HEAT STRESS ALLEVIATION FROM BROILER CHICKEN FED TUMERIC

BY

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SUPERVISED BY
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CERTIFICATION PAGE

This is to certify that this project works has been read and approved at meeting part of the

The requirement for the award of Higher National Diploma in Agricultural Technology, Department Of Agricultural Technology, Kwara State Polytechnic,Ilorin.

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DEDICATION

I dedicate this report first and foremost to Almighty (Allah) who has been there for me right from the beginning to the very point. Also I dedicate it to my ever supportive and loving parents for their relentless support and compassion towards me during the course from fresher to final year.

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ABSTRACT

An experiment was conducted to alleviate heat stress using Tumeric powder, 360 broiler birds was used for the experiment, there are two graded levels with three replicate of 10 chicks each with two control of both positive and negative located in a control room to have adequate temperature for birds at 38-29^{0}C, the chicks were brooded for three weeks and the experiment started on the 4th week that lasted for another three weeks, the temperature was maintained at 34^{0}C for 7hours + or – 1^{o}C, at the end it was discovered that birds that took 5g of Tumeric performed better

Introduction

In many parts of the world, poultry farming occupies a significant position among agricultural industries since it contributes major portion of the animal protein to human population.

There has been an unprecedented increase in global animal production, especially in subtropical and tropical areas in the last two decades (Renaudeau et al., 2012). The increase in the demand for food is due to a rise in human population (Godfray et al., 2010). Due to its potential role to provide food and livelihood securities (Paswan et al., 2014), poultry production, especially broiler production, are expected to meet the critical shortage in animal protein needed by Africa (Hatab et al., 2019).

There has been growing concerns on the impacts of climate change on livestock production. For example, in West Africa, the expected increase in average temperature by 2°C–6°C by the year 2100 (Sylla et al., 2016) portends a serious challenge to sustainable broiler production. Due to the climatic challenge, heat stress events are expected to become more frequent in livestock species (Rahimi et al., 2020).

High ambient temperature adversely affected the performance of broiler chickens Tawfeek et al. (2014). However, the authors indicated that supplementation of antioxidants ameliorated the effects of thermal stress on the birds. Therefore, the diets of the birds are required to be adjusted to the climatic conditions (Attia & Hassan, 2017; Nir, 1992; Suganya et al., 2015) and also to the prevailing economic status of the countries where they are produced.

The growth rate of commercial broiler chickens is fast and they are able to reach market weight of two kilogram and above at about seven weeks of age or less (Smith, 1990; Tallentire et al., 2016). However, optimal growth of the birds can only take place when the birds are reared under a thermoneutral zone of 18°C–24°C (Charles, 2002; Oke et al., 2020; Olanrewaju et al., 2010). Indeed, harsh environmental conditions circumscribe the growth potential of the birds (De Basilio et al., 2001; Sohail et al., 2012). Also, Ahaotu et al. (2019) emphasized the negative influence of seasonal fluctuations on poultry

production in different parts of Africa. Liverpool Tasie et al. (2019) suggested that farmers who had been confronted to economic losses due to heat stress adopt adequate strategies.

In this research, various materials will be used to alleviate heat stress including lycopene, herbal materials and drugs, so that effect of heat is reduced to bearest minimum not to seriously affect growth.

1.2 Statement Problem

Statement of Problem Heat stress in broilers represents a significant challenge in the poultry industry, impacting both animal welfare and economic productivity. As global temperatures continue to rise above 270C due to climate change, poultry farmers in tropical and subtropical regions face increasingly frequent and severe episodes of heat stress. Broilers, being fast-growing meat-type birds, are particularly susceptible to heat stress because of their high metabolic rates and relatively limited ability to dissipate excess heat. Consequently, heat stress can lead to a host of physiological, economic and environmental factors, posing major threats to sustainable poultry production. The physiological impact includes increased respiration rates (panting), reduced feed intake, and impaired immune responses, it exacerbates oxidative stress, causing damage to cellular structures, which further compromises the birds' health. Heat-stressed in broilers often display poor growth performance, higher morbidity, and increased mortality rates. Prolonged exposure to high temperatures can induce chronic stress, discomfort, and suffering, raising ethical concerns about poultry management practices. The economic impact includes poor feed digestion and nutrient metabolism with the resultant slower growth rates and lower feed conversion efficiency, the latter is one of the those with critical factors in broiler production profitability. Additionally, heat stress can lead to lower carcass quality, with potential decreases in meat yield and alterations in meat composition and 1 yield. Moreover, the increased mortality rates during heat waves directly translate to financial losses for producers. This economic burden is further compounded by the additional costs incurred for cooling systems, energy

consumption and veterinary care aimed at mitigating the effects of heat stress. These problems could be alleviated with the use of herbal plants and will cause broiler birds no side effect. A lot of the herbal plants has both phytochemical and antioxidant qualities that could be of use in alleviating heat stress problems in broiler birds.

1.3 Justification

The necessity of herbal materials has recently been mentioned in several public and international Lectures, Most of the herbal plants that are very useful medically and are readily available all year round have been abandoned for a very long time. Among the herbal plants that can be used for militating heat stress are Adasonia digitata, Pakia biglobosa, Tumeric, Tamarind and Moringa olifera because of their Anti-oxidant properties. Several occasions, both World health organization (WHO) and Food and Agricultural organization (FAO) has strongly advised against the continuous use of vetenary drugs because of their negative consequence both to birds and the final consumer of broiler meat.

Climate change has been a major factor that is setting back the poultry industry in Nigeria and all over the world, climate change causes heat stress in birds that leads to under production, this problem occur every year and farmers keep losing.

Farmers are finding it difficult to pay back loan given to them by central bank of Nigeria as a result of loss caused by sickness, mortality and poor production which is turn caused by heat stress and this heat stress is caused by climate change.

The herbs are available in large quantity in our environment, the five herbs are perennial, they are readily available and cost little or nothing to get them.

The main objective of this research work is to alleviate heat stress from broiler birds using our local herbs called Tumeric that is readily available and cheap, to avoid heat stress that causes huge loss by the broiler farmer every year

1.3 Objective of the study

i- To carry the characterization of the herbs under investigation
ii-Provide pen that can supply a 32^{O}c for six (six)hours
iii- Measure the effect of this herbs in alleviating heat stress on the birds
iv- Measure the effect of this herbs on the meat of the birds

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 CONSTRAINTS TO DEVELOPMENT OF POULTRY MEAT INDUSTRY IN HOT & HUMID ENVIROMENT.

Beside the challenges of feed quality (Bastianelli et al., 2005; Houndonougbo et al., 2012) and feed costs (Leeson & Summers, 2005; Omole et al., 2005), there is serious challenge of negative effect of high ambient temperature (Attia, Al-Harthi, et al., 2020; Attia, Bovera, et al., 2020; Fathi et al., 2013; Khan et al., 2011; Mashaly et al., 2004; Muiruri & Harrison, 1991) which has posed a serious constraint to a profitable and sustainable broiler chicken production under hot and humid tropical climate. In fact, tropical conditions limit growth and performance of broiler chickens (Gordon & Charles, 2002; Renaudeau et al., 2012). Thus, high ambient temperature in the tropics constitutes thermal stress on the birds and this remains a major constraint in poultry production, particularly, broiler chickens (Ahaotu et al., 2019; Ayo-Enwerem et al., 2017). Two major issues will be x-rayed here, viz: the problem of thermal stress and of its influence on broiler strains raised under hot and humid environments.

2.2 IMPACT OF TROPICAL CONDITIONS ON BIRDS

The challenges posed by climate change has become a global concern and this is not sparing the poultry sector either. The increase in ambient temperature and relative humidity are causing serious disruption to the poultry industry, particularly in opened-sided poultry house in tropical environments. Due to fast growth of commercial broiler chickens, they are particularly susceptible to these climatic extremes.

2.3 UNDERSTANDING OF THE CONCEPT OF HEAT STRESS

There is no universal definition for stress. It refers to any situation that elicits the biological stress mechanisms of an animal (Selye, 1970). It is also defined as a biological response elicited when the homeostasis of an animal is interrupted (Moberg, 2000) or responses to external stimuli that make an animal adapt to a new or abnormal situation (Puron et al., 1994; Virden & Kidd, 2009). Broadly, stress is the sum of defence mechanisms or non-specific

responses of an organism when it is faced with abnormal situation or extreme demands (McEwen & Akil, 2020; Sahin et al., 2009). The negative impacts of heat stress on poultry have been reported (Marchini et al., 2016; Oke, 2018; Oke et al., 2020; Olanrewaju et al., 2010; Wan et al., 2018; Yahav et al., 1997). The responses of birds to high ambient temperature includes high body temperature; lower feed intake, feed efficiency, live weight and growth and performance (Ozbey & Ozcelik, 2004). In poultry farm, heat stress sets in when the ambient temperature exceeds 25°C (Merat, 1990), and cold temperature is temperature less than 20°C on average, the optimum is being located mostly between 22°C and 25°C. High relative humidity could modify the perception of the heat by animals (Yahav et al., 2000). Then, temperature must be associated with relative humidity in order to properly assess heat stress.

2.4 DIFFERENTS TYPES OF HEAT STRESS

The concept of heat stress or the exposure to high ambient temperature can be broadly categorized into two: - The acute heat, which refers to exposure to stress with a very high temperature during short period. Its main effect on broiler chickens is an increase in mortality, often by suffocation; - The chronic heat, which refers to the exposure of an animal to a prolonged high temperature for several weeks. The resultant consequence of this is a decrease in performance of the birds. Both continuous and cyclical heat stress affects broiler performance by decreasing weight gain by 36% and 21%, respectively (de Souza et al., 2016). Several studies have been conducted on the responses of broiler chicken to different heat stress durations as shown in Table 1. The trials were generally conducted from a few minutes (45 min, Washburn et al., 1992) to several days (de Souza et al., 2016; Park & Zammit, 2019) when the thermotolerance of birds to heat stress was assessed. To assess the capacities of the animal to maintain good performances in hot climate, the length of trials was longer, varying from few days (3–10 days, Yamada & Tanaka, 1992) to some weeks (de Souza et al., 2016.

2.5 BROILER CHICKEN'S BEHAVIOUR AND RESPONSES TO HEAT STRESS

It has been shown that fast growth rate in broilers is linked with increased appetite and accelerated rate of voluntary intake with the digestive capacity of the gastrointestinal tract almost being used to the fullest (McCarthy & Siegel, 1983). Additionally, studies have shown that broiler conserve energy through reduced activity but spend more time in sitting/resting as they grow older (Newberry et al., 1988). The resultant effect of this is metabolic disorders leading to lameness and abnormal gait (Bradshaw et al., 2002; De Smit et al., 2005). Metabolic disorders are associated with a failure in one of the body hormone or enzyme systems, storage disease related to lack of metabolism of secretory products because of the lack of production of a specific enzyme, or the failure or reduced activity of some metabolic function (Khan et al., 2012; Stanbury et al., 1983). Basal metabolism of broiler chickens has been reported to reduce under chronic heat stress with an increase in additional heat from metabolizable energy (Sayed & Downing, 2015; Tesseraud et al., 1999). Also, the proportion of energy retained in the form of of lipid reserves to meet the energy needs of the birds (Tesseraud & Temim, 1999).

2.6 EFFEC TS OF HE AT STRESS ON BROILER CHICKENS

Broiler production in the sub-Saharan region of Africa is encumbered by a problem of high temperature and relative humidity (Ayo-Enwerem et al., 2017). The increase in temperature coupled with high humidity usually becomes critical (Pragya et al., 2014). Farmers are faced with serious thermal challenge, particularly during the dry season, when daily temperatures reach their extremes (Ahaotu et al., 2019).

A peculiar challenge of broilers in hot climate is that the birds are selected for greater growth rate and generate more heat (Sandercock et al., 1995) and thus need lower ambient temperature to maintain normal body temperature in order to attain genetic potential for rapid growth (Emmans & Kyriazakis, 2000). There has been a rapid increase and expansion in commercial broiler production in tropical countries where climatic control of broiler houses is lacking (Cahaner et al., 2008).

Most farmers cannot afford a controlled housing system for the birds and in most cases, there is no adequate power supply to support this, especially, in the developing countries. Lower feed intake, growth and protein deposition combined with an increase of fat deposition in broiler chickens has been reported under chronic hot ambient temperatures in poultry houses (Geraert, 1991). In broilers, feed intake is depressed when ambient temperature rises. However, the reduction of growth in broilers is often greater than the reduction in feed intake, resulting in a lower feed efficiency (Al-Fataftah & Abu-Dieyeh, 2007; Geraert et al., 1993).

The fasting heat production is the main component being affected by high temperature in chickens (Geraert et al., 1996). Broilers chickens exposed to thermal stress has been reported to gain less protein (Temim & Tesseraud, 1999) but retain more fat, growth, reproduction, thermoregulation and defence mechanisms (Khan et al., 2011; Quinteiro-Filho et al., 2012). In order to cope with heat stress challenge, they redistribute body reserves of energy and protein at a cost of decreased reproductive efficiency and growth performance (Park & Kim, 2017; Puron et al., 1994). Continuous stress causes fatigue and weakness (Sayed & Downing, 2015). Birds are more likely to succumb to starvation and infectious diseases (Quinteiro-Filho et al., 2012) if the condition becomes protracted (Khan et al., 2011).

2.7 MECHANISMS OF BODY HE AT REGULATION IN POULTRY

Environmental stressor is one of the main limiting factors of broiler production efficiency in hot and humid areas (Renaudeau et al., 2012). Production performance, health and product quality of broiler chickens are influence by climatic conditions including temperature, relative humidity and ventilation influence (Lin et al., 2006; Yahav et al., 2000). It increases panting and mortality in birds (Abidin & Khatoon, 2013). Generally, the severity of the effect of environmental temperatures in thinner animals is lower than in the larger ones (Ozbey & Ozcelik, 2004).

Poultry birds are more susceptible to climate change because birds can only tolerate narrow temperature range of 18°C–24°C as their thermoneutral zone (Weaver, 2002).

According to Charles (2002), the optimum temperature of (thermoneutral zone) for performance is between 18°C and 22°C for growing broilers. Broiler chickens do not experience heat stress when they reared under thermoneutral zone, as their body temperature is held constant and the birds lose heat at a controlled rate without discomfort. However, under high ambient temperature, the birds need to regulate their body temperature. Thermoregulation is the balance between heat production and heat loss, mechanisms that occur to maintain a relatively constant body temperature (Khan et al., 2011). Thus, when birds' temperature exceeds the upper critical limit of thermo-neutral zone, it is considered to be heat stressed. Five mechanisms of thermoregulation have been identified in birds, namely, radiation, conduction, convection, evaporation and excretion (Defra, 2005; Ruvio et al., 2017).

Some of the adjustments make under stressful conditions include dilation of the blood vessels of the skin, wattles and comb to bring internal body heat to the skin surface, to facilitate conductive, convective and radiative heat loss. The absence of sweat glands makes broiler chickens susceptible to high ambient temperatures (Fathi et al., 2013), as sweating is not possible. To compensate for this, they try to lose heat by evaporative heat loss mechanism such as panting. When the use of such mechanism get exhausted and the cooling becomes insufficient, then death occurs (Al-Fataftah & Abu-Dieyeh, 2007; Sahin et al., 2009). Under heat stressed conditions, birds usually have limited nutrients for growth, reproduction, thermoregulation and defence mechanisms (Khan et al., 2011; Quinteiro-Filho et al., 2012).

In order to cope with heat stress challenge, they redistribute body reserves of energy and protein at a cost of decreased reproductive efficiency and growth performance (Park & Kim, 2017; Puron et al., 1994). Continuous stress causes fatigue and weakness (Sayed & Downing, 2015). Birds are more likely to succumb to starvation and infectious diseases (Quinteiro-Filho et al., 2012) if the condition becomes protracted (Khan et al., 2011).

2.8 Adasonia digitate (Baobab)

Baobab (Adansonia digitataL.)Baobab (Adansonia digitataL.) is a multipurpose tree species belongingto the Malvacea family (Bremer et al., 2009) and is a deciduous tree (Yazzie et al., 1994).Baobab fruit tree occurs naturally in dry areas of Africa, mainly in the Sahelian, Soudano-Sahelian and Soudanian zones; the distribution extends through the woodlands, savannas, and grasslands of Sub-Saharan Africa to about 25°S. It is characterised by its massive size, reaching toa height of 18 –25 m. The bark is smooth, reddish-brown, greyish-brown or purplish-grey, soft and fibrous (Chadare et al., 2008).In Malawi baobab fruit treesare found along the shores of Lake Malawi and Shire River. The fruits are in season from April to September(Saka et al., 2002;Tembo, 2008). Ripe fruits are large, egg shaped;15 to 20 cm long with a hard woody outer shell covered with yellowish brown hairs and is filled with a dry white powdery pulp that covers brownish seeds having a bean-like structure. The pulp falls off upon cracking the shell and is eaten fresh like sweets and having a slightly lemon sherbet texture and taste.

Traditional use of baobab

Baobab fruit throughout Sub-Saharan Africa every part of baobab fruit is used where trees are found. Baobab is used as a source of food, traditional medicine, as well as sold (fresh fruits or processed) for household income. Seeds, leaves and bark are used for the treatment of malaria, tuberculosis, fever, diarrhoea, anaemia, dysentery and toothache while fruits are used for treatment of microbial infections (Caluwéet al., 2010; Kaboré et al., 2011; Vermaak et al., 2011).Because of the multipurpose and growing efforts and interests by rural communities to process into different products, baobab fruit was selected for this study amongst several priority indigenous fruits of Malawi. Further postharvest handling and transportation of baobab fruit samples to the United Kingdom was easier as the fruits are not perishable and well protected with a hard outer shell. Unlike other indigenous fruits, transportation of baobab was cheaper and possible at ambient conditions without any loss

of quality. Baobab fruits are processed into different products including juice, yoghurt, gruel, sour dough, oil, a coffee-like drink and dried as food reserves (Saka et al., 2002). However, these products are achieved through local processing knowledge and often of low quality. Baobab fruit products are already gaining popularity on the international market including the UK because of global increasing demand for dietary sources of bioactive compounds. Most western organic food and drug companies are realising or becoming aware of 9 potential health benefits of baobab from traditional knowledge of its use by local African people. Currently baobab pulp (a dry white powder) is purchased from Malawi and used by a few companies in European countries including the UK for manufacturing of health organic food products, medicines and cosmetics. In the UK several baobab products including Minvita Superfruit Powder, Minvita Baobab Body Oil, Baobab Vitamin C Capsules and Baobabs were identified in supermarkets(Holland & Barrett, Leeds). These products are sold at much higher prices compared to cost of raw materials.For instance, pulp powder (5000 g) costs less than £5 including transportation to the city centre within Malawi. However the cost of 250 g baobab pulp powder called Minvita Baobab Superfruit Powder is £14.99 (Hollard and Barrett, Leeds, UK).

2.9 Tamarind

Tamarind (Tamarindus indica L) is primarily used for its fruits, which are eaten fresh or processed, used as a seasoning or spice. It is better known for the pod pulp (40%) which is rich in vitamin C and contains tartaric, malic, and citric acids as well as sugars, has a sweet-sour flavor and is used in drinks, sweet meats, curries, and chutneys. It is an essential ingredient in Worcestershire sauce. Pulp is the richest known natural source of tartaric acid (8 to 18%) which is the main acidulant used in the preparation of foods in India. Almost every part finds at least some use, either in textile, carpentry, nutritional or medical. Tamarind seeds are flattened, glossy, and orbicular to rhomboid. They are 3-10 cm x 1.3 cm in size. They are dicotyledonous. Seeds are hard, red to purple brown in color. Seed chambers are lined with a parchment like membrane. Cotyledons are thick. Seed size varies between 320-700 g per kg

of fruit. Tamarind seed consists of the seed coat or testa (20-30%) and the kernel or endosperm (70-75%) (Shankaracharya, 1998). Seed portion in tamarind is about 40% of the total weight. It is a by-product of the commercial or noncommercial utilization of the tamarind fruit for various purposes. This waste product mainly from commercial utilization can serve as good source for tamarind seed. At present tamarind is cultivated in 54 countries of the world: 18 in its native range and 36 other countries where it has been introduced. The major producers for tamarind are India, Thailand, Bangladesh, Sri Lanka and Indonesia. In America, Mexico and Costa Rica are the biggest producers . India is world's largest producer of tamarind products. It is particularly abundant in the states of Madhya Pradesh, Bihar, Andhra Pradesh, Karnataka, Tamil Nadu and West Bengal. India has traditionally exported processed tamarind pulp to Western countries, mainly the European and Arab countries and more recently to the United States of America.

Chemical composition

Whole tamarind seed and seed kernel are rich sources of protein. Fat or oil comprise of 4.5-16.2% of total composition. Crude fiber percentage is very less in whole seed while the seed coat is rich in fiber (20%) and tannins (20%). Remaining 50 to 57% is carbohydrate.

Amino acid profile

From the chemical composition, it can be seen that tamarind seeds are a good source of protein. Amino acid profiles of tamarind reveal that the proteins contain fairly balanced essential amino acid levels (Table 3). Except a few, all the amino acids such as Isoleucine, Leucine, Lycine, Methionine, Phenylalanin, Valine content are considerably high in seed. In terms of protein content and WHO standards, tamarind seeds score well for 3 of the 8 essential amino acids. However, for each of the eight essential amino acid s score is close to or above the 100% mark, except tryptophan.

Mineral Composition

Tamarind seeds appear to be a good source of different mineral elements such as calcium, phosphorus, magnesium and potassium. Of all the minerals studied K is the element in highest concentration (Siddhuraju et al.2015), with the values for the trace mineral copper also relatively high (Glew et al., 2007). The high concentration of potassium is nutritionally significant by playing a key role in neuro-muscular function (Ajayi et al., 2006).

Anti-nutritional Factors

Tamarind seeds have low levels of phytic acid comparable to that of lima bean. Phytic acid decreases bio- availability of certain minerals, may interfere with the utilization of proteins due to the formation of phytateprotein and phytate-mineral-protein complexes, and also inhibits the digestive enzymes (Reddy et al. (1982; Siddhuraju et al., 1995). Processing methods such as soaking and autoclaving are effective to eliminate phytate Tamarind seeds contain 2.8 mg/100 g cyanogens, which is probably too low to cause any concern since cooking is known to reduce cyanogens content significantly.Trypsin inhibitor activity of tamarind is 26. Trypsin Inhibitor Unit per mg is low and exhibits lower inhibitory activity than that of various edible legumes like soybeans. It was reported that cooking eliminates more than 98% trypsin inhibitor activity.

Immunity booster

Tamarind seeds contain immunity boosting properties and can protect from many diseases and disorders. TSP prophylactically enhanced haemoglobin (Hb), red blood cells (RBCs), white blood cells (WBCs), and platelets. The increased expressions of CD4+ and CD8+ cells

suggested a strong predominance of TH1 cytokine producing T cells on treatment with TSP (Aravind et al., 2012).

Antibacterial activity

Tamarind seed has antibacterial benefit that can protect from pneumonia-causing bacteria, Typhus and Staphylococcus aureus. This also protects from a bacterium that causes skin infections as well as intestinal and urinary tract infections (Daniyan and Muhammad, 2008).

Protection against LDL oxidation and DNA damage

Methanolic extract from seed coat of Tamarindus indica L. containing polyphenol, procyanidins, (“)- epicatechin shows protective effect against Cu2+-induced human low-density lipoprotein (LDL) oxidation and oxidative damage of plasmid DNA. Hence, seed coat extract may be useful for preventing LDL oxidation and DNA damage (Suksomtip and Pongsamart, 2008).

2.9.1 PAKIA BIGLOBOSA

Parkia biglobosa (Jacq) Benth and Parkia bicolor A. Chev belong to the plant family Mimosaceae of the order Leguminisae. In Yoruba, P. bicolor is referred to as Igba Odo; Dorowa, in Hausa, and in lbo as Origili Okpi. P. biglobosa popularly known as the African locust bean tree is known in Yoruba as Igba, or Irugba, in Hausa as Dorowa and in lbo as Origili. The fermented seeds of P. biglobosa are used in all parts of Nigeria and indeed the West Coast of Africa for seasoning traditional soups. Similarly, both trees form a crown so are often grown as shade trees (Daziel, 2017). However, there are some distinctive characteristic differences. P. bicolor is a tree usually found by the river bank and can grow up to about 100m high. On the other hand P. biglobosa is found commonly everywhere in the Savannah and it grows up to about 20m high. The pinnae of the former is about 10 - 26 pairs while that of the latter is about 6 - 11 pairs. The leaflets of P. bicolor occur in 20 – 55 pairs, those of P. biglobosa in 14 -

30 pairs (Andrew, 2006). Parkia species have found use traditionally as foods, medicinal agents and are of high commercial value. The pulverized bark of P. bicolor is employed in wound healing. P. biglobosa is known to provide an ingredient that is used in treating leprosy, and for treating hypertension. In Gambia, the leaves and roots are used in preparing a lotion for sore eyes. A decoction of the bark of P. biglobosa is also used as a bath for fever, as a hot mouthwash to steam and relieve toothache. The pulped bark is used along with lemon for wound and ulcers (Irvine, 1961). Parkia plants have been identified as source of tannins, saponins, gums, fuel and wood Seeds of various species of Parkia have also been investigated for their protein and amino acid contents (Fetuga et. al., 1974). In continuation of our study of chemical constituents of different parts of P. bicolor and P. biglobos (Aiyelaagbe, et. al., 2016) and plant foods (Ajaiyeoba, 2018) for their medicinal and food values, the photochemical screening and antimicrobial studies of P. bicolor and P. biglobosa is presented.

2.9.2 Moringa olifera

Moringa (Moringa oleifera Lam). is a type of local medicinal Indian herb which has turn out to be familiar in the tropical and subtropical countries. The other terms used for Moringa are Horseradish tree, Mulangay, Mlonge, Benzolive, Drumstick tree, Sajna, Kelor, Saijihan and Marango. Moringa oleifera division to become from Kingdom: Plantae, Division: Magnoliphyta, Class: Magnoliopsida, Order: Brassicales, Family: Moringaceae, Genus: Moringa, Species: M. oleifera (Fahey, 2005). Moringa oleifera is one of the vegetables of the Brassica order and belongs to the family Moringaceae. The Moringaceae is a single genus family with 13 known species (Khawaja et al., 2010). Moringa oleifera is a small native tree of the sub-Himalayan regions of North West India, which is now indigenous to many regions in Islands and South America. Traditionally, besides being a daily used vegetable among people of these regions, the Moringa is also widely known and used for its health. Among commoners, it has earned its name as ‘the miracle tree’ due to its amazing healing abilities for various ailments and even some chronic diseases. Several investigations were carried out

to isolate bioactive compounds from various parts of the plant due to its various applications (Guevara et al., 2009). Therefore, herbal plants in medicine or known as phytomedicine are still trustworthy and widely applied as one of the alternative way in medicine due to its affordable cost (Abalaka et al., 2009)

For centuries and in many cultures around the world, the medicinal usage of the Moringa has been used to treat problem such as skin infection, anaemia, anxiety, asthma, blackheads, blood impurities, bronchitis, catarrh, chest congestion, cholera and many other illnesses (Khawaja et al., 2010; Hamza, 2010; Singh et al., 2012). Moringa oleifera also contain anti inflammatory, anti spasmodic, anti hypstensive, anti tumor, anti oxidant, anti-pyretic, anti-ulcer, anti-epileptic, diuretic, cholesterol lowering, renal, anti-diabetic, (Paliwal et al., 2011; Sharma et al., 2012) and hepatoprotective activities (Lai et al., 2010; Huang et al., 2012). It has also long been labelled for its great cosmetic value in which in recent years, the Moringa has commonly been found to be used in various health care products including body and hair moisturisers and conditioners. It was also discovered that Moringa oil was used in skin ointments ever since the Egyptian times. The Moringa was claimed to be 'the most nutrient-rich plant yet discovered' by Khawaja et al. (2010).

2.9.3 Tumeric

Turmeric of commerce is the dried rhizome of the plant Curcuma domestica Val. syn. C. longa L Turmeric is mentioned in the 'Atharva Veda' of 1000–1500 bce, a holy treatise of the Hindus, as 'haldi' or 'haridrar' (AV/1/22/4) (Shah,1977). Ethnobotanical evidence indicates that it has been used in India since very ancient times. It is believed that the crop spread out from India to distant Asian countries under the infl uence of the Hindu religion. According to Marco Polo (1280), the spread of turmeric to China took place in ce 700 cf (Ridley, 1912). Burkill (1966) believed that the crop spread to West Africa in the thirteenth and to East Africa in the seventeenth centuries, respectively. It was introduced to Jamaica in 1783 (Velayudhan et al., 1999). Although turmeric is now grown in India, Pakistan, Malaysia, Myanmar, Vietnam,

Thailand, Philippines, Japan, China, Korea, Sri Lanka, Nepal, South Pacifi c Islands, East and West Africa, Malagasi, Caribbean islands and Central America, India is the major producer and exporter of turmeric at present. Turmeric is used in curry powder, chicken bouillon, sauces, gravies, dry seasonings, baking mixes, processed cheese, pickles, relishes, breading, soups, beverages and confections (Peter, 1999). In addition, it is used in medicine, at religious functions and as a biopesticide (Sasikumar, 2005)

Chemical composition

Thomas (2009) studied the chemical and biochemical profi le of some of the traded turmerics from India such as 'Alleppey Finger', 'Rajapuri', 'Wynadan' along with the popular varieties, namely 'Prabah', 'Prathibha' and 'Alleppey Supreme' (Table 28.1). The nutritional profi le of turmeric can be found in Table 28.2. Turmeric is valued mainly for its principal colouring pigment, curcumin, besides other nutritive constituents like potassium (Peter, 1999) (Table 28.2). Curcumin, which has the molecular formula C21H20O6, is the major constituent that imparts the yellow colour to turmeric. The curcumin content in different turmeric varieties varies from 2–7 % (spectrophotometric estimation). Besides curcumin there are a few other related pigments which impart the yellow colour, which, together with curcumin, are named curcuminoids. Curcumin 1,7-bis (4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione], demethoxy curcumin [4-hydroxy-cinnamoyl (4-hydroxy-3-methoxycinnamoyl) methane and bis-demethoxy curcumin [bis-(4- hydroxy-cinnamoylmethane] together make the colouring pigment in the turmeric rhizomes. There are not many reports on the curcuminoid profi le of traded turmerics barring the reports by Jayaprakasa et al., (2002) and Paramasivam et al., (2009). Jayaprakasa et al., (2002) analysed the curcuminoid profi le of the traded varieties like 'Salem' (9.18 %), 'Erode' (9.11 %) and 'Balasore' (7.10 %) using HPLC, whereas Paramasivam et al. (2009) described a high-pressure thin-layer chromatography (HPTLC) method for the determination of curcuminoids of C. longa germplasm from India. The result suggested that two Indian turmeric varieties, viz. 'Nimbarg' and 'Kalimpong', have

higher amounts of total curcuminoids, 6.18 and 5.37 %, respectively. Recently, Thomas (2009) studied the curcuminoid profi le of six popular/traded turmeric varieties, namely 'Prabha', 'Prathibha', 'Alleppey Supreme', 'Alleppey Finger Turmeric', 'Rajapuri' and 'Wynadan', and observed that, among the varieties, 'Prathibha' contains the highest amount of curcumin I and curcumin III (Table 28.3). The essential oil of turmeric contains a variety of molecules credited with very many pharmacological properties. In the traded Indian turmerics, the major compounds identifi ed are turmerone (26.20–31.55 %), curlone (18.64–20.48 %) and ar-turmerone (19.11–23.94 %) (Thomas, 2009). In 'Alleppey Finger Turmeric' and 'Prathibha', turmerone was identifi ed as the major essential oil component, using gas chromatography–mass spectroscopy (GC–MS), at levels of 31.55 % and 30.60 %, respectively (Thomas, 2009).

CHAPTER THREE

MATERIAL AND METHODS

Site of the experiment: The research will be conducted at the Poultry section of the teaching and research farm of Kwara State Polytechnic, Ilorin in Moro local government area of Kwara state

Sources of chicks: Two hundred and forty (240) day old chicks will be purchased from Affcom farm Nigeria ltd, Ilorin for this experiment.

Sources of stress alleviator: Herbal plants will be sourced in the school environment

Sources of feed ingredients: Feed ingredients are purchased from Oluwagbemisola feeds Nig Ltd along Offa garage road in Ilorin.

Experimental feed composition: straight feed containing about 23% crude protein will be used for the experiment, from the beginning till the end instead of using starter and finisher at three weeks each as shown below in table 3.1

Table 3.1: showing the composition of the experimental feed

Ingredients	**Kg**
Ingredients	
Maize	450
Soy bean	239
Groundnut cake	117
Wheat offal	111
Palm oil	17.5
Fish meal	30
Bone meal	20
Limestone	10
DL-Methionine	2.5
Lysine	1
Vitamin/mineral premix[a]	2.5
Salt	2.5
Enzyme	0.5
Nutrients[b]	
Metabolizable energy (MJ/kg)	11.03
Crude protein	230.3
Crude fibre	40.1
Lysine	11.2
Calcium	12.8
Phosphorus	7.9
Methonione	3.0

[a]Providing per Kg diet: 12,500IU vitamin A,; 2,500IU vitamin D3; E,18.75mg vitamin; 2.65mg vitamin K3; 2mg vitamin B1; 6mg riboflavin,; 0.025mg vitamineB12; 0.0325mg Biotin; 1.25mg Folic acid; 12mg Panthothenic acid; 50mg Niacin; 8mg Copper; 75mg Zinc; 80mg Iron; 100mg Manganese; 0.15mg Selenium; 0.35mg Iodine; 60mg Salinomycine; 0.1g Chlortetracycline; 2.0g Choline chloride; 0.3g Ethoxyquin.
[b]Determined values except for metabolizable energy,lysine,methionine, calcium and phosphorus were calculated from the published composition of the ingredients used

Managements of experimental birds: The chicks will be fed with fresh feed and water everyday *ad libitum* and the drug and vaccine programme will be followed strictly to ensure the birds are healthy.

Table 3.2 shows the Vaccination and medication Programme.

WEEK	DAYS	MEDICATION
1st	Day 1	Antistress, Glucose, Multivitamin
	2nd – 6th	Multivitamins
	7th	Gomboro vaccine
2nd	8th – 13th	Vitamins
	14th	Lazota
3rd	15 – 20th	Anticocci then vitamins next day
	21st	Vitamins
2nd Gamboro		
	22nd – 27	Vitamins
4th	28th	2nd lazota
	29th – 34th	vitamins
5th	35th	Fowlpox vaccines
	36 – 41	Vitamin
6th	42	Decorim

Metrological condition of experimental pen: The temperature of the inner part of experimental pen will be monitored using thermometer, humidity meter, radiation meter, so that the temperature is measured at 32^0C ±1^0C for 6 hours (between 10am – 4pm), heat will be generated using briquette, so that the amount and quality of energy produced is controlled, a thermostat will be installed to monitor when the temperature is below or above 32^0C and an alarm will ring to indicate which of the situations, so that an appropriate step is taken on time to remove or add briquette

Metrological stations: Visit will be made to metrological station to really enquire when the sun rises, when it is most hot and when the heat start reducing and finally set.

Data collections: Data on Performance characteristics, Blood indices, nutrient digestibility, Immunological parameters, morphological expression, Stress marker (corticosterone and lymphocytes) will be collected and analyzed

Experimental design: Two hundred and forty (240) day old chicks (D.O.C) will be distributed randomly to five (5) different herbs with two (2) control of both positive and negative, with each herbs replicated three (3) times. There will be just one inclusion level 3.75/litre (15g/4litres) of drinking water. Each replicate will have ten (10) DOC. There will be only a source of heat 32^0C ±1^0C and will be applied for 21 days till end of experiment for 6 hours (10am-4pm) for three weeks, the best three of the herbal plants will be picked for next feeding trial

Statistical analysis: All data collected will be subjected to statistical analysis using SAS (version 2.8, 2012).

CHAPTER FOUR

RESULT AND DISCUSSIONS

Randomized Complete Block Design (RCBD) with Replications

A two-way layout is called a randomized block design (RBD) or a randomized complete block design (RCBD), the t treatments are randomly assigned to b experimental units such that each of the $t!$ ways of assigning the treatments to the units has the same probability of being adopted in the experiment and the assignment in different blocks are statistically independent.

Hypothesis:

There are two null hypotheses to be tested.

(i) Treatment Effect

$H_0: \alpha_1 = \alpha_2 = \cdots = \alpha_t = 0$ vs $H_1: All\ \alpha_i's\ are\ not\ equal$

(ii) Block Effect

$H_0: \beta_1 = \beta_2 = \cdots = \beta_b = 0$ Vs $H_1: All\ \beta_j's\ are\ not\ equal$

The linear model under consideration is

$$y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}, \qquad i = 1,2,\ldots,t \text{ and } j = 1,2,\ldots,b \tag{1}$$

Where,

y_{ij} = the observed value for replicate j^{th} block of i^{th}treatment;

μ = the overall mean;

α_i = the effect of i^{th} treatment

β_j = the effect of j^{th} block; and

e_{ij}= experimental error

Assumptions of RCBD

i. y_{ij} are assumed to independent and normally distributed

ii. $\sum \beta_j = \sum \alpha_i = 0$

iii. $e_{ij} \sim NIID(0, \sigma^2)$ i.e. independently and identically normally distributed with mean 0 and constant variance σ^2

Computational formular:

$$SST = \sum_{i=1}^{t}\sum_{j=1}^{b}(y_{ij} - \bar{y}_{\bullet\bullet})^2 = \sum_{i=1}^{t}\sum_{j=1}^{b}y_{ij}^2 - \frac{y_{\bullet\bullet}^2}{bt} = \sum_{i=1}^{t}\sum_{j=1}^{b}y_{ij}^2 - \frac{G^2}{N} = \sum_{i=1}^{t}\sum_{j=1}^{b}y_{ij}^2 - C.F$$

$$where, G = y_{\bullet\bullet}\ , N = bt, C.F = \frac{G^2}{N} = correction\ factor$$

$$SSt = \sum_{i=1}^{t}\sum_{j=1}^{b}(\bar{y}_{i\bullet} - \bar{y}_{\bullet\bullet})^2 = \sum_{i=1}^{t}\frac{y_{i\bullet}^2}{b} - C.F$$

$$SSB = \sum_{i=1}^{t}\sum_{j=1}^{b}(\bar{y}_{\bullet j} - \bar{y}_{\bullet\bullet})^2 = \sum_{j=1}^{b}\frac{y_{\bullet j}^2}{t} - C.F$$

$$SSE = SST - SSt - SSB$$

Under H_{0b}: $\beta_1 = \beta_2 = \ldots = \beta_b = 0$

E(MSB) = E(MSE), and SSB and SSE are independent ,

$$F_b = \frac{MSB}{MSE} \sim F[(b-1),(t-1)(b-1)],\alpha^*$$

$$where, \alpha^* = level\ of\ \ significance \qquad (2)$$

Similarly, under H_{0t}: $\alpha_1 = \alpha_2 = \ldots = \alpha_t = 0$

E(MSt) = E(MSE), and SSt and SSE are independent ,

$$F_t = \frac{MSt}{MSE} \sim F[(t-1),(t-1)(b-1)],\alpha^*$$

$$where, \alpha^* = level\ of\ \ significance \qquad (3)$$

Decision rule:

(i) $Reject\ H_{0t}\ if\ F_t > F_{[\alpha^*;(t-1).(t-1)(b-1)]}$

(ii) $Reject\ H_{0b}\ if\ F_b > F_{[\alpha^*;(b-1).(t-1)(b-1)]}$

(Montgomery, 1991, 2013)

Duncan's new multiple range test (MRT)

Duncan (1955) used a different approach to compare means, called the multiple range test, instead of comparing the difference between any two means with a constant least significant difference, each pair of means is compared against a different critical value which depends on the ranks of these means in the ordered array.

The formula for calculating critical values is

$$DMRT = Q_p . S_{\bar{y}} = Q_p . \sqrt{MSE / r} \quad (4)$$

Q_p is the tabular value from critical value for Duncan table for a given α, df for experimental error, and the degree of separation of the means in the array.

HEAT STRESS DATA ANALYSIS AND RESULTS

Table 1. Descriptive Statistics

Descriptive Statistics					
Dependent Variable:Weight gain (gramm)			gram		
Week	Treatments	Replication	Mean	Std. Deviation	N
		Replication1	310.0	41.8	5
		Replication2	490.0	41.8	5
		Replication3	310.0	54.8	5
		Replication4	440.0	41.8	5
	Treatment1(5ml)	Total	387.5	91.6	20
		Replication1	340.0	65.2	5
		Replication2	460.0	96.2	5
		Replication3	270.0	57.0	5
		Replication4	410.0	65.2	5
	Treatment2(10ml)	Total	370.0	99.2	20
		Replication1	325.0	54.0	10
		Replication2	475.0	71.7	10
		Replication3	290.0	56.8	10
		Replication4	425.0	54.0	10
Week 1	Total	Total	378.8	94.7	40
		Replication1	440.0	54.8	5
Week 2	Treatment1(5ml)	Replication2	660.0	65.2	5

		Replication3	300.0	93.5	5
		Replication4	530.0	130.4	5
		Total	482.5	158.3	20
		Replication1	436.0	119.3	5
		Replication2	512.6	54.5	5
		Replication3	363.0	74.0	5
		Replication4	850.0	100.0	5
	Treatment2(10ml)	Total	540.4	208.5	20
		Replication1	438.0	87.5	10
		Replication2	586.3	96.1	10
		Replication3	331.5	86.2	10
		Replication4	690.0	201.1	10
	Total	Total	511.5	185.1	40

Week	Treatments	Replication	Mean	Std. Deviation	N
		Replication1	510.0	119.4	5
		Replication2	580.0	57.0	5
		Replication3	580.0	57.0	5
		Replication4	570.0	67.1	5
	Treatment1(5ml)	Total	560.0	78.8	20
		Replication1	638.0	230.2	5
		Replication2	588.0	113.9	5
		Replication3	580.0	115.1	5
Week 3	Treatment2(10ml)	Replication4	625.0	103.1	5

		Total	607.8	139.8	20
		Replication1	574.0	185.5	10
		Replication2	584.0	85.0	10
		Replication3	580.0	85.6	10
		Replication4	597.5	87.0	10
	Total	Total	583.9	114.6	40
		Replication1	420.0	113.1	15
		Replication2	576.7	88.4	15
		Replication3	396.7	149.4	15
		Replication4	513.3	99.0	15
	Treatment1(5ml)	Total	476.7	133.6	60
		Replication1	471.3	192.2	15
		Replication2	520.2	100.8	15
		Replication3	404.3	156.1	15
		Replication4	628.3	204.2	15
	Treatment2(10ml)	Total	506.1	183.4	60
		Replication1	445.7	157.1	30
		Replication2	548.4	97.4	30
		Replication3	400.5	150.1	30
		Replication4	570.8	168.2	30
Total	Total	Total	491.4	160.4	120

From table 1 the average weight gain for 5ml inclusion level was 387.5g±91.6g, while for 10ml inclusion level was 370g±99.2g and total/aggregate weight gain was 378.8g± 94.7g in week1. In week 2, weight gain is 482.5g±158.3g for 5ml inclusion level, 540g±208.5g is weight gain for 10ml inclusion level and the overall weight gain is 511.5g±185.1g in week 2. In week 3, 560.0g±78.8g is the weight gain for 5ml inclusion level, 607.8g±139.8g is the weight gain for 10ml inclusion level and the total weight gain for week 3 is583.9g±114.6g.

Finally, the aggregate weight gain for the duration of research work is 476.7g±133.6g for 5ml inclusion level, 506.1g±183.4g for 10ml inclusion level and 491.4g±160.4g for the total weight gain. It is observed that there is relatively increase in weight gain from the week 1 to week 3.

Table 2. Levene's Test of Equality of Error Variances[a]

Dependent Variable:Weight gain (gramm)			
F	df1	df2	Sig.
4.771	23	96	.000
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.			
a. Design: Intercept + week + Treatments + week * Treatments			

From Table 2, p-value (0.000) suggests that the null hypothesis of equal error variance is rejected, hence we conclude that the distribution of error variance is not equal at α =5% level of significance.

Table 3. ANOVA

Dependent Variable:Weight gain (gramm)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	925133.042[a]	5	185026.608	9.868	.000
Intercept	2.897E7	1	2.897E7	1.545E3	.000
Week	865745.817	2	432872.908	23.086	.000
Treatments	25901.408	1	25901.408	1.381	.242
Week * Treatments	33485.817	2	16742.908	.893	.412
Error	2137524.550	114	18750.215		
Total	3.203E7	120			
Corrected Total	3062657.592	119			

a. R Squared = .302 (Adjusted R Squared = .271)

From Table 3, the p-value (0.000) for the chicken weight gain between and within the week based on 5ml and 10ml inclusion level is statistically significant at $\alpha = 0.05$ level of significance. However, the main effect of 5ml and 10ml as well as their interaction effect of the chicken weight gain are not statistically significant at 5% level of significance. This implies that no significant difference in chicken weight gain between the effect of the two treatments (5ml &10ml) weekly for the experimental period. That is, 5ml or 10ml inclusion level can be used for chicken experiencing heat stress without any significance difference in chicken weight gain based on treatment inclusion level.

Post hoc test was performed using Duncan multiple range test (DMRT) to determine the week with significant weight for the chicken during the heat stress period and results is displayed in the Table 4 below.

Table 4. Post Hoc Test for the Weekly weight gain

Duncan

week	N	Subset		
		1	2	3
Week 1	40	3.7875E2		
Week 2	40		5.1145E2	
Week 3	40			5.8387E2
Sig.		1.000	1.000	1.000

From the Table 4, it is observed that chicken average weight gain (583.87g) in week 3 is significantly different from chicken average weight gain (511.45g) in week 2 and chicken average weight gain (378.75g) in week 1. Also, chicken average weight gain in week 2 significantly differ from week 1. That is, week 3 can be describe as the chicken best average weight gain.

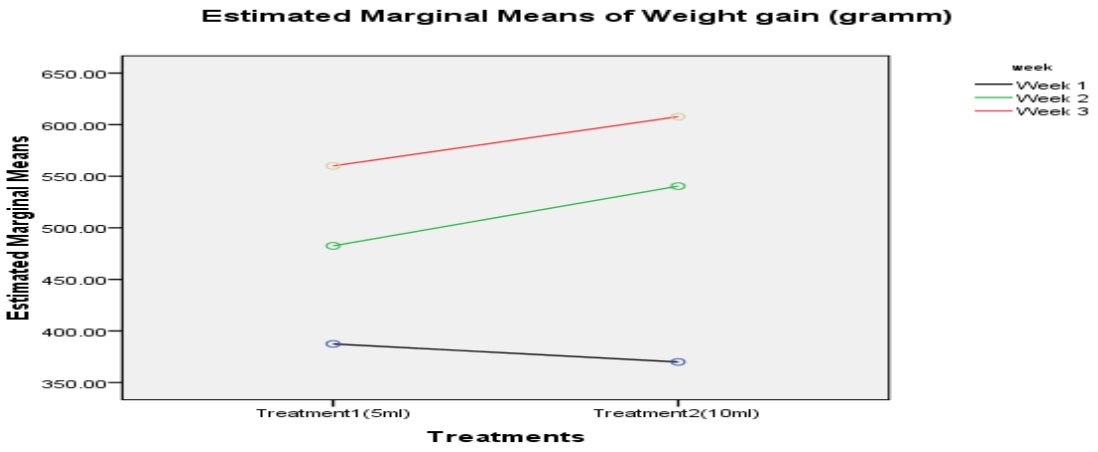

Figure 1. Estimated marginal means of the chicken weight gain

From Figure 1, week 3 is shows the best marginal mean weight gain for chicken during the heat stress experiment follow by week 2 and week 1 marginal mean weight gain, respectively.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

i- Heat stress reduces the performance of broiler birds

ii-When powdered Tumeric is added to broiler water at 1.25g per litre of water, it alleviate heat stress

iii-In addition to Tumeric, there should be cross ventilation in the poultry pen

5.2 Recommendation

i-1.25g/litre of water or 5g/4litres of broiler drinking water is recommended for broiler to alleviate heat stress

ii- Tumeric should be tried for other livestock with heat stress problem

REFERENCES

Abidin, Z., & Khatoon, A. (2013). Heat stress in poultry and the beneficial effects of ascorbic acid (vitamin C) supplementation during periods of heat stress. World's Poultry Science Journal, 69, 135–152. https:// doi.org/10.1017/S0043933913000123

Ahaotu, E. O., Patricio, D. R., Ibe, L. C., & Singh, R. R. (2019). Climate change in poultry production system - A review. Acta Scientific Agriculture, 3(9), 113–117. https://doi.org/10.31080/ASAG.2019.03.0617

Ain Baziz, H., Geraert, P. A., Padilha, J. C., & Guillaumin, S. (1996). Chronic heat exposure enhances fat deposition and modifies muscle and fat partition in broiler carcasses. Poultry Science, 75(4), 505–513. https:// doi.org/10.3382/ps.0750505

Al-Fataftah, A. R. A., & Abu-Dieyeh, Z. H. M. (2007). Effect of chronic heat stress on broiler performance in Jordan. International Journal of Poultry Science, 6, 64–70. https://doi.org/10.3923/ ijps.2007.64.70

Al-Zghoul, M. B., Sukker, H., & Ababneh, M. M. (2019). Effect of thermal manipulation of broilers embryos on the response to heatinduced oxidative stress. Poultry Science, 98, 991–1001. https://doi. org/10.3382/ps/pey379

Ali Shah SR and Çetingül IS (2022) Nutritional advances in production performance and product quality of poultry husbandry under heat stress. Online J. Anim. Feed Res., 12(2): 53–65

Arnal, M. E., & Lalles, J. P. (2016). Gut epithelial inducible heat-shock proteins and their modulation by diet and the microbiota. Nutrition Review, 74(3), 181–197. https://doi.org/10.1093/nutrit/nuv104

Attia, Y. A., Abdalah, A. A., Zeweil, H. S., Bovera, F., Tag El-Din, A. A., & Araft, M. A. (2010). Effect of inorganic or organic selenium supplementation on productive performance, egg quality and some physiological traits of dual-purpose breeding hens. Czech Journal of Animal Science, 55(11), 505–519. https://doi.org/10.17221/1715-CJAS

Attia, Y. A., Bovera, F., Wang, J., Al-Harthi, M. A., & Kim, W. K. (2020). Multiple amino acid supplementations to low-protein diets: Effect on performance, carcass yield, meat quality and nitrogen excretion of finishing broilers under hot climate conditions. Animals, 10(6), 973. https://doi.org/10.3390/ani10060973

Attia, Y. A., & Hassan, S. S. (2017). Broiler tolerance to heat stress at various dietary protein/energy levels. European Poultry Science, 81, https://doi.org/10.1399/eps.2017.171

Awad, E. A., Zulkifli, I., Farjam, A. S., & Chwen, L. T. (2014). Amino acids fortification of low-protein diet for broilers under tropical climate. 2. Nonessential amino acids and increasing essential amino acids. Italian Journal of Animal Science, 13(3), 3297. https://doi.org/10.4081/ ijas.2014.3297

Awad, E. A., Zulkifli, I., Soleimani, A. F., & Loh, T. C. (2015). Individual nonessential amino acids fortification of a low-protein diet for broilers under the hot and humid tropical climate. Poultry Science, 94, 2772– 2777. https://doi.org/10.3382/ps/pev258

Ayo-Enwerem, M. C., Ahaotu, E. O., Nwogu, C. M., & Opara, J. (2017). Growth performance of starter broilers fed diets containing red sandalwood (Pterocarpus santolinoides) leaf meal. Direct Research Journal of Veterinary Medicine and Animal Science, 2(4), 106–109.ISSN: 2734–2166.

Bastianelli, D., Fermet-Quinet, E., Hervouet, C., Domenech, S., Bonnal, L., & Friot, D. (2005). Qualité des aliments pour volailles en Afrique de l'Est. Intérêt de la spectroscopie dans le proche infrarouge (SPIR) pour l'estimation de leur composition. In *Sixième Journées de la recherche avicole*, Proceedings of 6th Poultry Research Workshop, Saint Malo, France 30–31 March, 184–188.

Crozier, A.; Jaganath, I.B.; Clifford, M.N. (2009) Dietary phenolics: Chemistry, bioavailability and effects on health. *Nat. Prod. Rep.* **2009**, *26*, 1001–1043.

Goel A (2021) Heat stress management in poultry. J. Anim. Physiol. Anim. Nutr., 105(6): 1136–1145.

Houndonougbo, M. F., Chwalibog, A., & Chrysostome, C. A. A. M. (2012).Effect of processing on feed quality and bio-economic performances of broiler chickens in Benin. *International Journal of Applied Poultry Research*, *1*(2), 47–54. ISSN: 2222-1263.

Leeson, S., & Summers, J. D. (2005). *Commercial Poultry Nutrition* (2nded.). University Books. ISBN 978-1-904761-78-5

Muiruri, H. K., & Harrison, P. C. (1991). Effect of Roost temperature on performance of chickens in hot ambient environments. *PoultryScience*, *70*, 2253–2258. https://doi.org/10.3382/ps.0702253.

Gordon, S. H., & Charles, D. R. (2002). *Niche and organic chicken products*. Nottingham University Press. ISBN 10: 1897676964 -ISBN 13: 9781897676967.

Bremer, B., Bremer, K., Chase, M.W., Fay, M.F., Reveal, J.L., Bailey, L.H., Soltis, D.E., Soltis, P.S. and Stevens, P.F. 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. Botanical Journal of the Linnean Society. 161(2),pp.105–121.

Yazzie, D., VanderJagt, D.J., Pastuszyn, A., Okolo, A. and Glew, R.H. 1994. The Amino Acid and Mineral Content of Baobab (Adansonia digitata L.) Leaves. Journal of Food Composition and Analysis. 7(3),pp.189–193.

Chadare, F., Linnemann, A., Houhouigan, J., Nout, M.J. and Van Boekel, M.A.J. 2008. Baobab Food Products: A Review on their Composition and Nutritional Value. Critical Reviews in Food Science and Nutrition,. 49(3),pp.254–274.

Saka J.D.K, Mwendo-Phiri, E. and Akinnifesi, F.K. 2002. Community processing and nutritive value of some miombo indigenous fruits in central and southern Malawi. In: F. K.

Akinnifesi and A. AGumya, eds. Proceedings of 14th Southern African Regional Review and Planning Workshop, 3 –7 September 2001, Harare, Zimbabwe, International Centre for Research in Agroforestry.Harare: ICRAF, pp. 164–169.

Caluwé, E. De, Damme, P. Van and Halamova, K.2010. Adansonia digitata L. A review of traditional uses , phytochemistry and pharmacology. Afrika Focus. 23(1),pp.11–51.

Ajayi, I.A., Oderinde, R.A., Kajogbola, D.O., Uponi, J.I. (2006). Oil content and fatty acid composition of some underutilized legumes from Nigeria. Food Chemistry, 99: 115-120.

Suksomtip M., Pongsamart S. (2008). Protective effect against oxidation of human low-density lipoprotein and plasmid DNA strand scission of Tamarind seed coat extract in vitro. LWT - Food Science and Technology. 41(10) :2002–2007.

Dalziel, J.M. (2017): The useful plants of West Africa. Crown Agents for Oversea Government and Administration, p. 217. D

Andrews, F.W. (2006): The flowering plants of Anglo-Egyptian Sudan, Vol. 11, Sudan Government.

Siddhuraju, P and Beecker K (2003) Antioxidant properties of various solvent extracts of total phenolic constituents from three different agrochemical origin of drumstick tree (Moringa oleifera Larn) Leaves J Agrivc Food Chem51-2144-5

Aiyelagbe, O.O, Ajaiyeoba, E.O and Ekundayo O.O (2016) Studies on the seed oils of Pakia bagloboba and Pakia bibolor. Plant food for human nutrition 49-229-23

Khawaja, T.M , Thairu M and Ikram UK (2010). Moringa oleifera: a natura gift, a reviw J. Phar Sci Res 2. 775-81

Guevara A.P, Vargas C, Sakurai H, (2009) : An antitumor promoter from Moringer oleifera Lam mutat Res 440-181-8.

R. G. Berger, S. Lunkenbein, A. Ströhle, and A. Hahn, 2012 “Antioxidants in food: mere myth or magic medicine?” *Critical Reviews in Food Science and Nutrition*, vol. 52, no. 2, pp. 162–171.

D. Huang, B. Ou, and R. L. Prior, (2005)"The chemistry behind antioxidant capacity assays," *Journal of Agricultural and Food Chemistry*, vol. 53, no. 6, pp. 1841–1856, 2005.

M. Musialik and G. Litwinienko,2005 "Scavenging of DPPH$^{\cdot}$ radicals by vitamin E is accelerated by its partial ionization: the role of sequential proton loss electron transfer," *Organic Letters*, vol. 7, no. 22, pp. 4951–4954.

L. M. Magalhães, M. A. Segundo, S. Reis, and J. L. F. C. Lima,2008 "Methodological aspects about in vitro evaluation of antioxidant properties," *Analytica Chimica Acta*, vol. 613, no. 1, pp. 1–19,.

K. Thaipong, U. Boonprakob, K. Crosby, L. Cisneros-Zevallos, and D. H. Byrne,(2006) "Comparison of ABTS, DPPH, FRAP, and ORAC assays for estimating antioxidant activity from guava fruit extracts," *Journal of Food Composition and Analysis*, vol. 19, no. 6-7, pp. 669–675, 2006.

Aksit, M., Yalcin, S., Ozkan, S., Metin, K., and Ozdemir, D. (2006). Effects of temperature during rearing and crating on stress parameters and meat quality of broilers. *Poult. Sci.* 85, 1867–1874. doi: 10.1093/ps/85.11.1867

Alley, R. B., Clark, P. U., Huybrechts, P., and Joughin, I. (2005). Ice-sheet and sea-level changes. *Science* 310, 456–460. doi: 10.1126/science.1114613

American Meat Science Association [AMSA] (2012). *AMSA Meat Color Measurement Guidelines*. 1–117. Available onilne at: http://www.meatscience.org

Arif, M., Fareed, S., and Rahman, M. A. (2016). Stress relaxantand antioxidant activities of acid glycoside from Spondias mangifera fruitagainst physically and chemically challenged albino mice. *J. Pharm. Bioall. Sci.* 8, 58–63. doi: 10.4103/0975-7406.171685

Barroeta, A. C. (2007). Nutritive value of poultry meat: relationship between vitamin E and PUFA. *Worlds Poultry Sci. J.* 63, 277–284.

Belay, T., Bartels, K. E., Wiernusz, C. J., and Teeter, R. G. (1993). A detailed colostomy procedure and its application to quantify water and nitrogen balance and urine contribution to thermobalance in broilers exposed to thermoneutral and heat-distressed environments. *Poult. Sci.* 72, 106–115. doi: 10.3382/ps.0720106

Bhadauria, P., Mamgai, P., Murai, A., and Jadoun, Y. S. (2016). *ICAR-Agricultural Technology Application Research Institute, Zone 1, India.* 1–30.

Brobeck, J. R. (1948). Food intake as a mechanism of temperature regulation. *Yale J. Biol. Med.* 20, 545–552.

Brodsky, V. Y., Malchenko, L. A., Butorina, N. N., Lazarev Konchenko, D. S., Zvezdina, N. D., Dubovaya, T. K., et al. (2017). Glutamic acid as enhancer of protein synthesis kinetics in hepatocytes from old rats. *Biochemistry (Mosc)* 82, 957–961. doi: 10.1134/S0006297917080119

Caulfield, M. P., Cambridge, H., Foster, S. F., and McGreevy, P. D. (2014). Heat stress: a major contributor to poor animal welfare associated with long-haul live export voyages. *Vet. J.* 199, 223–228. doi: 10.1016/j.tvjl.2013.09.018

Cavani, C., Petracci, M., Trocino, A., and Xiccato, G. (2009). Advances in research on poultry and rabbit meat quality. *Italian J. Anim. Sci.* 8, 741–750.

Cavitt, L. C., Youm, G. W., Meullenet, J. F., Owens, C. M., and Xiong, R. (2004). Prediction of poultry meat tenderness using razor blade shear, Allo-Kramer shear, and sarcomere length. *J. Food Sci.* 69, SNQ11–SNQ15.

Chen, I. C., Hill, J. K., Ohlemuller, R., Roy, D. B., and Thomas, C. D. (2011). Rapid range shifts of species associated with high levels of climate warming. *Science* 333, 1024–1026. doi: 10.1126/science.1206432

Chua, B. H., Giger, K. E., Kleinhans, B. J., Robishaw, J. D., and Morgan, H. E. (1984). Differential effects of cysteine on protein and coenzyme A synthesis in rat heart. *Am. J. Physiol.* 247, C99–C106. doi: 10.1152/ajpcell.1984.247.1.C99

De Basilio, V., Requena, F., Leon, A., Vilarino, M., and Picard, M. (2003). Early age thermal conditioning immediately reduces body temperature of broiler chicks in a tropical environment. *Poult. Sci.* 82, 1235–1241. doi: 10.1093/ps/82.8.1235

Duraisami, R., Mohite, V. A., and Kasbe, A. J. (2010). Antistress and adaptogenic activity of standardized dried fruit extrect of Aegle marmelos against diverse stressors. *Asian J. Pharmaceut Clin. Res.* 3, 1–3.

Dutta, R., Khalil, R., Green, R., Mohapatra, S. S., and Mohapatra, S. (2019). Withania Somnifera (Ashwagandha) and withaferin A: potential in integrative oncology. *Int. J. Mol. Sci.* 20:5310. doi: 10.3390/ijms20215310

Flees, J., Rajaei-Sharifabadi, H., Greene, E., Beer, L., Hargis, B. M., Ellestad, L., et al. (2017). Effect of morinda citrifolia (Noni)-Enriched diet on hepatic heat shock protein and lipid metabolism-related genes in heat stressed broiler chickens. *Front. Physiol.* 8:919. doi: 10.3389/fphys.2017.00919

Food and Agriculture Organization [FAO] (2018). Rome: Food and Agriculture Organization, 224.

Fouillet, A., Rey, G., Wagner, V., Laaidi, K., Empereur-Bissonnet, P., Tertre, A. L., et al. (2008). Has the impact of heat waves on mortality changed in France since the European heat wave

of summer 2003? A study of the 2006 heat wave. *Int. J. Epidemiol.* 37, 309–317. doi: 10.1093/ije/dym253

Furlan, R. L., Macari, M., Malheiros, E. B., Secato, E. R., and Guerreiro, J. R. (1998). Effect of indomethacin on hyperthermia induced by heat stress in broiler chickens. *Int. J. Biometeorol.* 42, 73–76. doi: 10.1007/s004840050087

Galbraith, R. A., and Buse, M. G. (1981). Effects of serine on protein synthesis and insulin receptors. *Am. J. Physiol.* 241, C167–C171.

Ghazi, S., Habibian, M., Moeini, M. M., and Abdolmohammadi, A. R. (2012). Effects of different levels of organic and inorganic chromium on growth performance and immunocompetence of broilers under heat stress. *Biol. Trace Elem. Res.* 146, 309–317. doi: 10.1007/s12011-011-9260-1

Giri, M., Rao, P. M., and Jayaveera, K. N. (2011). Evaluation of adaptogenic activity of Prunella vulgaris. *Int. J. Pharm. Sci. Res.* 8, 62–65.

Giri, M., Vrushabendra Swamy, B. M., and Jayaveera, K. N. (2013). Evaluation of adaptogenic activity of Unani herb Borago officinalis. *Res. Rev. J. Pharm. Pharmaceut. Sci.* 2, 10–15.

Gu, X. H., Hao, Y., and Wang, X. L. (2012). Overexpression of heat shock protein 70 and its relationship to intestine under acute heat stress in broilers: 2. Intestinal oxidative stress. *Poult. Sci.* 91, 790–799. doi: 10.3382/ps.2011-01628

Gunal, M. (2013). The effects of early-age thermal manipulation and daily short-term fasting on performance and body temperatures in broiler exposed to heat stress. *J. Anim. Physiol. Anim. Nutr. (Berl.)* 97, 854–860. doi: 10.1111/j.1439-0396.2012.01330.x

Jakubczak, L. F. (1976). Food and water intakes of rats as a function of strain, age, temperature, and body weight. *Physiol. Behav.* 17, 251–258. doi: 10.1016/0031-9384(76)90073-1

Koohmaraie, M., Kent, M. P., Shackelford, S. D., Veiseth, E., and Wheeler, T. L. (2002). Meat tenderness and muscle growth: is there any relationship? *Meat Sci.* 62, 345–352.

Lara, L. J., and Rostagno, M. H. (2013). Impact of heat stress on poultry production. *Animals (Basel)* 3, 356–369.

Liu, L., Ren, M., Ren, K., Jin, Y., and Yan, M. (2020). Heat stress impacts on broiler performance: a systematic review and meta-analysis. *Poult. Sci.* 99, 6205–6211. doi: 10.1016/j.psj.2020.08.019

Liu, W., Yuan, Y., Sun, C., Balasubramanian, B., Zhao, Z., An, L., et al. (2019). Effects of dietary betaine on growth performance, digestive function, carcass traits, and meat quality in indigenous yellow-feathered broilers under long-term heat stress. *Animals (Basel)* 9:506. doi: 10.3390/ani9080506

Liu, Z., Anderson, B., Yan, K., and Dong, W. (2017). Global and regional changes in exposure to extreme heat and the relative contributions of climate and population change. *Sci. Rep.* 7:43909.

Loyau, T., Bedrani, L., Berri, C., and Metayer-Coustard, S. (2015). Cyclic variations in incubation conditions induce adaptive responses to later heat exposure in chickens: a review. *Animal* 9, 76–85. doi: 10.1017/S1751731114001931

Loyau, T., Berri, C., Bedrani, L., and Metayer-Coustard, S. (2013). Thermal manipulation of the embryo modifies the physiology and body composition of broiler chickens reared in floor pens without affecting breast meat processing quality. *J. Anim. Sci.* 91, 3674–3685. doi: 10.2527/jas.2013-6445

Malik, S., Suchal, K., Bhatia, J., Khan, S. I., Vasisth, S., Tomar, A., et al. (2016). Therapeutic potential and molecular mechanisms of emblica officinalis gaertn in countering nephrotoxicity in rats induced by the chemotherapeutic agent cisplatin. *Front. Pharmacol.* 7:350. doi: 10.3389/fphar.2016.00350

Marangoni, F., Corsello, G., Cricelli, C., Ferrara, N., Ghiselli, A., Lucchin, L., et al. (2015). Role of poultry meat in a balanced diet aimed at maintaining health and wellbeing: an Italian consensus document. *Food Nutr. Res.* 59, 1–11. doi: 10.3402/fnr.v59.27606

Marimuthu, S., Selvam, R., Kaninathan, A., and D'Souza, P. (2020). Effect of dietary supplementation of phytogenic feed additive on performance traits, serum neopterin, and cutaneous basophil hypersensitivity response in heat-induced stress model of broiler chickens. *J. Adv. Vet. Anim. Res.* 7, 141–147. doi: 10.5455/javar.2020.g403

McCarthy, D. O., Kluger, M. J., and Vander, A. J. (1986). Effect of centrally administered interleukin-1 and endotoxin on food intake of fasted rats. *Physiol. Behav.* 36, 745–749. doi: 10.1016/0031-9384(86)90363-x

McKee, S. R., and Sams, A. R. (1997). The effect of seasonal heat stress on rigor development and the incidence of pale, exudative turkey meat. *Poult. Sci.* 76, 1616–1620. doi: 10.1093/ps/76.11.1616

Meehl, G. A., and Tebaldi, C. (2004). More intense, more frequent, and longer lasting heat waves in the 21st century. *Science* 305, 994–997. doi: 10.1126/science.1098704

Monson, M. S., Van Goor, A. G., Ashwell, C. M., Persia, M. E., Rothschild, M. F., Schmidt, C. J., et al. (2018). Immunomodulatory effects of heat stress and lipopolysaccharide on the bursal transcriptome in two distinct chicken lines. *BMC Genom.* 19:643. doi: 10.1186/s12864-018-5033-y

Mora, C., Dousset, B., Caldwell, I. R., Powell, F. E., Geronimo, R. C., Bielecki, C. R., et al. (2017). Global risk of deadly heat. *Nat. Clim. Change* 7, 501–506.

Mora, C., Frazier, A. G., Longman, R. J., Dacks, R. S., Walton, M. M., Tong, E. J., et al. (2013). The projected timing of climate departure from recent variability. *Nature* 502, 183–187. doi: 10.1038/nature12540

Nardone, A., Ronchi, B., Lacetera, N., Ranieri, M. S., and Bernabucci, U. (2010). Effects of climate change on animal production and sustainability of livestock systems. *Livest Sci.* 130, 57–69. doi: 10.1016/j.livsci.2010.02.011

Nawab, A., Ibtisham, F., Li, G., Kieser, B., Wu, J., Liu, W., et al. (2018). Heat stress in poultry production: mitigation strategies to overcome the future challenges facing the global poultry industry. *J. Therm. Biol.* 78, 131–139. doi: 10.1016/j.jtherbio.2018.08.010

Orlowski, S., Flees, J., Greene, E. S., Ashley, D., Lee, S. O., Yang, F. L., et al. (2018). Effects of phytogenic additives on meat quality traits in broiler chickens1. *J. Anim. Sci.* 96, 3757–3767. doi: 10.1093/jas/sky238

Owens, C. M., McKee, S. R., Matthews, N. S., and Sams, A. R. (2000). The development of pale, exudative meat in two genetic lines of turkeys subjected to heat stress and its prediction by halothane screening. *Poult. Sci.* 79, 430–435. doi: 10.1093/ps/79.3.430

Panossian, A., and Wikman, G. (2009). Evidence-based efficacy of adaptogens in fatigue, and molecular mechanisms related to their stress-protective activity. *Curr. Clin. Pharmacol.* 4, 198–219. doi: 10.2174/157488409789375311

Panossian, A., and Wikman, G. (2010). Effects of adaptogens on the central nervous system and the molecular mechanisms associated with their stress-protective activity. *Pharmaceuticals (Basel)* 3, 188–224. doi: 10.3390/ph3010188