad et al., 2016) Lin et al.,2004; Deng et al.2012; Ebeid et al.,2012; Renaudeau et al., 2012; Allahverdi et al., 2013; Mack et al., 2013; Ma et al., 2014; Pawar et al., 2016; Radwan, 2020).

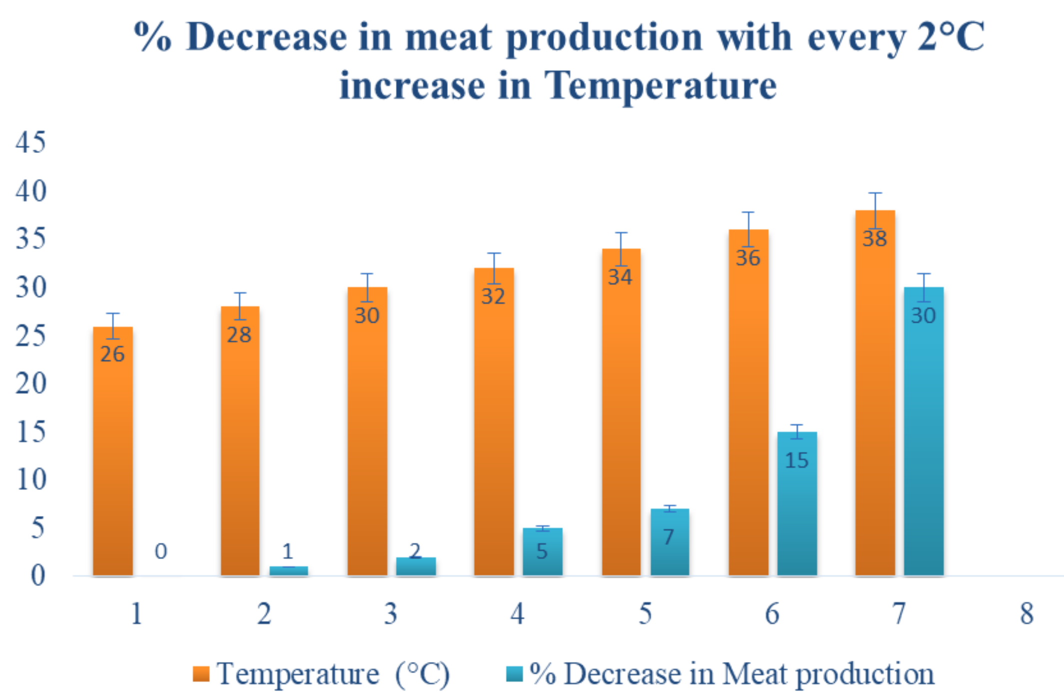

Figure 3. Impact of Increase in Temperature on meat production

Even while the negative effects of heat stress on broilers appear to be pretty constant, stocking density is a significant issue as a possible aggravating factor, both in terms of productivity and welfare (Imik et al., 2012).

According to research, the length of time that broilers are exposed to heat has an adverse effect on the fat deposition and meat quality depending on the breed (Warriss et al., 2005). Broilers under heat stress lose their carcass traits, including as the size of their thighs and breasts (Lu et al. 2007). A study conducted by Zhang et al. (2012) found that the proportion of breast muscle in broilers decreased while the proportion of thigh muscle rose under high temperature conditions. Another recent study, conducted by Sinha et al. (2017), showed broilers subjected to extended heat stress had greater thigh muscle and less breast muscle. Furthermore, birds under heat stress showed higher fat deposition and lower protein levels.

The intramuscular fat and quantity of protein formed in the breast muscle is decreased by heat stress, which diminishes meat quality, nutritional value, and flavor (Zaboli et al. 2018). The tenderness and juiciness of the meat as well as the lightness value and shear force of the breast and thigh muscles are also diminished by heat stress. Additionally, it causes increased cooking and drip losses. Meat often becomes pale, exudative, and soft (PSE), which was shown to speed up post-mortem muscle metabolism and biochemical alterations (Kapetanov et al., 2015).

According to Mahmoud et al. (2019) the flesh of heat-stressed turkeys was darker and had more drip loss than the meat of control turkeys. Heat stress was found to be the main factor contributing to PSE in poultry meat, aside from management and genetic variables (Petracci et al. 2009). Furthermore, it was shown that PSE-like chicken had different expression and distribution levels of HSP70, a crucial molecular chaperon playing a crucial function during heat stress (Xing et al. 2016). When compared to regular meat, PSE-like meat had a considerably reduced HSP70 level and its distribution. While in normal meat it is found mainly in the cytoplasm and in heat stress it moves to the extracellular matrix. According to Wang et al. (2017), heat stress greatly enhances lactate production in the muscle, which increases the pace of pH decline after culling and results in PSE-like meat in chicken. Therefore, heat stress is a possible component that may affect the development of PSE-like meat in chicken.

4.2 The impact of heat stress on egg production

Similarly to broilers, negative effects of heat stress on layers are also confirmed. In a recent study a 12-day heat stress phase caused 30.98 g/bird reduction in the daily feed consumption, and consequently the egg production had declined with 31.8% (Renaudeau et al., 2012). Farnell et al. (2001) discovered that feed conversion was reduced by 31.6%, and egg weight was decreased by 3.68%, while egg production has declined by 39.6%, in laying hens under heat stress. Under heat stress, feed intake decreases, which affects the availability of nutrients, lowers the plasma protein content, and results in the laying ofsmaller eggs (Lara & Rostagno, 2013, Taylor et al, 2009). In the hot, dry season, coupled with high ambient temperature and high relative humidity, Morrell & Rodriguez-Martinez, (2011) found that heat-stressed layer hens consumed 20% less feed. Similar results were found also by Khan & Sarda, (2003) and Bollengier-Lee et al. (1999),

As a summary of researches in regions with hot climate the following tendency was found: Birds perform normally up to a temperature of 28 °C and feel comfortable around 26 °C. However, from 25℃ as the temperature has increased with 2℃ increments egg production was reduced almost linearly as is is shown on Figure 4 (Donoghue et al., 1989; Lin et al., 2004; Mashaly et al., 2004; Deng et al., 2012; Ebeid et al., 2012; Renaudeau et al., 2012; Allahverdi et al., 2013; Mack et al., 2013; Dayyani and Bakhtiari, 2013; Lara and Rostagno, 2013; Ma et al., 2014; Fouad et al., 2016; Pawar et al., 2016; Nawab et al., 2018; Sahin et al., 2018; Ranjan et al., 2019; Saeed et al., 2019; Radwan, 2020).

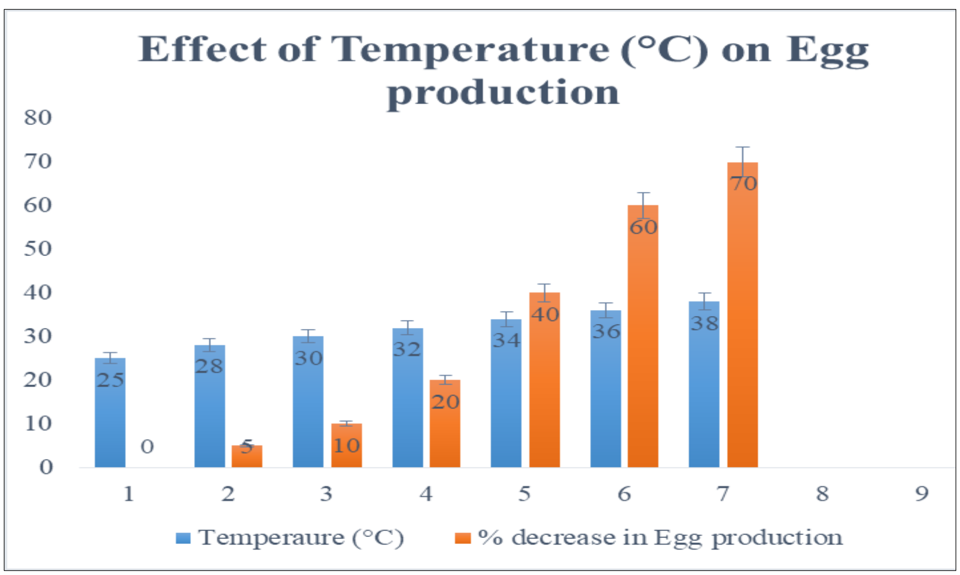

Figure 4. Impact of increase in temperature on egg production

Another study (Lin etal. 2004) reported that heat stress resulted in increased egg breakage and decreased reduced eggshell thickness. Similarly, reduced egg weight, egg shell thickness, and egg production were revealed by Mack et al. (2013), due to elevated temperature in the stall (Figure 5). Similar results were reported by Dayyani & Bakhtiyari (2013) and Ebeid et al. (2012), as well.

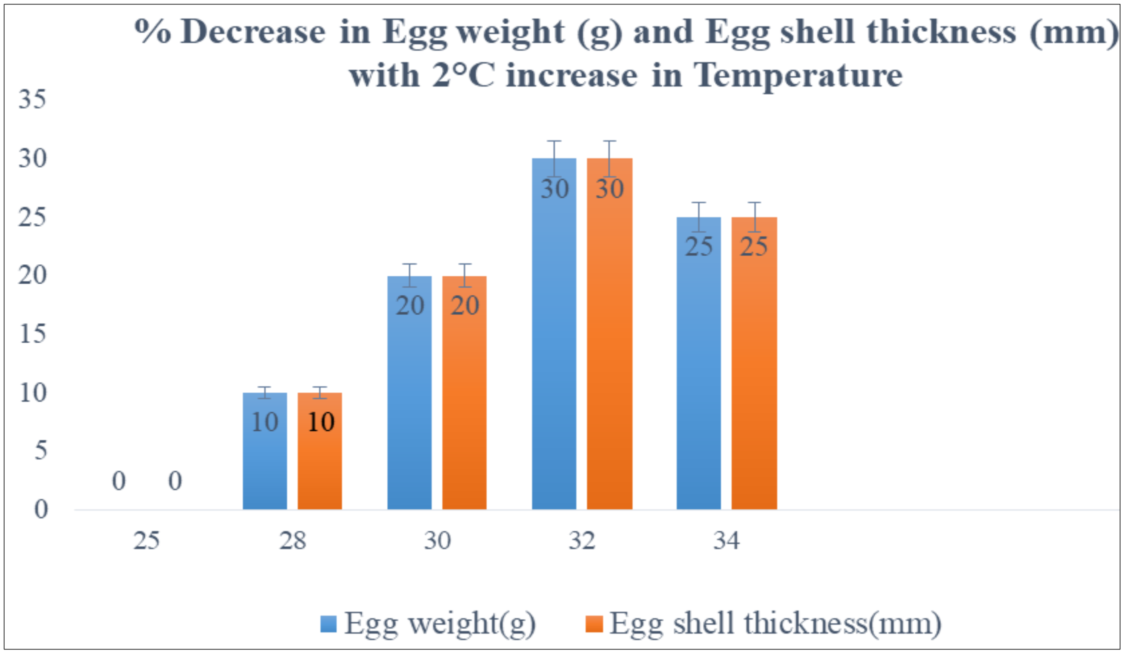

Figure 5. Impact of increase in climate temperature on body weight change and egg shell thickness

At high environmental temperature, birds lose a lot of carbon dioxide by panting. As carbon dioxide is necessary for the synthesis of calcium carbonate in eggshell, heat stress causes eggshell problems. The defective eggshell construction therefore can result in reduced egg weight (10g/egg reduction in average), and consequently extremely significant decline in egg production, (Dai et al., 2012).

Heat exposure affects calcium metabolism by reducing the expression of carbonic anhydrase and calcium-binding proteins. Eggshell thickness is decreased and the number of cracked or broken eggs is increased as a result.

4.3 Influence of Heat Stress on Reproductive Performance

Heat stress results in reduced reproductive performance in breeder hens as it causes decline in ovulation rates (Ma et al., 2012). One possible target of high temperature might be the hypothalamic control and the consequent reduced production of luteinizing, follicle- stimulating, and gonadotropin-releasing hormones (Cheng et al., 2015). As heat stress induces oxidative stress it can cause changes in the physiological performance of the ovaries, small yellow follicles and oviducts, as well (El-Tarabany, 2016).

As summary it is confirmed in several research projects that as the temperature increases the reproductive performance of layers is reduced linearly (Figure 6) (Donoghue et al., 1989; Novero et al., 1991; Kala et al., 2017; Abidin and Khatoon, 2013; Kala et al., 2017; Donoghue et al., 1989; Lin et al., 2004; Mashaly et al., 2004; Deng et al., 2012; Ebeid et al., 2012; Renaudeau et al., 2012; Allahverdi et al., 2013; Mack et al., 2013; Dayyani and Bakhtiari, 2013; Lara and Rostagno, 2013; Ma et al., 2014; Fouad et al., 2016; Pawar et al., 2016; Nawab et al., 2018; Sahin et al., 2018; Ranjan et al., 2019; Saeed et al., 2019; Radwan, 2020; Donoghue et al., 1989; Fouad et al., 2016; Yousaf et al., 2019).

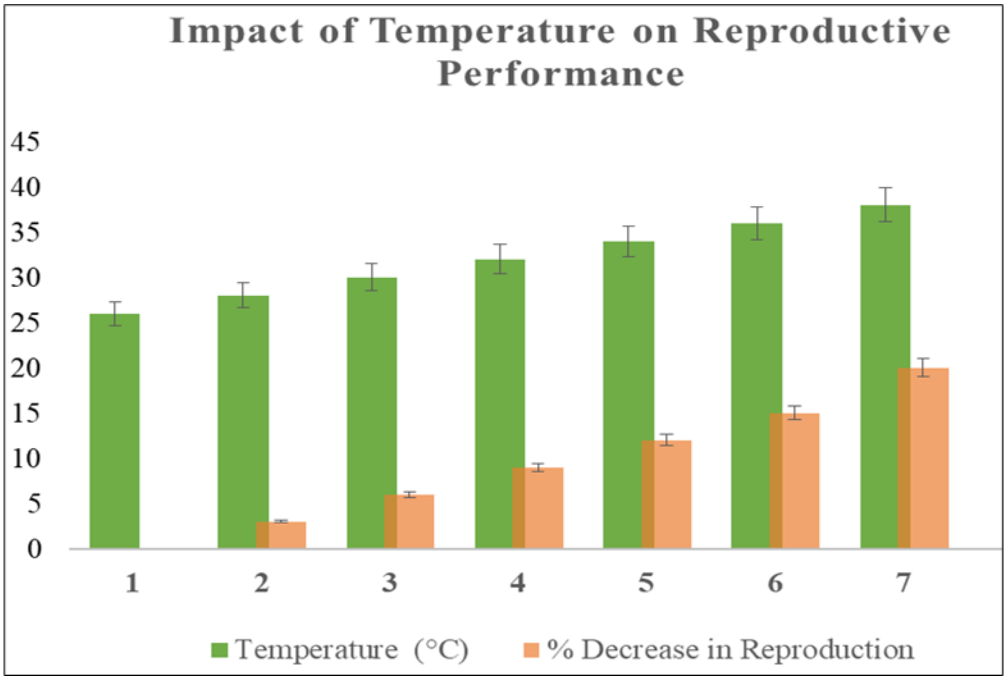

Figure 6. Impact of Temperature and Heat stress on reproduction

When the fertility of male poultry and its relation to heat stress considered, responses of various cell types differ. Heat has little to no direct effect on the Leydig cells that are located in the testicles, while the Sertoli cells in the seminiferous epithelium might be drastically affected (Aggarwal et al., 2013). As the germ cells receive all of their nourishment from the Sertoli cells they are also thought to be affected by elevated temperature (Fouad et al., 2016).

In terms of fertility, male breeders are more vulnerable to heat stress than female breeders as reactive oxygen species are produced more often causing damages in the testes and finally has negative effects on the seminal parameters (Morera et al., 2012). Sperm concentration, semen volume, testicular weight, sperm viability and motility. (Ayo et al., 2011).

A rise in temperature exhibits drastically reduced reproductive effectiveness (Ramasamy., 2009). According to Turk et al. (2015), rooster semen collected in hot temperaturecause increased morbidity of sperm cells like cytoplasmic droplets, malformed heads, and divided mid-pieces. Similar data were reported by Wang et al. (2018). Altogether, heat stress results in reduced fertility of hatchery eggs and reduced hatchability.

4.4 Effects of Heat Stress on Behavior of Chickens

Birds change their activity in order to find thermoregulation in high-temperature situations, which lowers body temperature. They generally respond to heat stress in a similar manner, displaying some individual variation in the severity and length of their responses. According to a recent study by Mack LA, et al. (2019), chickens under heat stress spend more time panting, drinking, and raising their wings, than they do walking, moving about, or eating. The way hens behave may have a big impact on their growth rate, which in turn can affect production costs. Young chickens have rapid metabolisms. Although they develop quickly, they have a limited capacity to adjust to changes in their environment. Furthermore, chickens are extremely sensitive to heat stress and prone to it since their skin lacks sweat glands, especially when they are young.

According to other research, hens exposed to heat stress had thermally induced, interrupted (interrupted) asthma as well as lowering both wings, which remained even after the heat stress phase. One of the main behavioral responses of hens to withstand the stimulation of high temperature is increased water sticking feathers. These findings suggest that heat stress has a substantial impact on poultry's everyday activity and that it is extremely important to look into how it changes the behavior of developing young chicks (Figure 7).

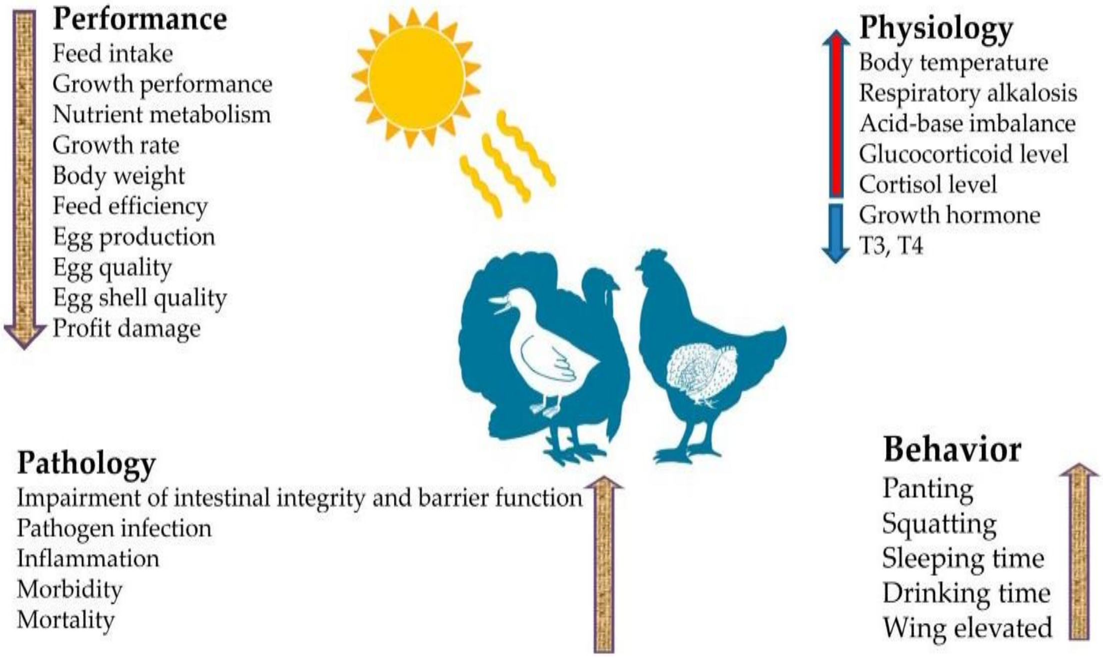

Figure 7 Effects of heat stress on behavioral, neuroendocrine, physiological, and production traits (Ahmad et al., 2022).

4.5 Impact of Temperature variations on Global Poultry Production in different continents (Asia, Europe, Africa, North America, Australia)

Recent years significant rise have seen in global temperature, with huge terrestrial regions with nearly 1°C between 1980-2016 as it is shown in Figure 8 (Archer,Oettlé, Louw, & Tadross, 2008; Thornton, Ericksen, Herrero, & Challinor, 2014).

Even at the lower end of the range, such increases are anticipated to have significant effects on food production and food security. Due to climate changes developing countries are expected to suffer more complex consequences.

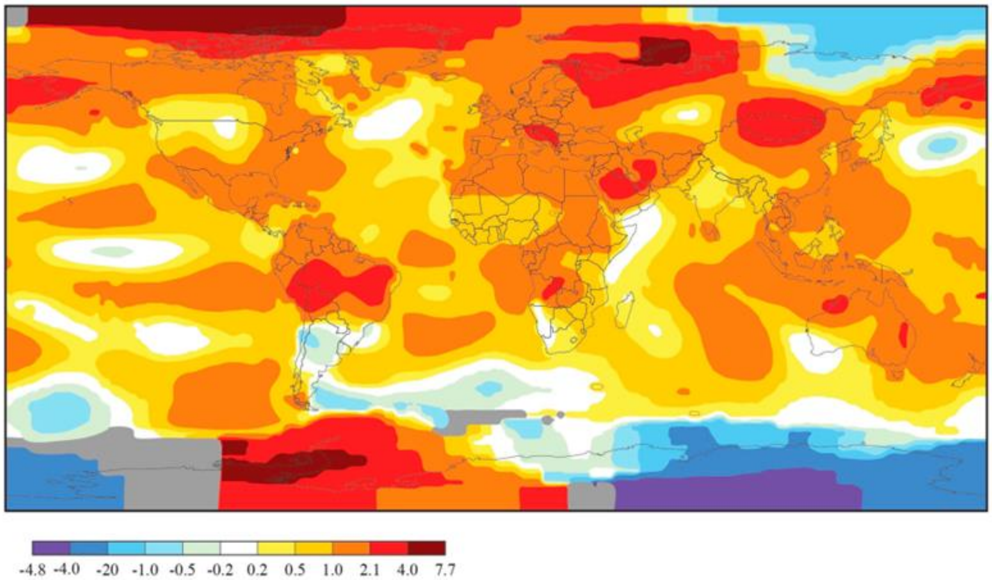

Figure 8 Global temperature (°C) trends (1980-2016) (Source: Hansen, Ruedy, Sato, & Lo, 2010; GISTEMP)

It can be see that the temperature of the world is increasing as the time passing as shown in figure 9.

Figure 9 Trends of annual average temperature in different regions of the Worldfrom 1950 to 2021 Source: (http 1)

The poultry industry is well developed in South Africa. The per capita consumption of chicken and eggs in African region is ~89-107 eggs and chicken meat consumption was from ~15-25 kg (2005). In America, the consumption was 109 eggs and 34 kg chicken meat for one man in a year. In Asian region China is the largest producers of chicken meat and egg followed by India and Japan. In the Middle East 2.5 % global egg production comes from Morocco, Algeria, Egypt and Syria). In South Asia, Pakistan has a sizeable increase in production of eggs and meat (2005). There is approximately 10% increase in poultry production in India, Pakistan, Sri Lanka, Nepal, Bangladesh and Bhutan. However, due to climate changes performance and production data seems to decline in certain regions.

Different studies concluded that the regions with excess or high heat stress particularly in summer when temperatures are at their peak (Africa, Asia, Australia) animals mortality rate is higher. On the basis of observations the regions with elevated temperature showed poor poultry output (measured in terms of eggs produced and/or the quantity of poultry animals consumed/ sold) figure 10

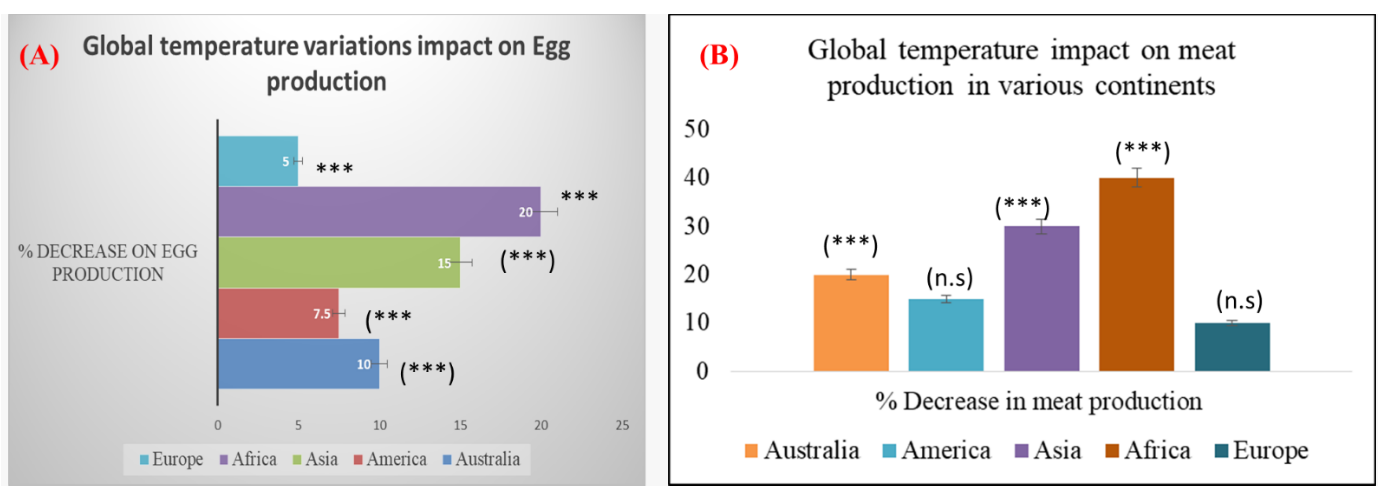

Figure 10 (A) (B) Comparison of global temperature variations impact on egg and meat production in different continents (***p<0.05) n.s (p>0.05)

Altogether, egg production is reduced significantly due to heat stress all over the World with the highest changes in Africa. Similar trends are present in meat production sector. Again Africa is the most vulnerable region, while the changes are not significant in Europe and in America.

5. CONCLUSIONS

One of the most significant environmental stressors that lower poultry production globally is heatstress. Numerous negative effects of heat stress on laying hens and broilers including decreased egg production and development, as well as reduced chicken and egg safety and quality were revealed in the last 2-3 decades. The most prominent ones are the reduced feed intake, weight gain, egg weight and increased feed conversion ratio together with elevated body temperature, and on top of all behavioral changes are common Figure 11

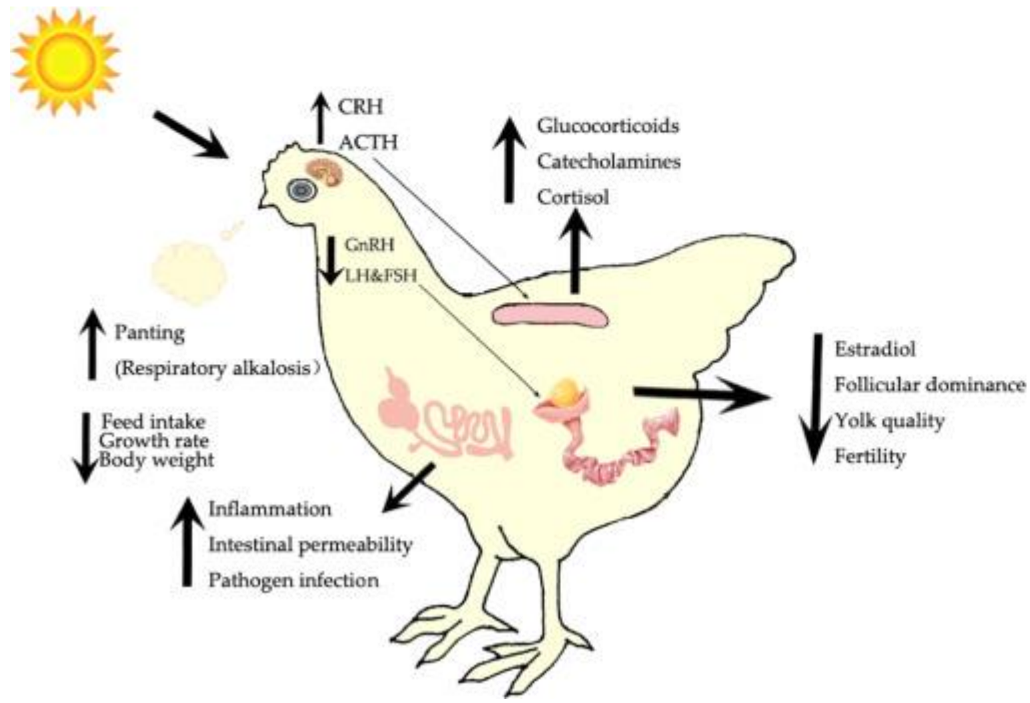

Figure 11. Symptoms of heat stress in poultry (Nawab et al, 2018)

It is significant to note that many published studies have focused on intervention strategies to deal with heat stress conditions. These apply various approaches, including nutritional manipulation (i.e., diet formulation according to the birds' metabolic condition), environmental management (such as sprinkling, shading, facilities design, ventilation, etc.), as well as inclusion of feed additives in the diet (e.g. vitamins, minerals, antioxidants), However, the majority of the therapies' efficacy has been erratic or unpredictable. Two cutting-edge strategies have recently been investigated, including genetic selection of breeds with improved resistance to heat stress conditions (i.e., increased heat tolerance) and early conditioning (also known as perinatal heat acclimation). Although encouraging, these prospective options still need further study and development, especially for the production of poultry in hot climates.

6. Summary

Due to excessive rises in global temperature, heat stress has become a severe hazard to the poultry industry in many nations that produce chicken. Heat stress can impact a bird's development, production level, reproductive activity, immune system, and digestive health, which can all have an impact on the bird's performance.

In my thesis I tried to overview the most important changes heat stress can cause in poultry meat and egg production as well as in the reproductive performance of birds. The most prominent signs of heat stress are found to be as follows:

Behavioral changes – panting, depression, respiratory alkalosis

- Performance changes – reduced feed intake, weight gain, meat or egg production, increased feed conversion ratio
- Quality changes – reduced carcass value and meat quality, reduced egg production, egg size and eggshell quality
- Physiological changes – increased oxidative stress, reduced immune response, leaky gut syndrome
- Reproductive changes – reduced hypothalamic control on reproductive functions, reduced ovary activity, affected spermiogenesis, lower level of egg fertility and hatchability.

Due to climate changes heat stress is common and becomes more and more frequent in different regions of the World, but Africa seems to be the most vulnerable continent. It is not always easy to prevent heat stress or at least to reduce its effects. However, the most important strategies are also collected in the thesis as follows:

- Management tasks – good ventilation, shades for birds in free-range management, drinking water supply
- Nutritional tasks – increased energy concentration in the diet, supplementing vitamins, minerals, using additives like pro- and prebiotics etc.

According to the literature data I have studied it is obvious that elevated temperature compromises poultry production efficiency and therefore further research is still needed to understand the molecular changes behind to venier and to create successful strategies to overcome its harmful effects as efficiently as it is possible.

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