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Chapter

The Effects of Heat Stress on Production, Reproduction, Health in Chicken and Its Dietary Amelioration

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Abstract

Farm profitability is the key driver of most livestock enterprises. The productivity and profitability are driven by genetic potential of the animals and the ability to express the superiority in the production environment. In an ideal situation, an animal should produce maximally as dictated by the genetic potential. It is noteworthy that the environment in which an animal lives in impacts on its ability to expose its genetic potential. Studies have shown that it is rarely feasible to provide animals with ideal conditions to express their full genetic potential. The environment in which animals are reared is characterised by many factors that interact in ways that result in different performance even in animals of similar genetic makeup. For instance, thermal environment is critical in poultry production as it affects both the production and reproduction in different ways. The thermal environment affects chicken differently depending on the stage of growth or production phase. This environment has been impacted by the climate change and subsequent increase in climatic variability resulting in thermal challenges in naturally produced chicken thus altering production and reproduction. This implies that there is need to consider thermal resource in the routine poultry management practices. This would result to design of poultry production systems responsive to the thermal environments more so in the light of climate change and the subsequent increase in climatic variability. This chapter explores the impact of heat stress on chicken production, reproduction, health and its dietary amelioration.

Keywords: Heat stress, Chicken, Production, Reproduction, Health

1. Introduction

Climate has been identified as a factor that has direct and indirect effects on animals via the animal's environment [1]. Farmers will bear direct costs of climate change characterised by reduction in poultry yields and indirect costs of adaptation [2]. This implies heat stress is contributing to low production while simultaneously increasing the production costs. This leads to reduction in poultry enterprises profitability and is a threat to the survival of the sector. Notably, all domestic livestock are homoeothermic which means that they are continuously attempting to maintain their body temperatures within the most suitable range for optimal

biological activities. However, poultry are more susceptible to heat stress because they can only tolerate a narrow temperature ranges [3]. Achieving a state of thermal stability without expending too much nutrients would result in high production in systems in where nutritional, health and general animal welfare environments are maintained at optimal states. Heat stress occurs when there is a negative balance between the amount of heat energy produced by the animal and the net amount of heat energy flowing from the animal to the environment [4].

In order to maintain a constant body temperature poultry must preserve a thermal balance between their heat production and gain from the environment. This is achieved physiologically through metabolic and physical means [5]. The metabolic heat production depends on the basal heat production for maintenance of essential body processes [6]. The imbalance in heat production in birds is attributed to various environmental factors such as thermal irradiation, sunlight, air humidity and animal characteristics such as metabolic rate, thermoregulatory mechanisms and species [7].

Whenever ambient temperatures increase beyond the thermo-neutral zone, mechanisms to dissipate heat are triggered (increased respiration and heart rate), and as a result, maintenance requirements increase [8]. Similarly, maintenance requirements also increase during cold weather as the animal needs to generate heat in order to maintain body temperature [6]. The heat production varies and corresponds to the nature of activities the animal is exposed to. Process such as growth, reproduction and health status results to an increase in metabolism and subsequently heat production. Animals are able to respond to decreases and increases in metabolic, digestive and nutrient metabolism, muscular, increased metabolism heats. However, an animal has to maintain basal heat production at constancy since essential or vital body processes must be maintained [5]. There are a number of body heat loss methods [9]. The most important one is evaporation. This method depends on the ambient air temperature, the amount of available moisture, the evaporative surface area, the humidity of the air surrounding the animal and the degree of air movement [7]. The amount of available moisture depends on the quantity of sweat produced by the animal while the area of evaporating surface depends on the surface area of the animal and the size of the lungs, with considerable evaporation being achieved by panting [5].

Loss of heat by livestock through the movement of heat from one object to the other at higher temperature (conduction) is limited. Heat is transferred from the body through conduction at relatively low temperature [9]. Loss of heat from the surface (convection heat loss) increases when a cool breeze blows on the animal and increased air movement. Research has shown that the loss of temperature by convection occurs when heat by from the comb, wattles, face, legs, toes, neck, body and wings is lost to the surrounding air as air circulates inside the poultry house [10]. The cool breeze and increases in air movement significantly increases evaporative heat loss. Livestock houses in the tropics should always be constructed in ways that encourage maximal air movement on and around the animal. This is achievable by ensuring that the animal houses are well ventilated.

The documented normal body temperatures of chicken ranges between 41 and 42°C, while the chicken thermal comfort zone falls within 18–21°C. Study by Wasti et al. [11] showed that temperatures above 25°C results to heat stress. When the balance between body heat production and loss is not maintained then the birds are subjected to heat stress. The balancing occurs in an environment charactersied by interactions of many factors key among them being high environmental temperatures, radiant heat, airspeed and humidity among others. When the ambient temperatures are high, chicken use various physiological and physical mechanisms to maintain a thermal comfort zone [9]. The birds use body energy reserves to

maintain a thermal comfort zone. This occurs at the expense of production and growth. This implies that heat stress negatively impacts the productivity and profitability of poultry enterprises. Broiler meat and eggs lose their quality under high temperatures resulting to further postharvest losses.

2. Heat regulation in poultry

Birds do not have sweat glands and rely on evaporative cooling which is aided by panting to regulate their body temperatures. It has been documented that due to lack of sweat glands in birds, most of the heat loss occurs through respiration [5]. Birds have an extensive air-sac system connected with their lungs which is important in heat regulatory function [5]. In the tropical environments, it has been observed that poultry frequently hold their wings slightly separately when standing to allow air flow through while at the same time extending the heat loss surface area [12]. The birds adopt an extended position when lying down to further increase the surface area. Collectively, these behavioural responses maximise on the surface area of the body in contact with the external environment for heat dissipation [12]. Studies have shown that when chicken are exposed to heat stressful conditions, they spend less time moving and more time resting in the shades or cool places [13]. Birds also manage heat by increasing or decreasing feed and water intake [14]. When the temperatures are high, birds tend to reduce their feed intake while increasing their water intake. The reverse holds when the temperatures are low.

Generally, chicks from many poultry species are not able to efficiently regulate body temperature during early and post hatching period [15]. However, at an early age, the chicks should be provided with right temperatures in the post-hatching stage without which they get chilled and die almost immediately. This underlines the importance of good brooding heat management by provide adequate heat (artificially) for the young chicks. The temperatures should be set at around 35°C in the first week after hatching, with a 3°C weekly reduction until normal ambient temperature of about 23°C - 26°C is attained. Lin et al. [16] proposed that the ideal temperature range for neonatal chicks should be set at between 32 and 35° C. It is important to maintain the right chicks' temperature range when transporting them from hatcheries to avoid overheating or chilling which reduces their post hatch-survival rate [17]. Abdelazeem [18] reported that, high ambient temperatures reduce the chicks' growth rate and feed intake. There is general sluggishness in chicks when temperatures are high [17]. This tends to reduce the feeding time and results in reduced feed intake and consequent poor performance in growth. This problem can be managed by formulating high nutrients density chick feeds which would ensure a good supply of nutrients in the face of low feed intake [19].

It has been observed that free range birds maintain thermal neutrality by hiding under shades during the hot hours of the day while resuming the scavenging in the cool hours of the day [13]. The pattern has also been noted with housed birds which stop feeding during the hot hours of the day and resume feeding in the cool afternoon. This is important for poultry producers to note so as to synchronise their feeding strategies to the behaviour in areas characterised by high ambient temperatures.

3. Effect of environment on poultry nutrition and production

Various environmental factors including temperature, light, rainfall, humidity and altitude collectively impact on an animal's nutrition [14]. The respective factors

can impact on the intake singly or cumulatively. There is an inverse relationship between energy requirements and effective temperature which subsequently affects feed intake mechanisms related to circulating levels of blood components [20, 21]. It has also been documented that high temperatures above the critical thresholds leads to reduced feed intake, lower feed conversion efficiency and lower body weight [19]. It has been observed that heat from an external source or from specific dynamic action of feed has effect on the rostral cooling centre of the hypothalamus which results to a stimulation of the medial satiety centre which in turn inhibit the lateral appetite centre [16]. This results to a decrease in feed intake and subsequent lower the production and/or reduced reproduction efficiency. Broiler birds when exposed to high solar radiation are coupled with depression of chemical composition and meat quality [22].

Birds experiencing heat stress usually pant with their mouths open, elevated wings and have higher tendencies of squatting near the ground [17]. It has been reported that laying flock when exposed to high temperatures shows disturbance in acid -base balance in the blood as a result of hyperventilation, there is excessive loss of CO^2 from their lungs due to gasping [20]. The lowered amount of CO^2 in blood leads to a rise in blood PH causing calcium ions to drop in blood that would have been utilised by the shell gland resulting to poor egg quality [23]. It is noteworthy that increased panting in poultry is a sign of heat stress. Other noticeable indicators of heat stress include elevated respiratory rate, and restlessness which lead to increased loss of body fluids and therefore dehydration [20]. The birds also tend to drink more water in order to cool their bodies while feed intake reduces drastically. These adversely affect the efficiency of meat production and the meat quality especially in the exotic birds not adapted to the tropics. Zhang et al. [24] demonstrated that, when broiler chickens were exposed to high temperature during the growing phase, it resulted to poor meat characteristics and loss of quality. Ranjan et al. [25] observed that when broiler birds are exposed to high ambient temperatures during the growth phase tended to result in poor meat characteristics as well as loss of storage quality [22]. Heat stress reduced the proportion of breast meat while increasing the proportion of fat in the carcass. Zeferino et al. [26] further noted that when broilers were exposed to high ambient temperatures during the finishing phase, the carcass lost quality characters related to consumer preferences such as colour, tenderness and shelf life due to increased meat PH. High altitude areas ranging from 2,900–3,900 m are characterised by hypoxia, lower air pressure and lower ambient temperature compared with the lower altitude areas. This in turn affects nutrients partitioning which has impact on productivity and profitability. More nutrients are shifted to deal with the cold and the low oxygen levels which subsequently affects nutrients digestibility and allocation of the nutrients to various biological processes [26]. In all cases, production and reproduction performances are affected negatively.

It is evident that temperature primarily affects production of poultry meat and eggs through increased or decreased feed intake. Various authors such as [20, 21] reported that there was notable reduction in egg production in hot environments due to decrease in feed intake, decreased digestibility of different diet components and reduced uptake of available nutrients [19, 27]. Generally, feed intake starts to decline when chickens are kept in an environment characterised by temperatures above 27°C. At 35°C there is a significant decrease in feed intake. Besides, studies have shown that the reduction in intake is accompanied by decrease in feed conversion ratio. Optimal nutrient intake and utilisation is a key factor in weight gain and egg production which are the key drivers of poultry enterprise productivity and profitability. Any factor that affect the intake is important to producers whose objective is production optimisation and profit maximisation. In a scenario where

the intake is negatively impacted by high ambient temperatures, producers can counter the reduction in feed intake by formulating high density diets. Besides, feed management can be accomplished through housing chicken in well ventilated pens especially in areas characterised by high ambient temperatures [15]. Poultry production systems in environments characterised by high ambient temperatures have reported steep rise in culled birds resulting from reduced productivity and death emanating from heat stroke. This loss makes such systems unproductive and unprofitable.

The high temperatures further cause a decrease in the egg shells thickness and weight [28] in laying hens. This leads to increased egg breakage during the storage and transportation. Generally, egg quality during storage decreases gradually with increasing temperatures [29]. Low temperatures have no impact on egg shell thickness while low temperatures have been shown to increase feed conversion ratio.

Climatic stress in laying hens leads to a reduction both egg production and quality [30]. The notable decrease in egg production can be explained by the imbalance between calcium-oestrogen and the reduced Haugh Unit of the albumen detected in birds subjected to heat stress [31]. This leads to a reduced yolk size, albumen consistency and normal calcium deposits on the egg shells. Birds tend to spend more time resting rather than eating which negatively impact on the available nutrients to satisfy production and reproduction processes and outcomes [32]. Climatic stressors trigger the behavioural, physiological and immunological responses which have detrimental consequences on production and quality. Heat stress shifts more energy to maintenance and acclimatisation functions at the expense of growth thus resulting to decreased body weight gain when subjected to heat stress. Lara and Rostagno [31] noted that the negative effects on production and quality emanate from the decreased feed intake, reduced feed digestibility, low plasma protein and calcium levels. Oguntunji and Olufemi [30] observed that egg sizes which affects their market value decreases with a decrease in feed intake. Scavenging poultry is affected more as the birds spend more time under shades when they should be harvesting nutrients necessary in production and reproduction [33].

It is noteworthy that exposure of day-old chicks to high ambient temperatures during transportation, which has been identified as one of the leading causes of chicks' mortality, leads to exhaustion and death [15]. This means there are less birds available for production and reproduction. Day old chicks should be transported in well ventilated trucks and in equipment that ensure air circulation while at the same time avoiding overcrowding. Besides the need to transport the chicks in appropriate temperature range, high temperatures during transportation of broilers from the farm to the slaughter and processing facilities have been shown to impact the quality meat negatively [34].

4. Heat stress and reproduction

Studies have shown that high ambient temperatures, outside the thermal-neutral zone results to negative effects on chicken biological processes. The optimal temperature ranges between 12°C -26°C. Research findings presented in Ebeid et al. [35] suggest that reproduction of the animal is highly affected with high temperatures. The study shows that when white leghorn hens are subjected to high temperatures there is a decline in reproductive activity leading to reproductive failure and poor egg quality.

Fouad et al. [34] further showed that increased environmental temperatures affect all stages of semen production. Slight elevation of the environmental temperature during the early phase of semen production has been shown to stimulate

testicular growth which in turn promotes increased quality and quantity of semen. However, high temperatures in mid and late semen production result in decreased the seminiferous epithelial cell differentiation which results a decrease in semen concentration and volume. This has negative impact on the cock's fertility and flock reproduction in general [34]. The work by Karaca et al. [36] confirmed that heat stress resulted to decreased semen quality.

Findings by Nidamanuri et al. [37] showed that the function of the hypothalamus and pituitary gland is negatively affected by heat stress. Results from a study [38] using leghorns chicken exposed to heat stress depicted a decline in the production of gonadotropin releasing hormone (GnRH) and luteinizing hormone (LH) which are associated with increased levels of prolactin. Rozenboim et al. [39] observes that the resulting low GnRH, LH and FH (follicle stimulating hormone causes regression of the ovary which reduces the capacity of the theca cells resulting in impaired steroidogenesis. Wasti et al. [11] indicated the levels of gonadotropin-releasing hormone, plasma progesterone, testerone and estradiol hormones is impaired in heat stressed birds which leads to a general reduction in reproductive efficency. The reduced effciency results in lost reproduction and subsequently poultry flocks productivity and profitability. It is further documented that eggs obtained from hens subjected to high temperatures have lower hatchability. High temperatures cause a decrease in granulosa cells responsiveness which results in the disruption of the hormones that are crucial in ovulation. Studies by Ayo et al. [40] and King et al. [41] involved collection of semen during summer to test the effects of heat on the characteristics of spermatozoa and found an increase in deformities including bent heads, cytoplasmic droplets and cut mid-piece. Ayo et al. [40] further demonstrated that semen collected during the cooler periods (especially in the morning) of the day resulted in higher rate of conception when used in artificial insemination.

The endocrine system and the environmental cues are the key drivers of reproductive patterns of an animal [42, 43]. There are various environmental factors that influence reproduction including the day length (more pronounced in temperate regions), temperature, rainfall patterns (seasons), human management practices such as feed and feeding management system, animal population interactions and socialisation, health and nutritional status of the individual among other factors [44]. Taberlet et al. [42] observed that significant alteration of one and/or a combination of the factors could partly or completely disrupt the reproduction function. The environmental factors that influence reproductive processes do so ultimately or proximately which is based on the time at which they affect the breeding activity. The ultimate influencers are more significant as they relate to the effects on long term basis. Food availability is the most important ultimate environmental factor that affects breeding due to the need to synchronise animal feed demand and supply. Ambient temperature is an important proximate environmental factor.

5. The effect of heat stress on response to diseases

The health of a flock has a direct relationship with poultry enterprise productivity and profitability. The costs and lost production associated with unhealthy flock leads to enterprise losses and at times to the collapse of the venture. There are a number of risk factors associated with the health of a flock including the climatic conditions of the area in which the production occurs [1]. Temperature is an important climatic factor that affects the bird's ability to fight off an infection. In order to resist or fight off an infection sufficient and high-quality nutrient are required [15]. The bird should also have minimal heat stress since there would be a

competition for nutrients between fighting the infection and search for heat balance in the body. High temperatures negatively affect both the nutrients intake and the chicken thermal neutrality thus exposing the birds to diseases [45].

High temperatures are commonly encountered in the tropics for most of the year and during summer in temperate regions. In sub-optimally managed flocks, the temperatures may rise above the thermal neutral zones thus stressing the birds and exposing them to diseases conditions [11]. This can be counteracted by housing the birds in well ventilated pens, provision of high-density nutrients diets and high level of diseases prevention technologies.

Heat stress compromises absorption of nutrients, integrity of gut wall and the immune system in birds [46, 47]. In addition, the weight of the liver reduced along with reducing levels of antibodies [48]. Another research found that the reduction of antibodies was could be the sole reason for increased incidences of diseases like infectious bursal disease virus (IBDV), Newcastle disease virus (NDV) and infectious bronchitis disease virus (IBDV) during heat stress in poultry birds [49]. High humidity alters the homeothermy in poultry birds and induces the growth of disease causing agents like viruses, fungi and bacteria [45]. Moreover, during hot conditions, incidence of many bacterial diseases such as salmonellosis, coccidiosis and *E. coli* infection increased [45]. It is also documented that broilers that were exposed to heat stress showed decreased immunity and became more susceptible to pathogens such as coccidia that induces necrotic enteritis [50]. Heat stress resulted in reduction of the relative weight of the thymus, Bursa of fabricius and the spleen which also suffered oxidative damage in exposed flock [34]. The decrease in the weight of the organs implied that the affected individuals suffered reduction in the production of antibodies. This results in higher exposure to infectious diseases in heat stressed birds. Wasti et al. [11] identified a spike in the prevalence of infectious and contagious diseases in poultry in summer seasons in the tropics which they related to the higher incidences of heat stress in poultry flocks.

6. Management of heat stress in poultry flocks

The primary objective of managing heat stress is to free up nutrients that would have otherwise gone into establishing and maintaining thermal neutrality in animals to be used in growth, maintenance of good health status, production and reproduction. This in turn lead to increased animal productivity and animal production enterprise profitability. The harmful effects of heat stress due to high temperatures are evident and therefore, it is necessary to adopt appropriate strategies to minimise the impacts of high temperatures and enhance production of eggs and chicken meat to meet the growing demand for poultry products [16]. Heat stress in poultry can be reduced by a multi-approaches strategy including modification of the surrounding environment (housing designs, ventilation systems, provision of shaded areas), nutritional management, stocking density management [51] and selection for heat tolerance genes [52, 53]. The approaches can be oriented towards general farm management or dietary manipulation.

6.1 Farm management

Designing well ventilated poultry house is the first step in the management of heat stress [15]. This can be achieved by installation of efficient air circulation systems in areas characterised by long periods of high ambient temperature. Butcher and Miles [54] notes that this not only ensures appropriate air movement in the poultry house in provision of sufficient air movement for convective heat loss

in hot conditions but also aids in maintenance of appropriate air quality in terms of oxygen, carbon dioxide, ammonia and humidity. In free-range production system poultry producers should avail shades by planting shrubs around the homestead or building a shade. This creates a conducive environment for the scavenging chicken to shelter during the hot periods especially in the tropics. Grass cover around the poultry shed is a way to reduce the heat load on birds, similar is the case with plantation of trees around the shade [15]. Furthermore, a shiny surface on the roof can reduce heating of the house from solar radiation. Provision of appropriate shelter, shade, sprinkling systems and ventilation are the various management strategies employed. To avoid compounding the effect of heat stress in poultry flocks, additional stress which could result from routine handling procedures such as vaccination, beak trimming, and transfers. If it is necessary, they should be effected during the cool hours of the day and if possible at night while making sure the birds are held gently and calmly.

Findings presented in a study by Bhadauria [14] indicates that heat stress can be reduced or eradicated by ensuring that birds are provided with the recommended floor space which ensures that there is no overstocking. A floor space of 0.06 m^2/bird for birds weighing 1.7 kg, 0.13 m^2/bird for those weighing 3.5 kg both of which translate to a density of 27.8 kg/m^2.

Besides the direct negative impacts of heat stress in poultry flocks, it has also been noted that hatchery eggs should be transported and stored in air-conditioned environment so as to maintain their quality [55]. It is noteworthy that good quality eggs have a high hatchability. Consumer eggs also need to be transported in an environment not detrimental to their quality as this will hamper their market price and preference [56]. Chicken meat is highly perishable under high temperatures and for that reason should maintained in a cold chain from slaughtering to the market to avoid loss of quality [57].

Animal breeding (selection) for chicken lines that perform better in environments characterised by high ambient temperatures has been identified as a potential heat stress management strategy [11, 52, 53]. This can be achieved by considering genes identified as having potential to be involved in thermal regulation. For example, the naked neck gene and the frizzle gene have been suggested in several literature potential genes to develop breeds that can cope with high ambient temperatures [11]. Other studies have also found that poultry breeds with superior thermotolerance can be developed by using thermo-tolerant genes such as frizzle gene, naked neck genes, dwarf gene and polymorphisms in heat shock proteins (HSP) genes using marker assisted selective breeding [52, 53]. The broiler lines have a high metabolic rate and are more susceptible to heat stress.

6.2 Dietary management

High ambient temperatures negatively impact nutrients intake and utilisation in chicken through different pathways [19, 27]. However, irrespective of the pathway, the net effect is poor performance in terms of production, reproduction and health. For example, results from the study carried out by Saeed et al. [15] indicated that the gut microorganisms' population and diversity was negatively affected by heat stress. The study findings indicated that the problem can be counteracted by supplementing the chicken with probiotics which have potential to restore the population and diversity in the jejunum and caecum thus resulting to microbial balance while maintaining the natural stability. This implies that prebiotics and probiotics can help in reducing heat stress and improving performance in poultry birds.

The study by Sohail et al. [19] showed that chronic heat stress reduced broiler production performance by interfering with the intestinal microarchitecture as

well as increasing the adrenal hormone concentrations, however, this challenge was counteracted by use of prebiotics like the mannan-oligosaccharides and probiotic mixture which reduced/eradicated the negative impacts caused by the anatomical and physiological changes. An analysis of the existing literature such as [19, 25, 49, 58–61] on potential approaches has shown that nutritional manipulation as well as inclusion of feed additives such as vitamins, antioxidants, probiotics, prebiotics has potential to eradicate and/or reduce the negative impact of heat stress on chicken performance. For instance, findings presented in a study by Ranjan et al. [25] showed that varying energy concentration in chicken diets, adjusting feeding times, manipulating protein to energy ratio in chicken feeds, wet feeding and using automated drinkers raised at an optimal height positively impacted on chicken performance in environment characterised by high temperatures.

The investigation by Ranjan et al. [25] concluded that birds should be supplied with high density diets to compensate for the lost feeding time and the decreased feed intake in response to high environmental temperature. The diets should be high in amino acids, vitamins, electrolytes and sodium bicarbonate to compensate for mineral lost through increased panting. Ratriyanto et al. [61] reported that during heat stress supplementing laying quails with feed additives such as the Betane at a rate of 0.06–0.12% increased feed intake, protein and energy ratio as well as improving the egg quality variables. It is noteworthy that addition of vitamins A, E and zinc is beneficial in increasing antioxidant levels as oxidative balance is disturbed in heat stressed birds [49]. The study indicated that supplementing chicken diets with vitamin E alleviated many negative effects that occur during heat stress. Crozier et al. [58] demonstrated that use of phytochemicals with antioxidant activity helps to solve heat stress in chickens. Phytochemicals like polyphenols, a vital secondary metabolite found in certain plants serve as a means to reduce heat stress. Furthermore, it has been found that polyphenols have the ability to boost the expression of heat shock proteins (HSP) and antioxidant enzymes which restrain reactive oxygen species in the body of poultry birds [62]. Inclusion of vitamins C and E, carotenoids and microelements such as zinc, copper and selenium in chicken diet act as antioxidant non-enzyme system which helps in during stressful conditions [62]. Study by Yosi et al. [60] showed that supplementation of minerals like potassium chloride (KCl) in poultry drinking water are beneficial effect under heat stress condition.

Further, findings in the research by Sahin et al. [59] demonstrated that feeding layers late in the evening in environments constrained by high ambient temperatures resulted in improved laying percentage and egg shell quality. This would be explained by the increased nutrients intake that would support improved laying and high-quality egg shell as calcium is an integral component of chicken feeds. Literature search and review indicates that early morning or late evening chicken feeding, when the ambient temperatures are low, is a potential strategy in managing heat stress in poultry production. Wet feeding is also used in managing heat stress as it results in compensation of the water lost when birds pants, which always increase with increase in ambient temperature [19, 27]. Besides, drinking water should be placed in the shades to supply the body requirements [27]. Since water plays a key role in regulating the body temperature of birds water tanks should be located in a shade and insulated [19]. The personnel working within the poultry houses should ensure at all times that there is sufficient water flowing in the drinkers. The findings presented in Gous and Morris [27] and Sohail et al. [19] indicate that birds water intake increases by 1.2% for every 1°C rise in the temperature range of 22–32°C and 5% for 1°C rise in the temperature range of 32–38°C rises which are able to control body temperature in hot environments. Optimal utilisation of increased nutrients and water intake has to be accompanied with a good supply of oxygen [14]. This

implies that there is need to enhance air flow in the chicken houses. In free range systems where ambient temperatures are high it would be advisable to place the supplemental feed near or under the shades [19].

7. Conclusion

Heat stress is one of the challenges faced by the poultry industry in the tropics and the world at large. In the recent years, global temperatures have been rising due to global warming. There are negative effects of heat stress that reduce the production and quality of poultry products. In addition, it impedes on the gains made in poultry welfare. Much information has been published concerning heat stress; nevertheless, there is need for more research on its effect and mitigation measures on free range chicken in the tropics.

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