Amelioration of Heat Stress for Poultry Welfare: A Strategic Approach
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Abstract
In many parts of the world, the poultry industry has conquered a leading position among all the agricultural and allied sectors. Egg and meat industries have shown terrific improvement due to adoption of modernized management tools and preventive measures to lethal diseases. On the other hand, heat stress has emerged as one of the major constraint for future development of this industry particularly in the hot and humid parts of the world. Since birds are deprived of sweat glands thermoregulation becomes challenging in hot weather. Affected birds become poor producers and huge death in the flock can also be observed in some cases. Therefore, the sole objective of this review is to gather and deliver available scientific reports on heat stress in poultry including its prevention measures.

Key words: Heat Stress, Poultry, Strategies, Acclimatization

Introduction
Stress represents a method adopted by body, as a response to any challenge. It can be defined as the set of responses to any external demand or challenge which lead the poultry flock to adapt to an abnormal phenomenon (Virden and Kidd, 2009; Khan et al., 2012). When the birds are in stress their normal physiological equilibrium or homeostasis is broken down. The requirement for the optimum performance of rearing poultry is to ensure the suitable environmental conditions necessary for their proper development, growth, maintenance and production (Muchacka et al., 2012). 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. This imbalance may be caused by variations of a combination of environmental factors like sunlight, thermal irradiation, air temperature, humidity and characteristics of the animal like species, metabolism rate and thermoregulatory mechanisms (Lara and Rostagno, 2013).
Birds are more sensitive to temperature associated environmental challenges, especially heat stress. Heat stress in poultry production as observed can be ‘acute’ or ‘chronic’ type (Emery, 2004). It has been suggested that modern poultry genotypes produce more body heat, due to their greater metabolic activity (Settar et al., 1999). Heat stress and exhaustion is one of the main causes of chicken death, especially when high temperature is coupled with high humidity, the combination becomes catastrophic. During the hot summer months the recommended standards of microclimatic conditions are exceeded, causing disturbances in the homeostasis of the body's internal environment of birds (Aksit et al., 2006). There is a need to re-evaluate the management of poultry and equipment used in hot weather so that heat stress is minimised. Heat Stress not only causes suffering and death in the birds, but also results in reduced or lost production, that adversely affects the profit from the enterprise.

Sources for Heat Stress and Their Effect on the Flock

Body heat is the main source of heat. In hot weather environmental temperature increases so the temperature of the ventilating air in the house also increases. Excluding temperature of the air ventilating the house, heat is also added from the roof and walls. Birds do not have sweat glands. Under high temperature conditions, birds alter their behaviour and physiological homeostasis seeking thermoregulation, thereby decreasing body temperature (Lara and Rostagno, 2013). Much of the heat from working litter is known to be used for the evaporation of moisture from litter. However, in hot weather it has been observed that damp litter makes heat stressed birds feel much more uncomfortable than dry litter. In dry litter, birds use to dust bathe more readily to aid cooling. A severely dehydrated bird may show neurological symptoms like severe head tilts and inability to perch or fly. A recent study (Mack et al., 2013) showed that birds subjected to heat stress conditions spend less time in feeding, moving or walking, but more time in drinking, panting and resting. Increased panting under heat stress conditions leads to increased carbon dioxide levels and higher blood pH which in turn hampers blood bicarbonate availability for egg shell mineralization and induces increased organic acid availability, also decreasing free calcium levels in the blood. This process is very important in breeders and laying hens, as it affects egg shell quality (Marder and Arad, 1989). 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 (Fedde, 1998). Heat stress causes slower growth and lower body weight of chickens, poor feed utilization, increases susceptibility to disease and increases mortality caused by weakness of the body's immune function (Altan et al., 2003; Sosnowka-Czajka et al., 2005).
Earlier reports showed that growth rate of broilers reduce significantly when the environmental temperature rises above 25°C (Njoya, 1995; Yahav et al., 1996)

**How Do Birds Loose Heat?**

Birds modify their behavior to stay in the ‘thermo neutral zone’. A bird controls its temperature by making use of its feather. A bird will fluff up in excess heat and the fluffed feathers form an insulating barrier for the birds. If this fails to work them start to pant and their wings will droop. Heat can be lost in a variety of ways. When the temperature of surrounding surfaces are below that of bird’s body surface, heat is lost through radiation, likewise hot walls and roofs may radiate heat to the bird surfaces. Heat can also be transferred by conduction from one surface to another surface in contact, for example, the birds are seated on litter that is cooler than their bodies. In convection method, heat loss occurs from the natural rise of warm air around a hot bird. Providing moving air has found to assist convection. After a bird can no longer maintain its body heat balance by one of these three methods, it must use “evaporative heat loss”, or panting (Department for Environment Food and Rural Affairs, 2005).

The main pathway of heat dissipation for birds in hot summer is respiratory (Hillman et al., 1985), especially when ambient temperature approaches body temperature. When air temperature rises, the frequency of breathing is increased and the evaporative heat loss is significantly enhanced (Wiernusz and Teeter, 1996).

**Observed Responses to High Temperature**

Chicks and matured chickens pant to keep cool. When heat stressed, they pant with opened mouth, spreading their wings and squatting close to the ground (Nardone et al., 2010). They try to lose heat by adjusting their feather position. The different signs observed in heat stress include Gasping, panting, spreading of wings, pale cones and wattles, closed eyes, lying down, drop in egg production, increased cannibalism and decreased appetite (Safdar and Maghami, 2014). Birds will change their normal behavior at high temperature. They may try to move away from other birds or move against cooler surfaces, such as the block walls or into moving air streams. They try to lift their wings away from their bodies to reduce insulation and expose any areas of skin that have no feathers. They use to rest to reduce heat generated by activity. Feed intake is reduced while water consumption increases. Birds divert blood from internal organs to the skin, which darkens skin colour. Finally they begin fast panting. Adult birds take about five days to acclimatize to high temperatures. Birds are more susceptible to sudden, large changes in temperature (Safdar and Maghami, 2014).
Impact of Heat Stress on Poultry Production

Different kinds of behavioral, physiological and immunological responses can be observed when birds are exposed to high environmental temperature, which impose detrimental consequences to their productivity and performance. It has been reported that chronic heat exposure to a broiler flock negatively affects fat deposition and meat quality in those birds, in a breed-dependent manner (Lu et al., 2007). The intensive genetic selection of broilers for fast growth rates seems to cause major difficulties in adapting with the extreme environmental conditions (Emmans and Kyriazakis, 2000; Yahav, 2000). For growing broilers the optimum temperature for performance as reviewed in literatures is 18-22°C (Charles, 2002). It has also been experimented that broilers exposed to heat stress had significantly reduced feed intake (16.4%), lower body weight (32.6%), and higher feed conversion ratio (+25.6%) at 42 days of age (Sohail et al., 2012). Broilers exposed to a variety of stressors during transport from the production farms to the processing facilities, but out of all the factors thermal stress plays the major role (Mitchell and Kettlewell, 1998). The confined atmosphere within the transport containers reduces the efficiency of the bird’s behavioral and physiological thermoregulatory mechanisms. Hence heat stress during transport may cause high mortality (Warriss et al., 2005). In a study to determine the factors influencing bruises and mortality of broilers at harvest, percentage of bruises was found to be correlated with ambient temperature; among other factors (Nijdam et al., 2004). There was a seasonal impact on mortality with peak mortality rates occurring in the summer months (Warriss et al., 2005). 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 (Mahmoud et al., 1996). Moreover, 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%) (Ebeid et al., 2012). Lower relative weights of thymus and spleen have been found in laying hens subjected to heat stress (Ghazi et al., 2012). A reduced liver weight was also observed in laying hens subjected to chronic heat stress conditions (Felver-Gant et al., 2012). Broilers subjected to heat stress had lower levels of total circulating antibodies, as well as lower specific IgM and IgG levels (Bartlett and Smith, 2003). It has been shown that heat stress causes an increase in heterophil:lymphocyte ratio (Felver-Gant et al., 2012). All these studies describe the immunogenic modulations those can also be used as a diagnostic tool for heat stress in a flock.

Preventive Measures

Various measures can be adopted to decompress the heat stressed birds. The key features for housing including insulation, house designing and location and ventilation have been very well elucidated by Department for Environment Food and Rural Affairs, London (2005).
Insulation as known greatly reduces heat transfer through a wall or roof and it’s effectiveness is described by the ‘U value’ (the lower the number the better). In new, clear span buildings, the U value is typically 0.35. It is inevitable in old houses that insulation will have degraded or be outside recommended standards. The design of the building including its ventilation system and construction materials has always an effect. Roof color, reflectivity, pitch and orientation have a small bearing on solar heat gain. To combat heat stress, the house and ventilation system must complement each other. Internal recirculation fans can be used where air speeds over birds are poor. Proper ventilation is the most important tool for heat stress management. A good ventilation system removes moisture laden air from the poultry house and brings in an equal amount of fresh outside air. High air speed is also essential in heat stress relief. When stocking rate is lower, the effects are greater. This makes birds feel cooler than the actual temperature (Department for Environment Food and Rural Affairs, 2005).

Sprinklers are commonly used in turkey barns for the purpose of evaporative cooling, which are used when temperatures are more than 79-86°F (26-30°C) and the air is very dry. Too much water can increase the humidity of the barn to dangerous levels (Ebeid et al., 2012). High temperatures along with high humidity make heat dissipation by evaporation very difficult. Death due to heat exhaustion will occur more quickly.

**Role of Acclimatization**

It has been proved that chickens can adapt to climatic alterations and attempts have been made to reduce heat-stress mortality in broilers by acclimatization. Birds reared at high environmental temperature are more heat tolerant than birds reared at lower environmental temperature (Al-Fataftah and Abu-Dieyeh, 2007). If house temperature is raised prior to the onset of a heat wave, reduction in flock mortality is observed. This may be due to the reduction in feed intake in response to the stress (Daghir et al., 2009; Teeter et al., 1992). Arjona et al. (1990) observed that exposure to 35-38°C for 24 hours at 5 days of age reduced mortality when these birds were heat stressed for 8 hours at 44 days of age. It has been also experimented that a temperature of 36-37.5°C at three days of age is optimum for early conditioning of broilers (Yahav and McMurty, 2001; Daghir et al., 2009). Incubating eggs at high temperature has shown to improve the tolerance of fast-growing broilers to heat stress (Yalcin et al., 2008) and this aspect is further to be studied. Acclimatization cause to increase the upper critical temperature which may be indicated by the longer time of onset of panting (Al-Fataftah and Abu-Dieyeh, 2007).

**Feeding Strategies**

Feed withdrawal leads to reduced heat production and a decrease in body temperature (Yalcin et al., 2001). Hence feed withdrawal during the hottest hours of the day has become a common practice in
many poultry farms. Conversely, a concern about feed withdrawal involves alterations in intestinal morphology and depletion of intestinal mucosa due to fasting which may damage the intestinal cells (Thompson and Applegate, 2006). During hot weather birds reduce feed consumption resulting in some nutrients becoming deficient. The energy content of the diet be increased during hot weather. Turkeys were also found to modulate their feed intake when exposed to high ambient temperature in relation to the caloric density of the diet (Veldkamp et al., 2002). Supplemental fat feeding is a common practice. In hot weather the need for maintenance energy is much lower than normal and birds consume less amount of feed. Due to reduction in consumption, there is a reduction in intake of essential nutrients such as protein, essential amino acids, minerals and vitamins. It is recommended that protein content of feed should be increased from 16% to 17-18% so that the birds will not suffer any nutritional stress. Increasing dietary protein might be detrimental to the bird as more heat is produced during its utilization that may well overload heat dissipation mechanisms (i.e., panting, blood circulation etc.). Therefore, improving overall balance of the diet by amino acid supplementation appears to be more effective than increasing protein intake (Moreki, 2008), however many trials were also carried out for evaluating the performance of broilers chickens under heat stress conditions and fed high protein diets and improvement in bird performance was observed (Temim et al., 1999; Temim et al., 2000). Maintenance of both carbon dioxide and blood pH is critical to heat-stressed broilers and the addition of ammonium chloride and potassium chloride to the drinking water to maintain this balance is advised. The dietary electrolyte balance is more critical at high temperature than at normal temperature. The addition of extra vitamins and electrolytes to the drinking water is also helpful and the use of ascorbic acid in the feed or in the drinking water has become a common practice in hot regions (Daghir et al., 2009). Drinking water cooler than body temperature will absorb body heat and this will help with cooling the bird. Adding an electrolyte to the drinking water will replenish vital nutrients that will help balance blood pH levels (Elnagar et al. 2010).

According to Moreki some feeding strategies can be standardized to combat heat stress in birds. They include feeding of Crumb, pellets or mash feed in hot summer to encourage appetite, feed should not be stored for longer than two months, so that it will reduce the possibility of mycotoxin build up, feeding should be done at cooler times of the day and lastly birds should not be fed or disturbed during the stress period. During feeding, light of low intensity should be used to decrease the heat load (Moreki, 2008).

**Conclusion**

Birds don’t have sweat glands. From various studies it has been proved that heat production is affected by body weight, species and breed, level of production, level of feed intake, feed quality and also by the amount of activity and exercise. Heat exhaustion is one of the chief causes of chicken death. Hence, it is
of utmost importance to learn how to recognise various signs of a heat stressed bird and to take different measures for the well-being of your flock. Negative effect of heat stress on poultry welfare is a measure concern both for backyard farmers and commercial enterprises.

References


