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Impact of Heat Stress on Poultry Production

Plan of Talk

1. Introduction to stress and heat stress
2. Behavioral effects of heat stress
3. Physiological effects of heat stress
4. Effect of heat stress on the immune response
5. Impact of Heat Stress on Poultry Production

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What is Stress?

Stress

› Is a response to adverse stimuli, is difficult to define and understand because of its nebulous perception.

› "stress is the nonspecific response of the body to any demand"

Stressor

› Is "an agent that produces stress at any time"

What is Heat Stress?

› Heat stress results from a **negative balance** between the net amount of **energy flowing from** the animal's body to its surrounding environment and the amount of **heat energy produced** by the animal.

Cont. ...

This imbalance may be caused by variations of a combination of:

1. Characteristics of the animal
    1. Species
    2. Metabolism rate
    3. Thermoregulatory mechanisms

1. Environmental factors as‘
    1. Sunlight
    2. Thermal irradiation
    3. Humidity
    4. Air temperature
    5. Air movement

Cont. ...

- Environmental stressors, such as heat stress, are particularly detrimental to animal agriculture.
- The issue of environmental stress has quickly become a great point of interest in animal agriculture, particularly due to public awareness and concerns.

Cont. ...

- The importance of animal responses to environmental challenges applies to all species.
- However, poultry seems to be particularly sensitive to temperature-associated environmental challenges, especially heat stress.
- It has been suggested that modern poultry genotypes produce more body heat, due to their greater metabolic activity.
- Understanding and controlling environmental conditions is crucial to successful poultry production and welfare.

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Behavioral Changes

- Under high temperature conditions, birds alter their behavior and physiological homeostasis seeking thermoregulation, thereby decreasing body temperature.
- In general, different types of birds react similarly to heat stress, expressing some individual variation in intensity and duration of their responses.

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- A recent study showed that birds subjected to heat stress conditions spend:
  1. Less time feeding
  2. Less time moving or walking
  3. More time drinking and panting
  4. More time with their wings elevated
  5. More time resting

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Physiological Changes

- Animals utilize multiple ways for maintaining thermoregulation and homeostasis when subjected to high environmental temperatures, including increasing radiant, convective and evaporative heat loss by vasodilatation and perspiration.

Cont. ...

- Birds have an additional mechanism to promote heat exchange between their body and the environment, which are the **air sacs.**
- Air sacs are very useful during panting, as they promote air circulation on surfaces contributing to increase gas exchanges with the air, and consequently, the evaporative loss of heat.

Heat Stress and Egg Shell Quality

- However, it is worth noting that increased panting under heat stress conditions leads to increased carbon dioxide levels and higher blood pH (*i.e.*, alkalosis), which in turn:
  1. Hampers blood bicarbonate availability for egg shell mineralization.
  2. Induces increased organic acid availability.
  3. Decreasing free calcium levels in the blood.
- This process is very important in breeders and laying hens, as it affects egg shell quality.

Heat Stress and Reproductive Functions

Heat stress can affect the reproductive function of poultry in different ways.

- **In females**
  - Heat stress can disrupt the normal status of reproductive hormones at the hypothalamus, and at the ovary, leading to reduced systemic levels and functions.
- **In males**
  - Heat stress can negatively affect semen volume, sperm concentration, number of live sperm cells and motility.

Heat Stress and Growth rate

- High environmental temperatures alter the activity of the neuroendocrine system of poultry, resulting in:
  1. Activation of the hypothalamic-pituitary-adrenal (HPA) axis.
  2. Elevated plasma corticosterone concentrations.

Cont. ...

- Body temperature and metabolic activity are regulated by the thyroid hormones, triiodothyronine (T3) and thyroxine (T4), and their balance.
- Previous studies report that:
  1. T3 concentrations consistently decrease in high temperature conditions.
  2. T4 concentrations in high temperature conditions are inconsistent with studies reporting decrease, increase, or no alteration.

Cont. …

- Due to the involvement of the thyroid during the onset of puberty and reproductive function in birds, a disruption of thyroid activity by heat stress would be expected to have an effect on reproductive performance of the hens.

Cont. ...

› Moreover, findings reported by Geraert *et al.* indicate that endocrinological changes caused by chronic heat stress in broilers stimulate lipid accumulation through:

1. Increased *de novo* lipogenesis.
2. Reduced lipolysis.
3. Enhanced amino acid catabolism.

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Heat Stress and Immune Response

- Many studies have been conducted to elucidate how stress affects the immune response in animals.
- Modulation of the immune response by the central nervous system (CNS) is mediated by a complex network that operates bi-directionally between the nervous, endocrine and immune systems.
- The hypothalamic–pituitary–adrenal (HPA) and the sympathetic–adrenal medullar (SAM) axes constitute the main pathways through which the immune response can be altered.

Cont. ...

- It has been shown that lymphocytes, monocytes or macrophages, and granulocytes exhibit receptors for many neuroendocrine products of the HPA and SAM axes, such as cortisol and catecholamines, which can affect cellular trafficking, proliferation, cytokine secretion, antibody production and cytolytic activity.

Cont. ...

- This topic has been the subject of several extensive reviews.
- However, knowledge continues to be generated, providing increasing insights on the interplay among the nervous, endocrine and immune systems.

Cont. ...

- In poultry, several studies have investigated the effects of heat stress on the immune response in recent years.
- In general, all studies show an immunosuppressing effect of heat stress on broilers and laying hens, although using different measurements.

Cont. ...

1. Lower relative weights of thymus and spleen has been found in laying hens subjected to heat stress
2. Reduced lymphoid organ weights have also been reported in broilers under heat stress conditions.
3. Reduced liver weights in laying hens subjected to chronic heat stress conditions.

Cont. ...

4. Broilers subjected to heat stress, during primary and secondary humoral responses, had:
   a) Lower levels of total circulating antibodies
   b) Lower specific IgM and IgG levels.
   c) Significantly reduced thymus, bursa, spleen, and liver weights.

Cont. ...

5. Aengwanich also demonstrated the occurrence of:
    1. Reduced bursa weight in broilers subjected to heat stress
    2. Decreased numbers of lymphocytes in the cortex and medulla areas of the bursa.

Cont. ...

6. Fewer intraepithelial lymphocytes and IgA-secreting cells in the intestinal tract of laying hens under heat stress have also been observed.
7. Reduced antibody response, as well as reduced phagocytic ability of macrophages, in broilers under heat stress.
8. Reduced macrophages performing phagocytosis, as well as reduced macrophage basal and induced oxidative burst were observed in heat-stressed broilers.

Cont. …

9. Recent studies have also demonstrated that heat stress can alter levels of circulating cells.
   - It has been shown that heat stress causes an increase in heterophil:lymphocyte ratio, due to reduced numbers of circulating lymphocytes and higher numbers of heterophils.

Cont. ...

- Under environmental stressful conditions, as the bird's body attempts to maintain its thermal homeostasis, increased levels of reactive oxygen species (ROS) occur.
- As a consequence, the body enters a stage of oxidative stress, and starts producing and releasing heat shock proteins (HSP) to try and protect itself from the deleterious cellular effects of ROS.
- In fact, higher concentrations of HSP70 were found in broilers and laying hens exposed to heat stress.

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Cost of Heat Stress

- Many studies have been published about the effects of heat stress on the efficiency of broiler production.
- Heat stress results in estimated total annual economic loss to the U.S. livestock production industry of $1.69 to $2.36 billion; from this total, $128 to $165 million occurs in the poultry industry.

Heat Stress and Production

- In a recent study, 42 days broilers, whom were subjected to chronic heat stress had:
  1. Significantly reduced feed intake (-16.4%)
  2. Lower body weight (-32.6%)
  3. Higher feed conversion ratio (+25.6%)

Heat Stress and Meat Quality

- Chronic heat exposure negatively affects fat deposition and meat quality in broilers, in a breed-dependent manner.
- Heat stress is associated with depression of meat chemical composition and quality in broilers.
- Chronic heat stress decreased the proportion of breast muscle, while increasing the proportion of thigh muscle in broilers.
- Protein content was lower and fat deposition higher in birds subjected to heat stress.

Transportation and Heat Stress

- Broilers may be exposed to a variety of stressors during transport from the production farms to the processing facilities, including thermal challenges of the transport microenvironment, acceleration, vibration, motion, impacts, fasting, withdrawal of water, social disruption, and noise.
- As part of this complex combination of factors, thermal stress, in particular heat stress, plays a major role.

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- The confined conditions within the transport containers reduce the effectiveness of the bird's behavioral and physiological thermoregulatory mechanisms.
- Consequently, the adverse effects of these factors and their combinations range from mild discomfort to death.
- In fact, heat stress during transport has been associated with higher mortality rate, decreased meat quality, and reduced welfare status.

Cont. ...

- In a study conducted during the course of 3 years, Warriss *et al.* demonstrated:
  1. Seasonal impact with peak mortality rates occurring in the summer months.
  2. progressive, marked increase in broiler mortality as the environmental temperature increased.

Cont. ...

- In a study to determine the factors influencing bruises and mortality of broilers at harvest, percentage of bruises was associated with season, moment of transport, and ambient temperature; the same factors were also associated with increased mortality, in addition to body weight and stocking density, transport and lairage time.

Cont. …

- Interestingly, it has also been reported that death in transit between production farms and processing facilities is associated with bird size (*i.e.*, larger birds = higher mortality risk) [60]. It is undisputable that the welfare of broiler production is becoming an increasing public concern in relation to both the production stage per se, but also to the harvest process. It is evident that not enough attention has been given to this area, and therefore, further research is critically needed.

Cont. …

- Productivity of laying hens flocks may also be affected by a multitude of factors, including environmental stress (such as heat stress), which is probably one of the most commonly occurring challenges in many production systems around of the world.
- Decreased feed intake is very likely the starting point of most detrimental effects of heat stress on production, leading to decreased body weight, feed efficiency, egg production and quality.
- However, in addition to decreased feed intake, it has been shown that heat stress leads to reduced dietary digestibility, and decreased plasma protein and calcium levels.

Cont. ...

- In a recent study, a 12-day heat stress period caused a daily feed intake reduction of 28.58 g/bird, resulting in a 28.8% decrease in egg production.
- Star *et al.* reported a reduction of 31.6% in feed conversion, 36.4% in egg production, and 3.41% in egg weight in laying hens subjected to heat stress.
- In another study, heat stress caused decreased production performance, as well as reduced eggshell thickness, and increased egg breakage.

Cont. ...

- Additionally, heat stress has been shown to cause a significant reduction of egg weight (–3.24%), egg shell thickness (–1.2%), eggshell weight (–9.93%), and eggshell percent (–0.66%).
- Corroborating these reports, Mack *et al.* also observed decreased egg production, egg weight and egg shell thickness in laying hens subjected to heat stress.

Cont. …

- An interesting series of experiments demonstrated the increasing detrimental effect that chronic heat stress has on egg production. In these experiments, a reduction of 13.2%, 26.4% and 57% occurred in egg production in laying hens subjected to heat stress during 8–14 days, 30–42 days and 43–56 days, respectively.
- In another study, a marked decrease in egg production (28.8%), feed intake (34.7%) and body weight (19.3%) was also observed in laying hens subjected to chronic heat stress, during a 5-week period.

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- Although much variation of effects is observed between many of the studies published, the consistent finding of significant impacts of heat stress on egg production and quality is noteworthy.
- The variability of the effects reported may be easily explained by the use of birds of different age or genetic background, as well as due to variable intensity and duration of the heat stress treatments applied.

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