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Heat Stress in Broilers and Effective Mitigation Strategies

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Introduction

One of the most important factors that negatively impacts poultry production is high environmental temperature that led to heat stress in chickens especially broilers as they are particularly sensitive to high temperature due to their fast growth rates and high metabolic activity. The ambient temperature for growing broilers is 18-22°C and any temperature range higher than the ambient temperature leads to heat stress in broilers. Physiologically poultry differs from other warm-blooded animals as they do not have sweat glands, have weaker vasomotor reaction, thermoreceptors are localized in the skin, tongue and brain, and heat-regulating centre is located in the hypothalamus. Under the condition of heat stress, chickens try to maintain body temperature to ensure the functioning of the vital organs but during this process they limit their feed intake, walking and standing and there is increase in resting time, drinking and panting. This continuous panting in birds could lead to respiratory alkalosis, leading to change in blood pH and thus creating more stressful condition. Blood flow also play an important role to maintain body temperature so during period of heat stress the blood flow is diverted to peripheral circulation and there is reduced blood flow to visceral organs leading to state of hypoxia. This hypoxia leads to oxidative stress in visceral organs especially intestine and the intestinal immune function is impaired which increase the chances of enteric infection. Heat stress also leads to decreased feed intake, increased feed conversion ratio and mortality thus negatively impacting broiler production efficiency causing a significant economic loss.

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Sharp rise in environmental temperature may lead to mass mortality of the stock. To restore balance with the rising ambient temperature, the bird stretches the wings and slows down its motor activity leading to decrease in depth of breathing and increase in rate of breathing by a factor of about 5-6. There is dilation of blood vessels of skin, wattles and combs and the internal heat is supplied to the skin surface leading to heat loss due to convection. To maintain homeostasis under heat stress birds do accelerated breathing for heat dissipation due to evaporation which leads to increased rate of CO_2 removal and hence leading to acid base imbalance. The main signs of heat stress include decrease in feed consumption and growth rate and increase in water intake and there is deterioration of carcass quality of broilers. So, there are several evidences that show that heat stress has detrimental effects on poultry health and performance so potential mitigation strategies are required to face the challenge of heat stress in poultry which are mentioned in the text below.

Mitigation Strategies

Integration of various mitigation strategies is crucial for sustaining broiler production under heat stress conditions. Implementation of these strategies is necessary to enhance heat tolerance in broilers, reduce economic losses, and ensure sustainable poultry production in challenging environmental conditions. The various mitigation strategies include:

1. **Genetic modifications:** Some of the potential target genes which can help to mitigate heat stress in poultry include Naked Neck (Na) gene, frizzle (F) gene, Dwarf (dw) gene *etc*. Na gene can help to reduce the feather cover in neck region and thus help in heat dissipation through neck region and thus help in reducing body temperature. F gene can lead to curving of the outline of the feather, thus reducing feather weight and increase heat radiation from the body.
2. **Environment and Housing Management:** The poultry hosing should be having east-west orientation and enough roof overhang should be there to keep away direct sunlight from entering the building. There should be proper ventilation as it impacts ambient temperature and relative humidity. A side wall height of at least 2.1 m should be there along with curtails that can be raised or lowered easily. A roof slope of 45°C is recommended as it decreases heat gain of roof from direct solar radiations, and materials such as thatched and bamboo can be used to insulate the roof. A sprinkling roof with cool water, fans and interior fogging can also be used in poultry houses to reduce heat load. Early heat conditioning can be done in birds as it increases the tolerance capacity of birds against high environmental

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temperature. Stocking density of the birds can be reduced in summers as it improves the feed and water accessibility and also increases heat dissipation from the body. Thinning of the litter can also be done during summers as it helps to make the litter dry, and thus birds can cool their body by dust bathing.

3. **Feeding Management:** Feed restriction during the hotter period of the day can be used in poultry for the management of heat stress as it helps in reducing rectal temperature, reduce the metabolic rate and minimize mortality in birds. Although this approach is not widely used in the industry as it leads to reduced growth rate and delay in market age of the birds. Another approach is dual feeding regime in which protein rich diet can be provided during the cooler times of the day and energy rich diet can be provided during the warmer period as thermic effects of protein is higher as compared to carbohydrate but this approach has also limitations with growth rate and feeding efficiency. Another approach is wet feeding in which water is added to the feed which helps in increased water intake and decreased viscosity in the gut helping in pre-digestion and improved absorption of nutrients from the gut. It can improve feed intake, body weight gain and weight of GI tract but is also associated with risk of fungal growth in feed. Higher amount of fat can also be supplemented in diet of birds as fat is known to cause lower heat increment as compared to protein and carbohydrates and diminish detrimental effects of heat stress. One of the most adaptable practices for the field condition in management of heat stress is providing fresh and cold drinking water along with electrolyte solution which help in maintaining the acid base balance and improve the heat tolerant capacity in chicken.
4. **Nutritional Management:** Supplementation of vitamins and minerals in feed of poultry can reduce the impact of heat stress. There are many reports which suggest that dietary supplementation of Vitamin A, C and E improves feed intake and body weight in broilers which are reared under heat stress. These vitamins are known to possess antioxidant activity and thus help in scavenging free radicals produced inside the cell. They can also modulate inflammatory signalling and regulate the production of various cytokines. Supplementation of various micronutrients such as Zinc, Chromium, Selenium *etc.* are associated with the antioxidant defence system, immune function, skeletal development, metabolism of carbohydrates, proteins, lipids, and nucleic acids. Panting in heat-stressed birds lead to acid-base imbalance in blood leading to respiratory alkalosis. Supplementation of electrolytes such as NH_4Cl, $NaHCO_3$, and KCl can lead to recovery from such imbalance.

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Various purified phytochemicals such as Lycopene, Resveratrol, Epigallocatechin Gallate, Curcumin *etc.* can be supplemented to the diet of poultry to mitigate heat stress. The main mechanism of action of these phytochemicals is by activation of antioxidant response element in the DNA and enhancing the production of antioxidant enzymes and they also possess anti-inflammatory effects. These phytochemicals are known to improve feed intake, body weight and FCR in heat stressed broilers. Osmolytes such as Betaine, Taurine *etc.* can be supplemented in the feed of birds as they help in mitigating the heat stress regulating the cellular osmotic environment and preventing dehydration by increasing the water-holding capacity of the cell. Betain is known to possess anti-inflammatory properties and thus improved gut health. Taurine is known to possess antioxidant activity, maintain calcium homeostasis, osmoregulation, and membrane stabilization. Feed supplements such as probiotics (*Lactobacillus plantarum, Lactobacillus salivarius, Pediococcus acidilactici etc.*), prebiotics (Galactoligosaccharides, Fructooligosaccharides, Plum fibres *etc.*) and herbal feed additives (Dried turmeric rhizome powder, *Nigella sativa* extract, *Thymus vulgaris* powder, *Moringa oleifera etc.*) can also be used in diet of poultry to mitigate heat stress as they possess antioxidant and immunomodulatory properties.

Conclusion

` In conclusion, heat stress poses a significant challenge to broiler production due to its adverse effects on feed intake, growth rate, and overall health. Broilers are particularly vulnerable to high temperatures due to their rapid growth and metabolic rates. Heat stress disrupts normal physiological functions, leading to reduced feed intake, altered blood pH, oxidative stress, and impaired immune function, all of which contribute to decreased production efficiency and economic losses. Effective mitigation strategies are essential to minimize the impact of heat stress. Genetic approaches offer potential solutions by enhancing heat dissipation through altered feather characteristics. Environmental modifications such as proper housing direction, ventilation, and cooling techniques can help maintain ambient conditions. Nutritional strategies involving feed manipulation, supplementation of vitamins, minerals, phytochemicals, and osmolytes are critical in supporting physiological resilience of heat-stressed birds, reducing oxidative damage, and maintaining metabolic balance.