`

EFFECT OF RED HOT PEPPER (*Capsicum annum*) ON PERFORMANCE AND MEAT SHELF LIFE OF BROILER CHICKEN

BY

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ABSTRACT

The experiment was conducted to study the effects of feeding diets containing different levels of red hot pepper (Capsicum annum) on the growth performance of broiler chickens. One hundred and twenty (120) day old unsexed broiler chicks were assigned randomly into four treatments replicated three times with ten birds per replicate using deep litter system of management. Red hot pepper was included at 0.00%, 1.00%, 1.25% and 1.50% representing T1, T2, T3 and T4, respectively. The red hot pepper was added to a commercial broiler starter diet. Parameters measured were average weekly feed intake, average weekly body weight, average weekly body weight gain and average weekly feed conversion ratio, capsaicin level, heamatology, serum biochemistry and meat shelf life of the broiler birds. The results showed that the consumption of higher (>1%) levels of feed containing red hot pepper significantly (P<0.05) affected feed intake (T1,T2,T3 and T4 are 365.19, 395.82, 426.33 and 430.70 respectively), body weight (T1,T2,T3 and T4 are 294.13,352.93, 353.83 and 331.56 respectively) and had significant effect (P>0.05) body weight gain and feed conversion ratio at the starter phase. At finisher phase, the results showed that the consumption of higher (>1%) levels of feed containing red hot pepper significantly (P<0.05) affected feed intake (T1, T2, T3 and T4 are 595.38, 734.17, 740.33 and 748.67 respectively), body weight (T1,T2,T3 and T4 are 1136.60, 1437.10, 1343.20 and 1305.0 respectively) and body weight gain (T1,T2,T3 and T4 is 191.06, 258.76, 242.23 and 231.75). Feed conversion ratio were not significantly affected (P>0.05) at the finisher phase. The red blood cell and the white blood cell were significantly (P<0.05) affected and thus control treatment T1 had highest value (RBC is 94.85 and WBC is 39.7). The cholesterol, glucose and free fatty acid were not significant affected (P>0.05). On meat shelf life, the result showed that the consumption of higher (>1%) levels of feed containing red hot pepper did not significantly (P>0.05) affect the meat shelf life. Cost of feed intake per kilogram body weight of the marshal broiler chicken on both the starter phase and the finisher phase showed no significant difference (p>0.05) although, at the finisher phase the value obtained from T2 andT3 (0.4502 and 0.4805) were lower than treatment T1 and T4(0.4433 and0.4433). It was concluded that, intake of capsaicin from red hot pepper inclusion in broiler diets improved the performance of the broiler chicken. Red hot pepper inclusion in broilers chicken diet at 1.25% is recommended to be used in broiler production.

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ABBREVIATIONS/ACRONYMS

AGPs = Antibiotic growth promoters

ASL = African sustainable livestock

BWG= Body weight gain

CAP = Capsaicin

CF= Crude fiber

CP= Crude protein

DM= Dry matter

DNA= Deoxyribonucleic acid

EE= Ether extract

EDTA = Ethylene-diamine-tetra acetic acid

FAOSTAT = Food and agriculture organization corporate statistical database

FCR= Feed conversion ratio

FFA =Free fatty acid

FI= Feed intake

FAO = Food and agricultural organisation

g = Gram

Hb= Haemoglobin

H/L=Heterophil/lymphocytes

MCHC = Mean corpuscular haemoglobin concentration

MCV = Mean corpuscular volume

ME=Metabolizable energy

NFE =Nitrogen free extract

NI = nutrients in feed

NVF = Nutrient voided in faeces

PV = Peroxide value

RBC = Red blood cell count

RHP = Red hot pepper

TBARS = Thiobarbituric acid reactive substances

WBC = White blood cell

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Nigeria is arguably the most populous black nation in the world. This burgeoning population is facing threat of nutritional deficiencies as a result of high cost or inadequate supply of these nutrients. According to Neeliah *et al*. (2008), nutrition is the fundamental prerequisite for human welfare and contributes to human and social capita. However, according to Wardlaw *et al*. (2002), malnutrition is a condition of impaired development caused by either a long–term deficiency or an excess in energy and or nutrient intake. Protein is one of the nutrients that causes malnutrition and it is he most important macro nutrients needed by the body. The United Nation's Food and Agricultural Organisation estimated minimum protein requirements at 70 gm/capita/day and the recommended protein intake from animal source to be 35gm/capita/day (Esobhawan *et al*., 2008).This indicate that Nigerians are gravely protein malnutrition. The major sources of protein for human consumption are plants and animals but plant as protein source lack some essential amino acid while animal protein contain all the amino acid needed in the body (Oloyede, 2005). The major sources of animal protein in Nigeria include chicken, cattle, pig, sheep, goat, rabbit, fish and games and the broiler chicken is considered as the fastest growing which reaches market weight within eight weeks. To meet the demand of animal protein supplies of the rapidly growing population of Nigerians, it requires the involvement of science and art of animal management and nutrition (Oloyede, 2005). Broiler chicken stand a better chance because the meat is one of the most accepted meat worldwide and thus, the use of dietary additives to stimulate their quick growth has become a thing of concern.

Synthetic additives or antibiotic growth promoters (AGPs) are commonly used by farmers to enhance faster growth of broilers. These antibiotics and growth promoters effects remained undetected until acquisition of resistance against antimicrobials extensive hence, extensive use of the antibiotics as feed additives has been banned in developed countries in Europe this because antibiotics use lead to accumulation of unsafe residues in the edible parts of treated animals (Muhammad *et al*., 2016). Alternative phytogenic source that can be used includes ginger, red hot pepper, garlic, bitter leave and st leaves and are safer for human health. Red hot pepper presents a natural and reliable alternative to synthetic commercial growth promoters because of its high quantity of bioactive substances called capsaicin.

Young-Joon, (2002) stated that although capsaicin can cause neurogenic inflammation that is under certain physiologic conditions, it also has a chemopreventive and chemotherapeutic effects. Capsaicin (CAP, 8-methyl-N-Vanilly-6-nonenamide) is the active substance responsible for the irritating and pungent effects of various species of hot pepper. CAP has emerged as a relatively selective neurotoxin for small-diameter sensory neurons (Galib *et al*., 2011b). Capsaicin which has a pungent effect is contained in red hot pepper and has been used as spices, feed additives and drugs (Nwaopara *et al*., 2007; Iqbal *et al*., 2011).

Research has shown increase in body weight and feed conversion ratio when using herbaceous plants in broilers diets (Great, 2003). These herbs includes red hot pepper which improves digestibility even as their age advances (Foluke *et al* ., 2013). Capsaicin in red hot pepper is a phytoadditive which has antibacterial, antimicrobial, anticancer, and antioxidant properties and improves the production performance of poultry (Prabhakaran *et al*., 2016). This study therefore is used to estimate the effect of inclusion of red hot pepper at a varying levels on the performance of broilers chickens.

1.2 Statement of the Research Problem

Most growth promoters used by farmer raising broilers are not natural products and their residues tend to be retained in the tissue of broilers after treatment and can alter consumers health (Muhammad *et al*., 2016). Galib *et al* . (2011a), Aghil *et al*. (2013) and Ndelekwute *et al*. (2015) reported improved performance of broilers fed with capsaicin in red hot pepper at a maximum inclusion of 1.00 % .. Red hot pepper is an agricultural perishable product whose excessive wastage can be converted into useful feed additives to improve broiler production. Although studies focusing on understanding the effect of red hot pepper in broiler diet and shelf life of broiler chickens meat are not common; but due to enormous bioactive compound in pepper, it could be explore as alternative source of antibiotics for broiler performance improvement. These are challenges identified by the study which informed the determination of red hot pepper intake on broiler's performance.

1.3 Justification of the Study

Research works of Galib *et al*. (2011a) had reported improved body weight gain, feed digestibility and feed conversion ratio on broilers fed with red hot pepper at 0.25%,0.50%,0.75% and 1.00%. AL-Kassie *et al*. (2012); Alaa (2010) showed how cholesterol profile was affected by capsaicin content in red hot pepper. This research was therefore expected to explore how red hot pepper will improve the performance of marshal broiler chickens when fed with higher inclusion (>1.00%) in diet. Also its effect on broiler cost per kilogram weight gain, meat shelf life, haematological and serum biochemistry indices will be determined.

1.4 Aim and Objectives of the study

The aim of this study was to determine the effects of red hot pepper (*Capsicum annum*) on performance and meat shelf-life of broiler chickens. The specific objectives of the study were to:

i. assess the effect of red hot pepper (RHP) on growth performance and nutrient digestibility of broiler chickens.

ii. estimate haematological and serum biochemistry of broiler chickens fed with diet containing red hot pepper (RHP).

iii. evaluate the shelf-life of meat obtained from broiler chickens fed with diet containing red hot pepper (RHP).

iv. evaluate the cost of feed intake per kilogram weight gain of broiler chicken fed with diet containing red hot pepper (RHP).

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 An Over View of the World Poultry Production

Demand for livestock products especially poultry, is expanding in Nigeria as a result of the ban on importation of frozen chicken and turkey, population growth and increased urbanization (SAHEL, 2015). Poultry production in Nigeria amounts up to 454 billion tons of meat per year, with a standing population of 180 million birds and has the second largest chicken population in Africa after South Africa SAHEL, (2015) producing 300 000 tons of poultry meat in 2013 (FAOSTAT, 2017). About 80 million chickens are raised in extensive systems, 60 million in semi-intensive systems and the remaining 40 million in intensive systems. Poultry is the major contributor to household livelihoods in Nigeria, through income and nutrition related benefits. The system contributes between 20 to over 50 percent (ASL 2050, 2018). The importance of broiler meat production in Nigeria cannot be overemphasized. Broiler meat production plays a vital role in protein supply for the booming population of Nigeria. Healthy labor force is guaranteed through sufficient protein intake (Omolayo, 2018).

Broilers dominate the world poultry consumption contributing about 70 percent to the world poultry market, turkeys account for about 8 percent while other poultry provides the balance of 22 percent According to FAO (2011), the production of 230 million tons of all meat was composed of about 65.2 million tons of poultry meat, 56.3 million tons of beef and 89.5 million tons of pork. The world meat economy has been characterized by the rapid growth of the poultry sector. Estimates for the combined annual production of the world's poultry industries put the total at about 95 million metric tons of meat and approximately 63 million metric tons of eggs

(Horizon, 2010). FAO (2010) reported that 281.5 million metric tonnes of all meats are been produced worldwide and that poultry meat accounted for about 92.3 million tons of this total, poultry's output compared with 103.6 million tons for pork and 64.7 million tonnes of beef. Total broiler production over the period 2009- 2019 will grow by 1.8% annually to reach 79.36 million metric tonnes, while the international trade in broiler meat grows by 1.3% per year to reach 8.29 million metric tons (FAO, 2011). Poultry production is an increasingly important agricultural industry in the world, poultry meat and egg account for about 10% of the total amount of all meat, eggs and milk produced in the world each year (Onu and Madubuike, 2012).

2.2 Broiler Chicken Meat as a Good Source of Protein

Chicken is a source of protein, low in fat, which is less saturated than beef fat. Chicken consumption is increasing as people look for alternative ways to reduce fat such as cholesterol in their diets (Jorge, 2010). Nutritionally, people eat chicken for its high content of high-quality protein. Chicken is slightly higher in protein and slightly lower in fat than beef and other red meats while others may prefer chicken because it's unique taste Jorge, (2010), as shown in Table2. 1.

2.3 Challenges of Poultry Production in Nigeria

Agriculture in Nigeria remains the pillar of the economic growth, development, employment for the timing population and income generation. Poultry has become the fastest growing segment in agricultural production while broiler production for meat is the highest segment of the poultry sub – sector (Assa, 2012). All over the world poultry sector is growing continuously due to an increase in human population, rising purchasing power and urbanization FAOSTAT, (2104).

Table 2.1. Comparative chemical composition of poultry meat (g/100 g)

Component	Broiler	Turkey	Duck	Quail
Water	74.60	72.50	70.80	74.30
Ash	1.00	0.80	1.20	1.10
Protein	12.10	13.70	12.80	13.10
Lipid	11.10	11.9	13.80	11.10
Fiber	0.00	0.00	0.00	0.00
Carbohydrates	1.20	1.10	1.40	1.40

Source: USDA (2006).

The significance of broiler production in Nigeria cannot be overemphasized as animal protein supply to the Nigerian populace is highly needed at a higher.quantity and at affordable prices (Omolayo, 2018) but this has been retard by so many factor which includes;

2.3.1 Measures to check high mortality rate due to diseases in poultry

The orientation and the basic requirement of a poultry house makes it possible to check bad weather condition, check diseases (excess ammonia, coccidiosis and aspergilosis) and predators (snakes rodent, dogs, possums, foxes, etc) and allow for better movement of air (Owen *et al.*, 2012). Although, mortality maybe experienced from brooding system (kerosene and grid based system are 7 and 10% respectively). Ammonia emission from the poultry litter is another major cause of poultry disease (such as chronic respiratory disease and coccidiosis) (Meda *et al.*, 2011) therefore ventilation helps in the control of ammonia retention in poultry houses. Pathogenic microorganisms can thrive in poultry wastes and constitute environmental and health hazards to livestock. The concern on how to manage poultry wastes under intensive production systems led to the discovery of suitable poultry droppings and moist absorbents referred to as litter materials. Litter materials should always be turned periodically to avoid caking and moisture retention as this will help also to reduce ammonia accumulation.

2.3.2 Litter management in poultry production

A good litter should be well dried, not injurious. When in use pplied to a depth of at least 2 cm (Cool sand), 5-10 cm (wood shavings), 10 cm (chopped straw) and 8 cm for any other litter material on a dry damp-free floor. Depth of the litter varies with the type of litter material in use and will influence performance particularly if it prevents dust bathing (Asaniyan *et al.*, 2007). Environmental and indoor conditions of poultry houses (temperatures flock density and air movements) have significant influences on litter quality and ammonia emissions (Meda *et al.*, 2011). Birds pass out concentrated waste (uric acid) making it possible to house a lot of birds on litter with the major problem of only moisture buildup (Musa *et al.,* 2012).

2.3.2.1 Ammonia management in poultry farms

Ammonia in the presence of rainfall contributes to soil acidification and also facilitates algae growth in water bodies (Meda *et al.,* 2011). Today there is growing concern in regulating ammonia emissions from livestock worldwide and the concept of litter amendments has shown drastic reduction of ammonia levels in poultry houses thereby improving birds' health and performance (Musa *et al.,* 2012). Ammonia emission is reduced with regular litter change, use of appropriate litter material, decreased manure moisture and improved indoor conditions (Meda *et al.,* 2011).

2.3.2.2 Litter amendments

Poultry litter amendments to effectively control ammonia levels involves application of acidifiers, alkaline materials, absorbers, inhibitors, microbial and enzymatic treatments, superabsorbent polymers and even dietary manipulations (Meda *et al.,* 2011). Acidifiers such as alum, sodium bisulphate, ferrous sulphate and phosphoric acid are the most effective and widely used poultry litter amendment and work by creating acidic conditions in litter so that ammonium rather than ammonia is retained and this helps facilitate bacteria and enzyme inactivity so that ammonia is not produced in the litter (Timmons and Harter-Dennis, 2011). They suppress ammonia levels below 25 ppm for 3-4 weeks post application and improve in-house air quality in poultry houses. Dietary manipulation involves reducing the nitrogen intake per bird by reducing the crude protein in poultry diet, because ammonia is formed by the breakdown of undigested protein and uric acid in the manure (Meda *et al.,* 2011). A 1% reduction of crude protein (CP) resulted to 10-22% reduced ammonia emission (Meda *et al.,* 2011).

2.3.3 Climatic factor

Poultry farming mainly depends on climatic conditions such as temperature and humidity. Several factors can be involved but heat stress is one of most important environmental factor influencing a wide range of chickens performances including reduced feed intake which, in turn, affects growth rate, body weight, meat quality, egg quality, egg production, semen quality and fertility; these negative influences result in great economic losses (Aamir *et al.*, 2018).

2.3.4 Cost of feeding in poultry

World production of poultry meat and eggs has consistently over the years has been on the increase. This increase is attributed to genetic progress in poultry strains, better understanding of fundamentals of nutrition and disease control. For instance, in 1976, the age of broiler to reach market weight was about 65 days and 35 days in 2009 which means better feed efficiency (Velmurugu, 2013).

This growth in poultry production is having a profound effect on the demand for feed raw materials. Etuk *et al.* (2012) report shows that the major factor limiting intensive poultry production in Nigeria is the high cost feed which arises from the cost of feed ingredient used directly in feeding the birds or in formulating animal feed; most especially the conventional energy and protein feed ingredients like maize, soybean cake and groundnut cake. The conventional protein feedstuffs for poultry such as soybean, groundnut cake and fish meal are scarce and expensive because they are competed for by humans as food and other industrial uses. There may be some divergence from the use of cereals for feed but the need for protein feed cannot be avoided (Conolly, 2012).

2.3.5 Little or no accessible veterinary service centres for poultry farmers

Biosecurity is the function of both the Veterinary professionals and government. This is a joint effort that must be shared by all who have obligations for animals and/or animal products, both farm and companion animals. The conventional barriers that nature provides can no longer be relied upon to exclude pandemic dissemination from country to country. In this view, the veterinarian is a sentinel for the early detection of, and early response to, accidental or intentional introduction of exotic diseases. The veterinarian is, in fact, the first line of defense that society counts on against agroterrorism and bioterrorism. In sum, veterinary professionals are key players on bio-defense, and thus for national security and welfare (FAO, 2015). The estimated cost function of commercial poultry farm revealed that the cost of veterinary services significantly affected the total cost of poultry output. The estimated demand function for veterinary services indicated that the scale of production and distance to the nearest veterinary office were the significant determinants of the demand for veterinary services. The propensity to supply veterinary services is mainly influenced by demand of poultry farmers and effective price that they are willing to pay (Achoja *et al.*, 2010).

2.4 The Antibiotic Growth Promoters (AGPS) used in Broiler Production

Broilers are one of the most economical meat protein sources available to consumers. The ability to efficiently use feed with minimal time to attain market weight and size is the primary reason some hormonal growth stimulant are introduced (Watkins *et al.,* 2011). This has become a worrisome issues among consumers in the developed countries in regards to their health (Devirgiliis *et al.,* 2013).

As per the current global scenario, the demand for cheap and quality food is continuously increasing due to the growing world population. This highlights the importance of maximizing the efficiency of poultry production in a cost effective manner, through the application of growth promoters, which are non-nutrients aimed to maximize utilization of the nutrients present in feed (Huyghebaert *et al*., 2011).

Antibiotic growth promoters (AGPs) have been widely used to improve performance of feed in animal. The effects of these drugs are not fully understood, but the potential of the intestinal microbiota in increasing feed efficiency has shown by several research works (Marcio *et al.*, 2017). The intestinal microbiota has been shown to have a tremendous influence on host health and disturbances in its balance (dysbiosis) have been associated with various diseases (Fasina *et al.,* 2015). Health awareness among the consumers has been increased with more preference to lean meat hence the use of feed additives like L-carnitine, ractopamine, nucleotides have

increased due to their lipolytic activity and better effect on growth performance of birds (Zuo *et al*., 2010; Yasmeen *et al*., 2013).

Antibiotic growth promoters (AGPs) used as growth promoters includes Bacitracin, Penillin, Chlortetracycline,Oxyteracyline,Colistinsulphate,Avilamycin,Tiamulin,Furazlidone,Lincomycin, enrofloxacin and neomycin sulphate (Chowdhury *et al*.,2009). World Organization for Animal Health (WOAH) encourages the health the use of other non-therapeutic alternatives such as probiotics, prebiotics, symbiotics, antimicrobial peptides, enzymes, etheric oils, essential oils, eucalyptus oil, medium chain fatty acids, clay minerals, egg yolk antibodies, rare earth elements, recombinant enzymes and immunostimulants have been introduced as an alternative to the antibiotic growth promoters recombinant enzymes and immunostimulants have been introduced as an alternative to the antibiotic growth promoters (Nava *et al.*, 2009; Wen and He, 2012; Tellez *et al.*, 2012; Mookiah *et al.*, 2014; Thacker, 2013).

European authorities ban the use of all antibiotic growth promoters (AGPs), starting with avoparcin in 1997 and ending with the banning of the remaining Antibiotic Growth Promoters (AGPs) on January 1st, 2006. The world health organization(WHO) evaluations has recommended that all uses of antimicrobials in human medicine for growth promotion should be terminated or quickly phased-out (WHO, 2000). The discovery of antibiotics has vastly increased the ability of medicine to cure diseases, not only in humans but also in animals. When added to animal feed, they also turn out to be excellent growth promoters, despite the fact that they are often used to alleviate the negative effects of poor hygiene and husbandry. However, the excessive use of antibiotics in veterinary medicine, particularly as growth promoters in animal feed may lead to the development of resistance. This is a serious potential risk to human health (Al-Dobaib and Mousa, 2009).

2.5 Spices and Herbs and their Uses

Spices are aromatic or pungent vegetable substance used to flavour food or used as medicine. Examples are garlic, cloves, ginger, pepper, or cumin also known for their preservative properties (Puvača *et al*., 2015a). Herbs generally refers to the leafy green or flowering parts of a plant (either fresh or dried) and have a variety of uses including culinary, medicinal, and in some cases, spiritual. Since ancient times, aromatic plants/photobiotic have been used because of their preservative as well as medicinal properties along with the characteristic of imparting aroma as well as flavour to food. Utility of plant extracts as perfume fumigations had been done by the father of medicine: Hippocrates. In traditional as well as veterinary medicine for centuries long aromatic plants (also called as herbs and spices), their essential oils as well as extracts from herbs has originated from sources like ethno veterinary medicine or even from folkloric sources (Fallah *et al.,* 2013; Midrarullah *et al.,* 2014).

The use of spices in feeding and medication for both human and animals has received global attention. Following the ban of Antibiotic Growth Promoters (AGPs) by the European Union and United States due to the possibility of developing resistant populations of bacteria (Hashemi and Davoodi, (2010), spices and herbs and some of their components as shown by research will be an alternative source or replacement to antibiotic growth promoters used in poultry production.

2.5.1 Use of spices and herbs in poultry production

Puvaca *et al.*(2015a) reported that spices, herbs and medicinal plants as a feed supplements present promising alternatives to antibiotic growth promoters due to their high content of bioactive substances some of them includes thyme, basil, oregano and have been identified. Now-a-days, natural products obtained from plants and fungi are gaining interest of consumers as natural additives (Toghyani *et al.,* 2010). Natural medicinal products originating from herbs, spices and their products including essential oils have been used as feed additives in poultry production (Hashemi and Davoodi, 2011; Khan *et al*., 2012a). Supplementation of Aspergillus niger fermented Ginkgo biloba leaves in diet of broiler enhanced the growth performance (Zhang *et al*., 2012). Compared with antibiotics or inorganic chemicals, these plant-derived products have proven to be natural, less toxic and are thought to be the ideal feed additives in the feed of poultry. Recently, there are increasing interest in the use of medicinal plants as feed additives in poultry diet to enhance the performance of poultry birds (Khan *et al*., 2012b) Spices have a wide range of activities and their active secondary plant metabolites typically belong to the classes of isoprene derivatives and flavonoids (Tajodini *et al.,* 2015). Good number of these spices contains chemical compounds exhibiting antioxidant, these properties of plant spices are mainly due to the bioactive compounds such as flavonoids and glucosinolates isoprene derivatives found in nature (Kutlu and Erdogan, 2010). Additionally, the properties probably are the major mechanisms by which spices exert positive effects on the growth performance and health of animals (Hashemi, and Davoodi, 2011). They can exhibit their effects by stimulating feed intake and endogenous secretions or having antioxidant, antimicrobial activities.

There are varieties of spices which are included into the poultry diets to enhance good growth performance and good animal health especially when there are health challenge and a lot of research works reported on these spices (Prabhakaran *et al*., 2016; Foluke *et al*., 2013; Tollba *et al*., 2007) to be very efficient in different aspects used.

Some of the areas of interest (reducing heat stress, intake of feed, body weight gain, feed conversion, antioxidants, carcass fatness, carcass leanness and cellular metabolism) as shown by research reports using pepper(*Capsicum annuum*), garlic (*Allium sativum*), turmeric

(*Curcuma longa*), thyme (*Thymus vulgaris L*.) aloe vera, onion (*Allium sepa*), ginger (*Zingiber officinale, Rosc*.), *Astragalus membranaceus*, noni (*Morinda citrifolia*) etc., as some of the major plant additives which have been extensively improved poultry feed for enhanced growth effect in broiler and had a profiting result capable of replacing the synthetic drugs (Sunder *et al*., 2013, 2014).

2.6 Nutrient Composition and Health Benefit of Red Hot Pepper (RHP)

Red hot pepper (*Capsicum annuum*) is a species of the plant genus *Capsicum* (chillies or peppers and capsicums or bell peppers) widely cultivated around the world and which is important in making human food (Dias *et al*., 2013). It is well known for its high content in bioactive compounds and strong antioxidant capacity and it is among the most popular of fresh spices worldwide due to its combination of color, flavor, and nutritional value (Wahyuni *et al*., 2013).

RHP is an important source of nutrients in human diet, and an excellent source of vitamin A and C as well asphenolic compounds, which are important antioxidants and are low in sodium, rich plus a good source of potassium, folic acid and vitamin E. Weight for weight, fresh green rhp contain more ascorbic acid than citrus fruits (Nitesh *et al*., 2014). Recently, more attention has been focused on the utilization of food processing by-products and wastes, as well as under-utilized agricultural products. Such utilization would contribute to maximizing available resources and result in the production of various new foods (Zou *et al.*, 2015). A number of

studies report that hot pepper seeds are rich in proteins, fats and minerals and these nutritional constituents, particularly essential amino acids and essential fatty acids, are necessary nutrients for the maintenance of healthy body (Koyuncu *et al.,* 2014).

Epidemiological studies have consistently demonstrated a positive relation between the consumption of fruits and vegetables and a reduction in the mortality rate due to heart disease, cancer, and other degenerative diseases, as well as aging. This is attributed to the fact that these foods are the main source of nutraceutical compounds, such as vitamins, minerals, and phenolic compounds, natural antioxidants, fiber, and other biotic compounds (Hallmann, 2012) .Thus, hot pepper seeds may be an inexpensive source of dietary proteins, fats and minerals. Although, factors like cultivars and environmental conditions have influence on the nutritional constituents of hot peppers and hot pepper seeds (Bae *et al.,* 2012).

Peppers also contain large quantities of neutral phenolic compounds or flavonoids called quercetin, luteolin and capsaicinoids. The consumption of these bioactive compounds provide beneficial effects in human health due to their antioxidant properties, which protect against the oxidative damage to cells and thus prevent the development of common degenerative diseases.

2.7 Biologically Active Constituents of Red Hot Pepper (C*apsicum annum*) and their Properties

Spices and herbs such as oregano, garlic, thyme, rosemary, black pepper, hot red pepper and sage are listed among the most commonly researched phytobiotics in broiler nutrition. This classification as phytobiotics is not only in terms of medicinal plants or their respective essential oil extracts but also as blended combinations of multiple phytogenic products because of the large numbers of their bioactive compounds. Spices and herbs represent an important part of the current literature on phytobiotic applications in broiler nutrition (Al-Kassie *et al.,* 2011; 2012, Kostadinović *et al.*, 2012; Puvača *et al.,*2015a). Biologically active constituents of plants are mostly secondary metabolites, such as terpenoids, phenolic, glycosides and alkaloids. Composition and concentrations of these biological chemicals in plants vary due to biological factors, manufacturing and storage conditions. Approximately 48% of the active substances in capsaicinoids are capsaicin (8-methyl-N-vanillyl-6-nonemide), which is an important alkaloid due to its neurotonic and antimicrobial activity and its potential to decrease lipid peroxidation. Research has proven that *Capsicum annuum* is the only plant that produces alkaloid capsaicinoids, which are responsible for their hot taste. Previous reports on the phytochemical properties of capsaicinoids have shown many biochemical and pharmacological properties which includes antioxidant, anti-inflammatory, antiallergenic and anti-carcinogenic activities, and may reduce the risk of cancer (Young-Joon, 2002). Arun and Gita (2014) reported that capsicum is more effective than vitamin E in inhibiting lipid peroxidation. Capsaicin can potentiate the activities of pancreatic and intestinal enzymes , increase bile acid secretion, and increase body weight gain in broiler chickens (Galib *et al.,* 2011; Puvača *et al.,* 2015b).

2.8 Effect of Red Hot Pepper (*Capsicum annum*) Inclusion in Poultry Diet on the Performance of Poultry

For thousands of years, rhp has been a staple ingredient all over the world and in some cases is referred to as "king of spices". However, rhp cannot be consumed beyond required quantity by man, excess produce which are not sold get spoil and are still discarded without treatment leading to the environment pollution (Jarret *et al.,* 2013). In poultry diet, the inclusion of rhp as therapeutic agents by different researchers has success in different areas. Red hot pepper contain some active substance which may be different from each other that could be responsible for improving growth in poultry (Al-Kassie and Witwit, 2010). Galib *et al*. (2011) revealed that the inclusion of hot red pepper in broiler diets improved body weight gain and conversion ratio improved and so concluded that use of hot red pepper as feed additive at 0.50%, 0.75% and 1% enhanced the overall performance of broiler chicks. Alaa (2010) reported that rhp increases activity of enzymes which are involved in the conversion of cholesterol to bilious acids and subsequently will result in lower cholesterol concentration in the carcass Some areas of poultry researchers have vigorously worked on includes;

2.8.1 Stress control in poultry

Hot red peppers are very rich in vitamin C, this have a considerable impact in improving production through reduction of stress in birds affected by heat stress Al-Kassie *et al.* (2012) and Puvaca *et al*. (2016). Active role of rhp compounds, specially the active compound (capscicine) rich in vitamin C that involved in stress hormones structures and this will defense the immune system of birds and enhances diseases resistance through decreasing H/L ratio.(Galib *et al.*, 2011a). Puvaca, *et al.*, (2015a) reported that high stocking density of broilers tended to increase stress index and free radical production, which could damage many biological molecules in cell membrane. Won-Young *et al.* (2010) suggest that red pepper seeds ethanol extracts may reduce oxidative damage, by activation of antioxidative defense system. Addition of methanolic extract of red and green pepper inhibited oxidation of linoleic acid. Methanolic extract of red pepper showed greater antioxidative potency. The different composition of lipophilic compounds and the various amount of phenolics, showed in the three stage of ripening of *Capsicum annuum* acuminatum fruits, modifies the antioxidant activity (Conforti *et al*., 2007).

2.8.2 Effect of red hot pepper inclusion in poultry diet on feed intake

A large number of experiments have confirmed a wide range of activities of spices in poultry nutrition such as stimulation of feed intake (Puvaca *et al.,* 2015a).The mean cumulative feed consumption (g/bird) of broilers as influenced by dietary inclusion of dried hot pepper powder were not significantly different among treatment (Safa *et al.,* 2014) and the isocaloric and isonitrogenous diet fed throughout the experiment could be the reason. Hot red peppers are rich in vitamin C, which have a considerable impact in improving production through reduction of stress in birds affected by heat stress and improving feed consumption (Al- Kassie *et al.,* 2012).

2.8.3 Effect of red hot pepper inclusion in poultry diet on growth performance

The process of increasing in size, height, weight and reaching maturity early in broilers have been reported to be greatly improved with an inclusion of red hot ppepper in the diet (Al- Kassie *et al.,* 2011; Safa *et al.,* 2014). A large number of experiments have confirmed a wide range of activities of spices in poultry nutrition such as stimulation increase of body weight gain (Puvuca *et al.*, 2015a), Similar results have been obtained by Al-Kassie *et al.* (2012) investigates the efficiency of utilization of broiler feed supplemented with red chilli peppers on productive performance. A total of 300 one day old chicks were divided into five groups of 60 birds each and were allocated to five feeding treatments, including a control group free from any additions, and groups with addition of 0.25, 0.5, 0.75 and 1% hot red pepper, respectively. The results showed a highly significant ($P<0.05$) increase in live weight gain, feed consumption, improved feed conversion ratio and dressing percentage, but no significant difference in the weight of edible giblets. Galib *et al*. (2011) revealed that the inclusion of hot red pepper at levels of 0.50%, 0.75% and 1% in the diets improved body weight gain and conversion ratio improved at levels 0.50%, 0.75% and 1% and so concluded that use of hot red pepper as feed additive at 0.50%, 0.75% and 1% enhanced the overall performance of broiler chicks. Puvaca *et al.* (2015c) reported that with different treatments of red hot pepper, ginger and garlic in broiler's diet at the end of the experimental period, addition of hot red pepper in treatments exerted the stimulating effect and led to significant differences ($p < 0.05$) in body weight in relation to the control and other experimental treatments.

2.8.4 Digestibility response of poultry fed diet containing red hot pepper

Capsaicin has been shown to have a protective function in the gastric mucosa as a stimulant of afferent nerve endings. Reports by Al-Kassie *et al.* (2012) show the level of this pepper used that reflects the high activity of piperazine citrate included in the broiler diet which may have affected the flow of digestive juices across the stomach. Puvaca *et al*. (2016) explained that hot red pepper is rich in vitamin C, which has a considerable impact on improving production by contributing to the reduction of heat stress in poultry. Although it is well known that plant extracts improve the digestibility of feeds in broilers, Hernandez *et al.* (2004) reported that such ingredients only slightly improved performance, and these differences were not significant.

2.8.5 Heamatology and serum biochemistry of poultry fed diet containing red hot pepper

In research of AL-Kassie *et al.* (2012) efficiency of utilisation of broiler feed with addition of hot red pepper supplementation on productive performance show that significantly affected the heterophil/lymphocytes (H/L) ratio, which reflects the role of hot red pepper, especially its active compound capisicine, which is involved in stress hormones, and which supports the immune system of birds and enhances its resistance against disease through decreasing (H/L) ratio Puvaca *et al.*(2015b) reported that red hot pepper in broiler diet could lower plasma cholesterol, triglycerides and LDL. Galib *et al.* (2011) reported that the Hb, RBC and H/L ratio concentration was depressed. It was concluded that the use of hot red pepper as feed additive improve the performance of broiler.

A large number of experiments have confirmed a wide range of activities of spices in poultry nutrition such as stimulation of feed intake, antimicrobial, antioxidative and coccidiostat stimulation, increase of body weight gain, lowering the mortality rate and improvement of the blood and tissue lipid profile. and other blood biochemical parameters (AL-Kassie *et al.*, 2012; Alaa, 2010). Samples were used for the measurement of various hematological parameters including PCV, WBC and RBC count, Hemoglobin (Hb) concentrations and Hetrophile to Lymphocytes ratio (H/L) glucose and cholesterol concentration. The result obtained showed no significant difference between experiment treatments with exceptional of (WBC) trait, seems that Hrp had no effect or any role on hematological traits indicated and in another result in a different Table it appeared an obvious dominancy for the treatment (1) control in (H/L ratio) as compared with the rest treatments. This is because active role of rhp compounds, specially the active compound (capscicine) rich in vitamin C that involved in stress hormones structures and this will defense the immune system of birds and enhances diseases resistance through decreasing H/L ratio.(Galib *et al.*,2011a)

2.8.6 Free fatty acid and cholesterol of poultry fed diet containing red hot pepper

Hot red pepper lowered the cholesterol concentrations in the meat (24.7 g/100 g in red meat), skin (87.4 g/100 g) and liver (263.1 g/100 g), while significantly ($P < 0.05$) reduced lipid oxidation in breast (0.05 mg MDA/kg tissue) and thigh with drumstick (0.12 mg MDA/kg tissue). On the basis of obtained findings, it can be concluded that the dietary spice herb had a positive influence on a proximate composition of chicken meat, cholesterol concentrations and lipid oxidation process (Puvaca *et al.*, 2015b). Furthermore, addition of spice herbs and medicinal plants can facilitate activity of enzymes which are involved in the conversion of cholesterol to bilious acids and subsequently will result in lower cholesterol concentration in the carcass (AL-Kassie *et al.*, 2012; and Alaa, 2010).

2.8.7 Peroxidation of poultry meat under storage

Supplementation of ethanol extracts from red pepper seeds groups resulted in significantly increased activities of hepatic glutathione peroxidase and catalase. Hepatic superoxide radical contents in microsome and mitochondria were significantly reduced in the groups supplemented with red pepper seeds ethanol extracts. Hepatic hydrogen peroxide content in the mitochondria was reduced in ethanol extracts from red pepper seeds supplemented groups (Won-Young *et al.*, 2010). Using the bovine brain peroxidation assay, the methanolic extract of green pepper showed significant antioxidant activity (Conforti *et al.*, 2007).

2.8.8 Thiobarbituric acid reactive substances of a broiler chicken under storage (TBARS)

TBARS values in the liver were reduced in red pepper seeds ethanol extracts supplemented groups according to research by (Won-Young *et al*., 2010). Another research by (Aksu *et al*., (2016) on packed breasts and drumsticks of broiler chicken which were stored at 3 ± 0.5°C for 12 days for TBARS value showed ($p < 0.01$) decreased compared to the control group.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of the Study

The experiment was conducted at Mike Farm Enterprise, Shango, Minna, Niger State. Minna is the capital of Niger state, North central Nigeria with population of 321,687, bordering Kaduna, Abuja, Kwara and Kogi. Minna lies on Latitude 9^0 22′ N and 11^0 30′ N and Longitude 3030′ N and 70 20′ E .The temperature range of Minna is between 23 ^{0}C and 34 ^{0}C with humidity between 90% - 98% and atmospheric pressure of about 1012- 1015mb. (Accuweather, 2021).

3.2 Experimental Materials

One hundred and twenty (120) one day- old unsexed marshal broiler chicks were used for the experiment. Dried powdered red hot pepper was used as the feed additives and a commercial feed was used for the experiment.

3.3 Source of Experimental Materials

Day old unsexed marshal broiler chicks were purchased from Zatech Farm Limited Ibadan, and transported over night to Minna. The red hot pepper used was purchased from Minna Central Market and ground to powder 0.01 and 1.28mm with an electric blender Polystar electric blender pv-BL999B (Polystar-technologies, U S A).

3.4 Preparation of Experimental Site

The experimental pen was washed with disinfectant (hypo bleach was used to wash the pen properly), dried and allow for two weeks so that the chemical will fizzle out before the arrival of birds. The floor was covered with wood shaving, foot dip was made available at the entrance of the pen and heat source was provided before the broilers arrive. The pen was subdivided into unit measuring 4 ft by 4 ft by 4 fit (1.2m×1.2m) to allow optimum stocking.

3.5 Experimental Design

A completely randomized design was used for the experiment. The study involved a total of 120 day-old Marshal broiler chicks. The chicks were allotted randomly into four treatments (four level of inclusions of red hot pepper) 0.00 %, 1.00 %, 1.25 % and 1.50% with three replicates (made up of 10 birds each) was used for the experiment.

3.6 Experimental Diet

For the experiment, a basal starter diet containing 22% crude protein and 2850 kcal/kg Metabolizable Energy (ME) was used from day 1 until 28 days of age and a basal finisher diet containing 20% crude protein and 3000 kcal/kg ME was used from 29 days (4 weeks) until 56 days (8 weeks) of age.

3.7 Experimental Birds and Management

The birds were kept in a deep liter system and brooded for the first 4 weeks (starter phase). Feed and water were served to the birds *ad libitum*. The birds were given anti-stress, vaccinated against Newcastle disease and infectious bursal disease. They were also treated against coccidiosis at four weeks using Amprolium® orally in drinking water for five days. The liter was kept dry, turned periodically and changed at intervals.

Table 3.1 Experimental design showing inclusion of red hot pepper in broilers diet

Replicate	T1	T2	T3	T4
R1	0.00	1.00	1.25	1.50
R2	0.00	1.00	1.25	1.50
R3	0.00	1.00	1.25	1.50

T1 = treatment with 0.00 % inclusion of RHP; T2 = treatment with 1.00 % inclusion of RHP; T3 = treatment with 1.25 % inclusion of RHP T4 = treatment with 1.500 % inclusion of RHP; R1 =replicate 1;R2= replicate 2; R3= replicate 3.

3.8 Capsaicin Concentration in Red Hot Pepper (RHP)

The capsaicin concentration was determined according to the method described by (Collins et al., 1995). The amounts of capsaicin consumed per bird during both phases of the study were evaluated as thus;

$$\text{Quantity of capsaicin consumed} = \frac{\text{amount of capsaicin in red hot pepper} \times \text{mean feed intake}}{\text{number of chickens}} \quad \ldots I$$

(Zeid *et al.*, 2011)

3.9 Data Collection

During the experiment data of the following parameters ware collected:

3.9.1 Growth performance

The growth performance parameters collected included:

3.9.1.1 Feed intake

Feed intake is the quantity of dry matter consumed. Feed were weighed, served to the birds and the refusal were weighed to get the average quantity of feed consumed by the birds. Thus it was calculated as follows:

$$\text{Average Feed Intake (FI)} = \frac{\text{Avg Feed intake}}{\text{Avg body weight gain}} \text{(g)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ II}$$ (Owen *et al*., 2013)

3.9.1.2 Body weight

The body weight is the mass or weight of the broilers and it is measured in kilograms (kg) or grams (g). The birds were weighed and recorded at the end of each week using an electronic compact digital scale model f18091710-w (Made in China).

3.9.1.3 Body weight gain

Body weight gain is an increase in body weight which can result from increase in fat deposits, excess fluid or other factors. The body weight gain of the broiler were obtained using:

Average Daily Gain (ADG) = $\frac{\text{Avg Final body weight} - \text{Avg Initial body weight}}{\text{Period (days)}}$…....... III (Owen *et al*., 2013)

3.9.1.4 Feed conversion ratio

Feed conversion ratio is the rate of measuring livestock conversion of feed into desired output. The rate of measuring feed efficiency with which the body of the birds the given feed into meat was calculated using:

FCR = $\frac{\text{Avg Feed intake}}{\text{Avg body weight gain}}$ (g) …………………………………………… IV (Owen *et al*., 2013)

3.9.2 Apparent nutrient digestibility

This is measured after food stuffs undergo digestion and assimilation as distinguished from the part rejected in faeces. This was conducted twice (between the 21st to 28th day at the starter phase, and the 49th and 56th day at the finisher phase, respectively). A total of 12 chickens, three each from each treatment were used for the digestibility trial. The chickens were placed in individual cages measuring 45 cm x 37.5 cm x 33 cm. Each cage was equipped with a feeder, a drinker and a faecal collecting device. The feed given and the feed refused after a 24 hours period was weighed daily. Droppings were collected daily per bird, weigh, wrapped in aluminium foil and taken to the laboratory for oven drying. The dry matter of the feed and faeces were determine by evaporation at 105° C for 24 h in a drying oven. The proximate composition of the feed and the faeces were also determined. Apparent nutrient digestibility coefficient of dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract were calculated by the following formula;

Apparent nutrient digestibility = $\frac{\text{nutrient in feed} - \text{nutrient in feaca}}{\text{nutrient in feed}} \times 100$ …. V (Owen *et al*., 2013)

Where NI = nutrients in feed consumed, NVF = Nutrient voided in faeces

3.9.3 Haematological and serum biochemical parameters

Blood samples (4ml) were collected from 3 chickens per group (12 birds in total) at the wing vein using a 22 gauge syringe. Samples were taken at the end of the experiment on the 56th day of age. The blood was divided into two tubes: one with EDTA (Ethylene-Diamine-Tetra Acetic acid), and the other without an anticoagulant, respectively for haematological and serum biochemical analysis. The samples from blood were separated by centrifugation (4000 rpm for 5 min at 20°C).Commercially available kits (Randox Laboratories Limited – United KIngdom) to analyse the serum biochemistry using Dietek veterinary hematological analyzer model DR-3125plus made in U.K. Aikpitanyi, (2020).

3.9.3.1 Haematological analysis

The haematological parameters determined are:

i. Red blood cell count (mil/mm^3) - A red blood cell count is a blood test that is used to find out how many red blood cells (RBCs) is available. It's also known as an erythrocyte count.

ii. Lymphocytes count - lymphocyte is a type of white blood cell that is part of the immune system.

iii. White Blood Cell- White blood cells are also called leukocytes. They protect you against illness and disease

iv. Haemoglobin - The hemoglobin count is an indirect measurement of the number of red blood cells in your body.

v. Mean corpuscular volume - Mean corpuscular volume (MCV) is the average volume of red cells in a specimen.

vi. Mean cell Haemoglobin - MCH value refers to the average quantity of hemoglobin present in a single red blood cell.

vii. Mean Corpuscular Haemoglobin Concentration - The mean corpuscular hemoglobin concentration (MCHC) is a measure of the concentration of haemoglobin in a given volume of packed red blood cell.

This assessment was made by introducing the blood sample into a haematology analyzer (Biotek VET haematology analyser model DR.-3125 plus) made by biotech U. k. Aikpitanyi, (2020)

3.9.3.2 Serum biochemistry

The following serum biochemical parameters were analyzed:

i. Glucose - blood glucose level is the concentration of glucose present in the blood of humans and other animals.

ii. Total protein - Serum total protein, also known as total protein, is a biochemical test for measuring the total amount of protein in serum.

iii. Alanine aminotransferase - Alanine aminotransferase (ALT) is an enzyme found mostly in the cells of the liver and kidney.

v. Cholesterol - Cholesterol is a waxy type of fat, or lipid, which moves throughout your body in your blood. Lipids are substances that do not dissolve in water, so they do not come apart in blood.

vi. Aspartate aminotransferase (AST) - Aspartate aminotransferase (AST) is an enzyme found in cells throughout the body but mostly in the heart and liver and, to a lesser extent, in the kidneys and muscles.

viii. Alkaline phosphatase levels - its concentration in the bloodstream is used by diagnosticians as a biomarker in helping determine diagnoses.

This assessment was made by introducing the blood sample into a biochemistry analyzer (Biotek VET haematology analyser model DR.-3125 plus) made by biotech U. k . Aikpitanyi, (2020)

3.9.4 Shelf-life of meat

Meat obtained from broiler chickens were stored at refrigerated temperature (2 - 4 ^{0}C) and at two days interval, samples were taken and analysed for lipid oxidation (expressed as a concentration of thiobarbituric acid reactive substances) (TBARS) value, Peroxide Value (PV), Free Fatty Acids (FFA) and ammonia content for a maximum of fourteen days using a clinical chemistry analyzer rx Modena SMT-120 veterinary automated biochemistry analyzer, made in China Alam (Zeb and Fareed Ullah, 2016)

3.9 Cost of Feed Per Kilogram Body Weight Gain

Diet cost and feed intake were separately calculated for the different treatment at the end of the experiment according to the method by (Anigbogu *et al*., 2019).

3.10 Data Analyses

The Statistical package for social science (SPSS,2016) was used to compile the data collected during the study and were analysed using one-way ANOVA. Means were compared where there is significant difference using Duncan multiple range test (IBM Corporation, 2016).

CHAPTER FOUR

4.0 RESULT

4.1 Proximate Composition of Red Hot Pepper (RHP)

Table 4.1 showed the proximate composition and capsaicin concentration of red hot pepper (RHP). The result showed that 91 % dry matter (DM) red hot pepper contained 16 % crude protein (CP), 24 % crude fibre (CF), 15.2 % fat, 8.5 % ash content, 27.3 % nitrogen free extract (NFE).

4.2 Proximate Composition of Diet Used in Feeding the Broiler Chicken

Table 4.2 showed the proximate composition of the diet used in the experiment at the starter and finisher phase. It shows 21.20 % and 18.50 % of CP, 6.97 % and 7.30 % of CF and moisture of 6.97 % and 8.00% respectively for starter and finisher.

4.3 Growth Performance of Broiler Chicken Fed with Diet Containing Varying Levels of Red Hot Pepper

The results of growth performance of broiler chick fed with diet containing different levels of red hot pepper as presented in Table 4.2 showed that the crude protein and the moisture in both starter and finisher diet varied greatly. Other parameters were which include crude protein, fat and ash had close values in Table 4.2.

4.3.1 Feed intake broiler chicken fed with diet containing varying levels of red hot pepper

The mean weekly feed intake of the broiler chicks at the starter phase were significantly different ($p<0.05$) from each other in Table 4.3. Broiler chicks on T3 (with 1.25 % inclusion) and T4

(1.50% inclusion) had the highest feed consumption (426.35g and 430.70g respectively) while chicks on T1 (0.00% inclusion) and T2 (1.00 % inclusion) were also significantly different ($p<0.05$) from each other with the chicks on T2 having higher (395.82g) feed consumption than T1 (365.19g) in Table 4.3.

At the finisher phase, the mean weekly feed intake followed similar result obtained from the starter phase. T2 (with 1.00% inclusion), T3 (with 1.25% inclusion) and T4 (with 1.50%

inclusion) were not significantly different ($p>0.05$) from each other but T4 had the highest value (748.67g) while T2 had the least value (734.17g). T1 (with 0.00% inclusion) was significantly different from T2, T3 and T4 (Table 4.3).

4.3.2 Body weight broiler chicken fed with diet containing varying levels of red hot pepper

The mean initial body weights of the day old broiler chicks were similar across the treatment and there was no significant difference ($p>0.05$) in Table 4.3.

Weekly mean body weight of the broiler chicks showed that T2 (with 1.00% inclusion) and T3 (with 1.25% inclusion) are similar having no significant different ($p>0.05$)from each other but are significantly different ($p<0.05$) from T1 (with 0.00% inclusion) and T4(with 1.50% inclusion). T4 (with 1.50% inclusion) showed that feed consumed by the chicks on this treatment were significantly higher than those on T1(with 0.00% inclusion) at the starter phase (Table 4.3).

The mean weekly body weight of broiler chicks in T2 (with 1.00% inclusion) showed that it was significantly different ($p<0.05$) from other treatments and having the highest mean weight (1437.10g). T3 (with 0.00% inclusion) and T4 (with 0.00% inclusion) were not significantly

Table4. 1. Proximate composition and capsaicin concentration of red hot pepper

Parameter	quantity (%)
Dry matter	91.0
Crude Protein	16.0
Fiber	24.0
Ash	8.5
Fat	15.2
Nitrogen Free Extract	27.3
Moisture Content	9.0
Quantity of capsaicin (mg/1000g)	29.20

DM = 100 – MC ; % NFE = (EE + CP + Ash + CF)

Table 4.2 Proximate composition of feed used in the experiment

Parameter	Starter	Finisher
Crude protein (%)	21.20	18.50
Crude fiber (%)	6.97	7.15
Ash (%)	7.55	7.30
Fat (%)	6.30	6.15
Moisture (%)	6.97	8.00
Dry matter (%)	93.03	92.00
NFE (%)	51.01	52.90

All parameters are measured in % of the dry matter different ($p>0.05$) from each other but are significantly different ($p<0.05$) from T1 (with 0.00% inclusion) in Table 4.3.

4.3.3 Body weight gain broiler chicken fed with diet containing varying levels of red hot pepper

Weekly Mean body weight gain (BWG) of broiler chicks fed diet containing red hot pepper at various levels at the starter phase showed no significant differences ($p>0.05$) across the treatments. Although, there was variation in value obtained across the treatment with T2 (142.38g) and T3 (143.66g) having the highest values in Table 4.3.

The mean weekly body weight gain of broiler chicks at the finisher's phase showed that T2 (with 1.00% inclusion) performed best and was significantly different (p<0/05) from other treatments. Marshal broiler chicks on T3 (with 1.25% inclusion) and T4 (with 1.50% inclusion) were similar and had no significant different from each other but were significantly different ($P<0.05$) than the chicks in T1(with 0.00% inclusion) in Table 4.3.

4.3.4 Feed conversion ratio broiler chicken fed with diet containing varying levels of red hot pepper

Table 4.3 also showed that feed conversion ratio of broiler chick at the starter phase showed no significant difference ($p>0.05$) across the treatment although, the best value (2.79g) was obtained in treatment T2 (with 1.00% inclusion).

The feed conversion ratio at the finisher phase showed no significant difference ($p>0.05$) although, the chicks in treatment T2 had the best value (2.85g) across the treatments in Table 4.3.

4.3.5 Quantity of capsaicin in red hot pepper consumed by broiler chicken fed with diet containing varying levels of red hot pepper

The quantity of capsaicin in red hot pepper consumed by broiler chicks in diet at the starter phase showed that there were significant different ($p<0.05$) among the treatments. T3 (with 1.25% inclusion) and T4 (with 1.50% inclusion) had similar values but were significantly higher than the chicks on T2 (with 1.00% inclusion) while T1 (with 0.00% inclusion) consumed no capsaicin in red hot pepper at the starter phase. This followed the pattern observed in feed intake at the starter phase (Table 4.3).

Quantity of capsaicin consumed at the finishers phase were significantly different ($p<0.05$) across the treatment except for T3 (with 1.25% inclusion) and T4 (with 1.50% inclusion) which were not significantly different ($p>0.05$) from each other. T4 (with 1.50% inclusion) showed the highest value (2.1861mg) which is similar to the result obtained in the starter phase. T2 (with 1.00% inclusion) showed the lowest value (2.14mg) similar to the starter phase (Table 4.3).

4.4 The Effect of Inclusion of Different Levels of Red Hot Pepper in Broiler Diet on Apparent Nutrient Digestibility of Broiler Chicken

The results of nutrient apparent digestibility of Marshal broiler chicken fed diet containing varying levels of red hot pepper had no significant ($p>0.05$) difference among the treatment and in all the parameters. Although, T4, showed higher values in all the parameters and T1 showed lower values in crude fiber, ash and ether extract. There is no significant effect ($P>0.05$) of the evaluated parameters on the treatments in Table 4.4.

Table 4.3. Growth performance of broiler chicken fed with diet containing varying levels of red hot pepper

	Treatment					
Parameter/phase	**T1**	**T2**	**T3**	**T4**	**SEM**	**p - value**
Starter						
Initial body weight (g/bird)	46.30	46.33	46.33	46.30	0.32	0.22
Weekly feed intake (g/bird)	365.19^{C}	395.82^{b}	426.35^{a}	430.70^{a}	8.38	0.00
Weekly body weight (g/bird)	294.13^{b}	352.93^{a}	353.83^{a}	331.58^{ab}	10.03	0.20
Weekly body weight gain(g/bird)	125.25	142.38	143.66	140.93	3.24	0.14
Feed conversion ratio	2.92	2.79	2.98	3.06	0.62	0.53
Quantity of capsaicin consumed (mg/bird)	0.00^{c}	1.16^{b}	1.24^{a}	1.26^{a}	1.53	0.00
Finisher						
Weekly feed intake (g/bird)	595.38^{b}	734.17^{a}	740.33^{a}	748.67^{a}	21.19	0.03
Weekly body weight (g/bird)	1136.60^{b}	1437.10^{a}	1343.20^{ab}	1305.0^{ab}	45.83	0.11
Weekly body weight gain (g/bird)	191.06^{b}	258.76^{a}	242.23^{ab}	231.75^{ab}	10.94	0.14
Feed conversion ratio	3.13	2.85	3.08	3.34	0.12	0.63
Quantity of capsaicin consumed (mg/bird)	0.00^{c}	2.14^{b}	2.17^{a}	2.12^{a}	2.22	0.03

T1= Control (without red hot pepper) ; **T2**=1.00% red hot pepper ; **T3**= 1.25% red hot pepper; **T4**= 1.50% red hot pepper ; **SEM**= Standard error of the mean;,**LS**= Level of significance; **abc**=Means in the same row with the same superscripts are not significantly different (P>0.05); *= Significant (P<0.05);**NS**= No Significant difference.

Table 4.4 The effect of inclusion of different levels of red hot pepper in broiler diet on apparent nutrient digestibility

	Treatment					
Parameters	**T1**	**T2**	**T3**	**T4**	**SEM**	**p - value**
Dry matter	74.84[a]	93.69[b]	79.89[ab]	86.81[ab]	2.99	0.64
Crude protein	64.43	77.00	61.00	84.50	4.45	0.20
Crude fibre	52.15	77.50	74.50	80.00	5.69	0.33
Ash	28.50	63.10	30.80	77.20	9.65	0.18
Moisture	13.20	6.16	10.63	25.15	3.341	0.06
Ether extract	75.80	86.00	82.65	83.60	2.41	0.59

T1= Control (without red hot pepper) ; T2=1.00% red hot pepper ; T3= 1.25% red hot pepper; T4= 1.50% red hot pepper ; SEM= Standard error of the mean;, p- value= Level of significance; abc=

4.5 The Effect of Inclusion of Different Levels of Red Hot Pepper in Broiler Diet on Heamatological and Biochemical Parameter of Broiler Chicken

Table 4.5 Clears the effect of using different levels of red hot pepper in the diet on hematological. The effect was shown to be significantly different ($p<0.05$) in the Red blood cell count (RBC). It was showed that T1 (with 0.00% inclusion) was significantly different ($p<0.05$) from other treatments with the highest value (94.85mm3).T2 (with 100 % inclusion) and T4 (with 1.50% inclusion) are similar and showed no significant difference among each other but are significantly different from other treatment (T1 and T3) in Table 4.5. The heamoglobin showed no significant difference ($p>0.05$) across the treatments although it showed that T1 had the highest value (Table 4.4). The white blood cells (WBC) across the treatments showed significant different ($p<0.05$). T2 and T3 are similar having similar values (28.25 and 21.60) and not significantly different ($p>0.5$) but were significantly different ($p<0.5$) from T1 and T4. T4 showed that it was significantly different ($p<0.05$) from all the other treatment with the highest value (Table 4.5).

The Haemoglobin, Mean Corpuscular Haemoglobin Concentration (MCHC), Mean corpuscular volume (MCV), Mean cell Haemoglobin (MCH), Lymphocytes count, Glucose, Total protein, Alanine aminotransferase, Cholesterol and Aspartate aminotransferase showed no significant .

4.6 The Effect of Inclusion of Different Levels of Red Hot Pepper in Broiler Diet on Thiobarbituric Acid Reactive Substances of Broiler Meat

The result of inclusion of different levels of Red Hot Pepper in broiler diet on Thiobarbituric Acid Reactive Substances of Broiler meat is presented in Table 4.5 .The treatment were not significantly different from each other, day 12 showed that T1 (with 0.00% inclusion) was

Table 4.5 The effect of inclusion of different levels of red hot pepper in broiler diet on heamatological and biochemical parameters

	Treatment					
Parameters	**T1**	**T2**	**T3**	**T4**	**SEM**	**p - value**
Heamotological parameters						
Red blood cell count (million/mm^3)	94.85^{b}	85.85^{ab}	72.90^{b}	81.20^{ab}	3.55	0.14
Haemoglobin(g/dl)	14.43	13.79	13.34	13.29	0.21	0.14
White Blood Cell (x10^3 µl)	39.75^{a}	28.25^{ab}	21.60^{ab}	14.05^{b}	3.96	0.06
Mean Corpuscular Haemoglobin Concentration (%)	1796.5	994.50	1432.00	1605.00	0.02	0.64
Mean Corpuscular volume (cuµm)	37.40	34.95	31.20	36.050	1.13	0.26
Mean cell Haemoglobin (fol/cell)	14.65	14.11	13.70	14.20	0.40	0.09
Lymphocytes count (10^9/L)	42.30	51.60	59.50	55.35	4.00	0.58
Biochemical parameters						
Glucose(mili mol/L)	140.93	138.70	138.07	139.13	2.68	0.99
Total protein(g/dL)	13.45	13.39	13.65	13.87	1.13	0.62
Alanine aminotransferase (IU/L)	13.01	13.78	13.78	13.00	0.21	0.52
Cholesterol(mmol/L)	108.42	100.53	102.36	100.53	2.14	0.62
Aspartate aminotransferas(µmol)	188.44	153.48	96.37	170.20	19.60	0.46
Alkaline phosphatase levels.	251.05	252.37	251.58	225.79	5.76	0.33

T1= Control (without red hot pepper) ; T2=1.00% red hot pepper ; T3= 1.25% red hot pepper; T4= 1.50% red hot pepper ; SEM= Standard error of the mean; p - value= Level of significance; abc=Means in the same row with the same superscripts are not significantly different (P>0.05); *= Significant (P<0.05).

difference(p>0.05) across the treatment. Although, some biochemical parameters like the cholesterol and glucose were found to be higher in treatment T1 than others (Table 4.5).

significantly different ($p<0.05$) from other treatments having the highest value (2.13µm/g). T2 (with 1.25% inclusion) and T3 (with 1.50% inclusion) are similar with no significant different ($p>0.05$) among each other but are significantly different from each other. Day 14 also showed that T1 was significantly different ($p<0.05$) from other treatment and also had the highest value (3.06µm/g). Similarly, T2 and T3 had no significant difference ($p>0.05$) with each but are significantly different ($p<0.05$) from other treatments (Table 4.5).

4.7 The Effect of Inclusion of Different Levels of Red Hot Pepper in broiler diet on Fatty Acid (FFA) Of Broiler Chicken Meat

The effect of inclusion of different levels of red hot pepper in broiler diet on Free Fatty Acid (FFA) of Marshal broiler chicken meat showed that from day 2 to day 14, across the treatment there was no significant difference ($p>0.05$). Although, day 14 the highest value in Table 4.7.

4.8 The effect of inclusion of different levels of Red Hot Pepper in broiler diet on Peroxide Value of Broiler Chicken Meat

The effect of inclusion of different levels of red hot pepper in broiler diet on peroxide value of Marshal broiler chicken meat in day 2 across all the treatment (T1,T2,T3 andT4) was not significantly different ($p>0.05$) in Table 4.8.

Day 4 showed that across all the treatment (T1,T2,T3 andT4),there was no significant difference ($p>0.05$) although, T1 had the highest value on.75).

Day 8 also showed that there were significant that day. Day 6 showed that there was significant difference ($p<0.05$) across the treatments (T1,T2,T3 andT4). It was observed that T2,T3 and T4 were similar and had no significant difference ($p>0.05$) among themselves.

Table 4.6 The effect of inclusion of different levels of red hot pepper in broiler diet on thiobarbituric acid reactive substances (TBARS)

	Treatment					
Parameters (u/mg)	**T1**	**T2**	**T3**	**T4**	**SEM**	**P - value**
Day 2	0.15	0.14	0 .15	0.13	0.00	0.48
Day 4	0.51	0.53	0.50	0.45	0.02	0.68
Day 6	0.59	0.58	0.55	0.52	0.03	0.70
Day 8	0.47	0.71	0.61	0.67	0.08	0.70
Day 10	1.02	1.04	1.06	1.08	0.02	0.67
Day 12	2.13^{a}	1.73^{ab}	1.59^{ab}	1.44^{b}	0.11	0.02
Day 14	3.06^{a}	2.43^{ab}	2.12^{ab}	1.83^{b}	0.20	0.01

T1= Control (without red hot pepper) ; T2=1.00% red hot pepper ; T3= 1.25% red hot pepper; T4= 1.50% red hot pepper ; SEM= Standard error of the mean;, p-value = Level of significance; abc= Means in the same row with the same superscripts are not significantly different (P>0.05); *= Significant (P<0.05).

Table 4.7 The effect of inclusion of different levels of red hot pepper in broiler diet on free fatty acid (FFA)

	Treatment					
Parameters (%)	**T1**	**T2**	**T3**	**T4**	**SEM**	**P - value**
Day 2	0.80	0.58	0.66	0.74	0.05	0.58
Day 4	1.75	2.12	1.70	2.01	0.10	0.41
Day 6	2.14	2.29	1.57	2.15	0.26	0.85
Day 8	1.84	1.69	1.41	1.34	0.10	0.23
Day 10	2.39	2.82	3.91	2.58	0.28	0.19
Day 12	3.17	2.95	3.71	2.61	0.24	0.53
Day 14	3.25	4.12	4.02	2.92	0.26	0.32

T1= Control (without red hot pepper) ; T2=1.00% red hot pepper ; T3= 1.25% red hot pepper; T4= 1.50% red hot pepper ; SEM= Standard error of the mean;, p- value = Level of significance; abc= Means in the same row with the same superscripts are not significantly different (P>0.05); *= Significant (P<0.05).

Table 4.8 The effect of inclusion of different levels of red hot pepper in broiler diet on peroxide value

			Treatments			
Parameters (meqO2/Kg)	**T1**	**T2**	**T3**	**T4**	**SEM**	**P - value**
Day 2	49.85	52.34	60.63	56.72	3.41	0.79
Day 4	117.50	85.33	94.92	98.97	7.65	0.62
Day 6	173.75[a]	144.70[b]	133.34[b]	140.06[b]	6.31	0.04
Day8	191.67[a]	161.67[b]	186.63[ab]	171.73[ab]	5.35	0.10
Day 10	214.59	240.63	220.50	176.90	26.92	0.15
Day 12	203.90	230.00	243.66	199.44	25.55	0.14
Day 14	330.91	340.42	245.48	240.47	19.95	0.18

T1= Control (without red hot pepper) ; T2=1.00% red hot pepper ; T3= 1.25% red hot pepper; T4= 1.50% red hot pepper ; SEM= Standard error of the mean; p - value= Level of significance; abc= Means in the same row with the same superscripts are not significantly different (P>0.05); *= Significant (P<0.05);

4.9 Cost of feed intake per kilogram body weight of Broiler Chicken Fed with Diet Containing varying levels of Red Hot Pepper

The result of inclusion of different levels of Red Hot Pepper in broiler diet on cost per kilogram body weight of marshal broiler meat at the starter phase in Table 4.9 showed that when there is increase in the level of red hot pepper (T1,T2,T3 and T4) the corresponding cost per kilogram increases too (N 402.00, N 420.90, N 429.08 and N 440.40). The starter phase shows no significant difference ($p>0.05$) among the treatment.

At the finisher phase, cost per kilogram body weight of marshal broiler meat showed no significant difference ($p>0.05$) among the treatment. Although , the higher values were obtained from T1 and T4 (N 450.20 and N 480.05) while lower values were obtained from T2 and T3 (N 443.30 and N 443.30) in Table 4.9.

Table 4.9 The effect of inclusion of different levels of red hot pepper in broiler diet on cost of feed intake per kilogram body weight gain

	Treatment					
Parameter	**T1**	**T2**	**T3**	**T4**	**SEM**	**P - value**
Starter phase						
Body wght gain(g)	125.25	142.38	143.66	140.93	3.24	0.14
Cost of feeding(₦)	52.59[a]	57.01[b]	61.40[c]	62.02[c]	0.25	0.00
Cost of feed /kg body wght gain(₦)	402.00	420.90	429.80	440.40	0.89	0.79
Finisher phase						
Body wght gain(g)	191.06[b]	258.76[a]	242.23[ab]	231.75[ab]	10.94	0.14
Cost of feeding(₦)	85.73[a]	105.72[b]	106.61[b]	107.81[b]	1.21	0.00
Cost of feed / kg body wght gain(₦)	450.20	443.30	443.30	480.50	1.74	0.61

T1= Control (without red hot pepper) ; T2=1.00% red hot pepper ; T3= 1.25% red hot pepper; T4= 1.50% red hot pepper ; SEM= Standard error of the mean;,p - value= Level of significance; abc= Means in the same row with the same superscripts are not significantly different (P>0.05); *= Significant (P<0.05.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Proximate Compositions and Quantity of Capsaicin in Red Hot Pepper

The red hot pepper crude protein, fat, and crude fiber content range were within the normal range obtainable in Nigeria and it is in agreement with Adeyeye and Otokiti, (1999) who reported that crude protein, fat, and crude fiber content in dried red hot pepper were 18.19, 16.53 and 27.90 respectively. The quantity of capsaicin obtained in the red hot pepper also is within the obtainable range and this agreed with Popelka *et al*., (2017) who stated that the quantity of capsaicin in is dried red hot pepper is between 25.94 % and 46.70 %.

5.2 Proximate Compositions of Feed Used in the Experiment

The proximate compositions of the diet shows that all the parameters are within the normal range for both starter and finisher there would not affect performance negetively.

5.3. Growth Performance of Broiler Chicken Fed with Diet Containing Varying Levels of Red Hot Pepper

5.3.1 Feed intake of broiler chicken fed with diet containing varying levels of red hot pepper

Feed intake of the broiler chickens was directly related to the to the quantity of red hot pepper included in the feed and higher inclusion of red hot pepper favoured better feed intake. The increase of feed intake by marshal broiler chickens in diets containing red hot pepper at 1.00%,1.25% and 1.50%. This agreed with Puvaca *et al*., (2015a) which stated that spicies stimulate broiler feed intake. This may be due to the active compound contained in the red hot pepper called capsaicin which is rich in vitamin C which stimulates the digestive liquid of the stomach (Safa and Wahab, 2013). Red hot pepper are rich in vitamin C, which have a considerable impact in improving poultry production through reduction of stress caused by heat and improving feed consumption of the poultry (Al- Kassie *et al*., 2012). This may be possible because of elimination some pathogenic microorganism making increased absorption in the ilium of the broiler possible. This may lead to increase in feed consumption and this agreed with Aghli *et al*.(2013).

5.3.2. Body weight gain of broiler chicken fed with diet containing varying levels of red hot pepper

The improvement observed on weekly mean weight on T2 (with 1.00 % inclusion), T3 (with 1.25 % inclusion), T4 (with 1.50 % inclusion) over T1 (with 0.00% inclusion) at the starter phase agreed with the findings of Aghil *et al*.(2013) and AL-Kassie *et al*. (2011) which revealed that the inclusion of hot red pepper at levels of 0.5 %, 0.75 % and 1 % into the diets of broiler chicken improved body weight gain over the control with an inclusion of red hot pepper at 0.00 %.The work of Thiamhirunsopit *et al*. (2014) using different forms of hot red peppers also showed that broiler chicken growth performance were enhanced and good result were obtained in treatment with inclusion of red hot pepper compare to the treatment used as control.

This may be because of the digestibility characteristics of red hot pepper which increases digestion through stimulating enzymes which aid digestion and reducing infectious bacteria (Aghil *et al*., 2013). It also agrees with Safa and Wahab (2013) which reveals that red hot pepper contain an active compound (Capsaicin) rich in vitamin C that help to improve feed intake and as result reflects on improved body weight gain. The body weight gain might be because of the increase absorption in the ilium which is stimulated by the active ingredient in red hot pepper call capsaicin and this is in agreement with Al – Kassie. (2012) which states the active compound (capisicine) which is in rich vitamin C can help to improves feed intake and that in turn reflected on body weight gain of the broiler. The result from work of Platel and Srinivasan (2000) revealed that the active component in pepper, promotes pancreatic digestive enzymes such as lipase, amylase and proteases, which play important roles in the digestion process in broiler production and which may translate into body weight gain.

5.3.3 Feed conversion ratio of broiler chicken fed with diet containing Varying Levels of Red Hot Pepper

The feed conversion ratio of broiler chicken fed with diet containing red hot pepper in all the treatment was not affected. It was observed that the best value was obtained from treatment with inclusion of 1.25 % of red hot pepper which translate that the broilers in that treatment had better absorption of nutrient. Although, the work of Thiamhirunsopit *et al*. (2014) obtained similar in his result across the treatment which revealed that feed conversion ratio in preparation period of chicken was uniform and ranged without significant difference and against the report of Aghil *et al.* (2013) who stated that the feed conversion ratio of broiler chicken fed with diet containing red hot pepper was low.

5.4 Digestibility of Broiler Chicken Fed with Diet Containing varying levels of Red Hot Pepper

Improved dry matter digestibility for broilers fed diet containing varying levels of red hot pepper compared with other treatments suggested that red hot pepper had digestion-stimulating properties. Capsaicin has been reported to stimulate digestion and increase absorption of nutrients (Reddy *et al*., 2004). Various plant extracts, spices, and herbs have been to improve nutrient digestion in poultry by stimulating secretion of saliva, intestinal enzyme secretion.

Red hot pepper did not affect other parameters apparent digestibility this is in agreement with Hernandez *et al.* (2004) reported that such ingredients only slightly improved performance, and their differences were not significant. This may be attributed to be attributed to the fact that the phyto growth promoters reduce the growth of many pathogenic or nonpathogenic intestinal microbes, and therefore a further increase in nutrient digestibility would be virtually undetectable (Lee *et al*., 2003b).

5.5 Heamatological and Biochemical Parameters Parameters of Broiler Chickens Fed Diets Containing Varying Levels of Red Hot Pepper

5.5.1 Heamatological parameters of broiler chicken fed with diet containing varying levels of red hot pepper

Following the data obtained from haematological parameters selected red blood cell count (RBC) and the white blood cell count (WBC) were observed to be affected by the diet with inclusion of red hot pepper. This however agrees with the finding of Alaa (2010) who reported that the hot red pepper of 0.25%, 0.75% and 1% keeps the Hb and H/L ratio within normal. The control T1 (with 0.00% inclusion), is seemingly dominant in all the heamatological parameters except in Lymphocytes count while the other treatment T2 (with 1.00% inclusion) T3 (with 1.25% inclusion) and T4 (with 1.50% inclusion) have distribution of the low values. This agreed with AL-Kassie *et al.* (2011) whose work showed that broilers fed with pepper in their diet had significantly lowered red blood cell count, packed cell volume and haemoglobin compared with the control group. It seems that red hot pepper had only effect on red blood cell and white blood cell while haematological traits remain unaffected. But appeared an obvious dominancy for the treatment (1) control in (H/L ratio) as compared with the rest treatments. Lazarevic *et al.* (2000) had reported that the active compound (capscicine) rich in vit C that involved in stress hormones structures and this will defense the immune system of birds and enhances diseases resistance through decreasing H/L ratio.

5.5.2 Biochemical parameters of broiler chicken fed with diet containing varying levels of red hot pepper

The data obtained in the biochemical analysis followed the pattern in heamatology in that most biochemical parameter had T1 dominating. Others have very clearly shown a declining effect. This agreed with the report of AL-Kassie *et al.* (2012) and Alaa (2010) which states that red hot pepper added to the broiler diet in different amounts from 0.25 to 1% had influence on decreased concentration of blood cholesterol, and other blood biochemical parameters. Furthermore, addition of red hot pepper and other spice herbs can facilitate activity of enzymes which are involved in the conversion of cholesterol to bilious acids and subsequently will result in lower cholesterol concentration in the carcass (Alaa, 2010).

5.6 The Meat shelf-life of Marshal Boiler Chicken Different Levels of Red Hot Pepper in Broiler Diet

5.6.1 Effect of inclusion of different levels of red hot pepper in broiler diet on thiobarbituric acid reactive substances (TBARS) of broiler chicken meat

The effect of red hot pepper inclusion at different levels in broiler chicken diet on thiobarbituric acid reactive substance (TBARS) value of the meat obtained did not affect the storage of the broiler meat from day 2 to day 10. This means that from day 2 to day 10 under the temperature of 2 – 4 ^{0} C the broiler meat were still safe for consumption. Day 12 and day14 had clearer view of how the broiler chicken meat on T1 had higher oxidation than other treatments. These variations in day 12 and 14 could be attributed to lipid oxidation produced and it agreed with AL-Kassie *et al*. (2011) who reported that the active ingredient in red hot pepper capsaicin which rich in vitamin C prevents oxidation in the tissue and it is against the reported of Koreleski and Swiatkiewicz (2007) who stated that plant extracts did not favorably affect TBARS value in broiler meat.

5.6.2 Free fatty acid (FFA) from broiler chicken meat fed diet containing varying levels of red hot pepper.

The red hot pepper inclusion in broiler chicken did not negatively affect the FFA value of the broiler chicken meat. But, it was noticed that as the meat stay longer more FFA value were produced at a stable rate. This is in agreement with AL-Kassie *et al*.,(2011) who reported that the active ingredient in red hot pepper capsaicin which rich in vitamin C prevents oxidation in the tissue and in agreement with Li and Liu (2012) who reported that the presence of exogenous antioxidants in the animal diet can increase the stability of lipid of meat. These antioxidants can reduce the impact of some sources of oxidative stress (heating) and thereby inhibit their adverse effect on the muscle tissue (Ismail *et al*., 2013). The research report of AL-Kassie *et al*. (2012); Alaa (2010) which states that red hot pepper added to the broiler diet in different amounts from 0.25 to 1% had influence on decreased concentration of blood cholesterol.

5.6.3 Peroxide value of from broiler chicken meat fed diet containing varying levels of red hot pepper

The effect of inclusion of red hot pepper in broiler chicken diet from day 4 to day 8 showed that T1 had higher value than others while in the rest days they were similar. Day 6 and day 8 showed that peroxide value were affected and even so the control treatment had a higher value that all other. This could indicate that since vitamin C is antioxidant and richly contained in red hot pepper it could be helping in reducing the of peroxide value of broiler the meat under storage therefor making it safe for human consumption. This agreed with the report of AL-Kassie *et al.*(2012) and Alaa, (2010) which states that red hot pepper added to the broiler diet in different amounts from 0.25 to 1% had influence on decreased concentration of blood cholesterol, and other blood biochemical parameters. Also, the report of Reitznerová *et at.* (2017) which states that the higher the lipid available in a meat the higher the oxidation.

5.7 Cost of Feed Intake Per Kilogram Body Weight Gain of Broiler Chicken Fed with Diet Containing Varying Levels of Red Hot Pepper

At the starter phase, the value obtained from the cost per kilogram body weight gain increases as the level of red hot pepper was increased. The finisher phase showed that the lowest value obtained for cost per kilogram body weight gain were in T2 and T3 even though they consumed more than T1. This is in agreement with the Afolabi *et al.* (2017) which stated that lower cost of feed intake/kg body weight gain was obtained for birds of diets with dried red hot pepper meal (T2 – T4) compared to those on control diet despite the least cost of feed per kg recorded for the control diet. The cost of feed both in the starter phase and the finisher phase were increased as the quantity of red hot pepper was increased. This indicates that the red hot pepper which is rich in vitamin C improved the feed consumption of broiler.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Based on the obtained results, it can be concluded with certainty that :

1. The addition of red hot pepper in broiler chicken diet has positive effect on production performances. Addition of red hot pepper in the amount of 1.25% has led to the highest final body weights, better feed conversion ratio and better feed utilization.
2. Red hot pepper in broiler chicken diet has significantly lowered plasma cholesterol, glucose and it maintained the heamatological parameters (Haemoglobin , Lymphocytes count , White Blood Cell).
3. Red hot pepper supplementation is effective in regulation of lipid metabolism in a favorable manner, act as an antioxidant and does not negatively affect the meat storage. Therefore, the general conclusion would be that the addition of red hot pepper has positive influence on the Marshal broiler chicken production and blood lipid profile, but further investigation of their mode of action is still necessary.

6.2 Recommendations

1. The recommendation from the study is that red hot pepper inclusion in broilers chicken diet at 1.25% is recommended to be used in broiler production.

2. Other methods can be used to increase the potency of red hot pepper when in use in broiler production.

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