PERFORMANCE CHARACTERISTICS OF BROILER CHICKENS FED GRADED LEVELS OF ONION (*Allium cepa*) AND ONION WITH BACTOFORT®

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AHMADU BELLO UNIVERSITY,

ZARIA, NIGERIA

MAY, 2018

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P14AGAN8013

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN ANIMAL SCIENCE

DEPARTMENT OF ANIMAL SCIENCE,
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MAY, 2018

DECLARATION

I declare that the work in this dissertation entitled **"PERFORMANCE CHARACTERISTICS OF BROILER CHICKENS FED GRADED LEVELS OF ONION (*Allium cepa*) AND ONION WITH BACTOFORT®"** has been carried out by me in the Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution.

……..	……	……
Name of student	Signature	Date

CERTIFICATION

The dissertation entitled **"PERFORMANCE CHARACTERISTICS OF BROILER CHICKENS FED GRADED LEVELS OF ONION (*Allium cepa*) AND ONION WITH BACTOFORT®"** written by **MOHAMMED ABDULLAHI TUKUR** meets the regulation governing the award of the Master of Science Degree of the Ahmadu Bello University, and is approved for its contribution to knowledge and literature presentation.

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ACKNOWLEDGEMENTS

All praise be to Almighty Allah the most beneficent the merciful for the life he has granted me with and the mercy, blessing, guidance and protection he bestowed on me throughout the course of my studies. My heartfelt gratitude and appreciation goes to my able and tireless supervisors, Professor T. S. Olugbemi and Dr. P. A. Onimisi whom despite their tight schedules were able to squeeze their valuable time going through my script, making objective criticisms, corrections, suggestions and approval so as to make this work witness the light of the day. I am highly honoured to work with them, may God Almighty reward them and their families abundantly, Amen. I will also like to appreciate the effort of the former head of Department, Animal Science, Professor S. Duru for giving me the opportunity to study M.Sc. Animal Science at this prestigious University, Ahmadu Bello University Zaria. My special regard also goes to the postgraduate coordinator, Dr S. B. Abdu for his fatherly advises. I must also at this juncture like to express my gratitude to my lecturers; Professor D. Zahraddeen, late Professor G. N. Akpa, Dr M. Kabir, Dr M. R. Hassan, Dr (Mrs) O.M. Daudu, Dr (Mrs) I.A. Adedebu and all other members of the Department. I thank them all for the knowledge they imparted to me.

My profound gratitude goes to the former Executive Director, National Agricultural Extension and Research Liaison (NAERLS), Ahmadu Bello University, Zaria, Dr. Y. Ilu who granted me the permission to carry out my studies at the Institute.

I am highly honoured to have the best parents on the surface of the earth who inculcated moral discipline and financially support, through my upbringing until this very moment. May God Almighty reward them with "Jannatul Firdhaus", Amen.

This will not be complete without applauding the efforts of my friends, colleagues, relatives, laboratory technicians, well-wishers and all other persons whom in one way or the other help with advice, energy, knowledge or support, especially; Haruna Ibrahim, Dr. I. Iyiola-tunji, Ishiyaku Y. Mohammad, Aisha M. Aliyu, Dr. Buba Wahe, Yunana Y. Lini, Izzadeen Saleh, Mustapha Y. Ahmad, Dr. N. Sulaiman, Safiyanu Ahmad, Musa Yusuf, Hudu I. Muhammad, Sulaiman Nazir and all other persons that space could not allow me mention. I really appreciate your contributions.

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ABSTRACT

Two feeding trials were conducted to evaluate growth performance, carcass characteristics, nutrient digestibility, haematological and serum biochemical parameters of broiler chickens fed graded levels of onion (*Allium cepa*) and onion with Bactofort® as eubiotics. Two hundred and forty (240) day old Ross 308 strain broiler chicks were allotted into five different dietary treatments with 0, 100, 200, 300 and 400g *Allium cepa* levels/100kg diet in the first experiment and 0, 15, 30, 45 and 60g Bactofort® levels added to 200g *Allium cepa*/100kg diet in the second experiment. Each treatment had 16 birds per pen replicated three times in a completely randomized design. Feed and water were given *ad libitum* while vaccination and other daily routine managements were duly observed throughout the experimental period. Data collected were subjected to analysis of variance using Statistical Analysis System and means were compared using Dunnett's package. Results of the first trial showed an insignificant ($P>0.05$) difference in performance parameters measured during starter period. At the finisher phase, final body weight (2137.47 – 2223.25g) and weight gain (1462.05 – 1548.10g) were significantly ($P<0.05$) higher in treatments receiving *Allium cepa* additions compared to the control (0g *Allium cepa* addition level) which had 2121.53g and 1445.53g respectively while feed intake and feed conversion ratio (FCR) were similar. Mortality was also higher in the control compared to *Allium cepa* treatment groups. 200g *Allium cepa* addition level had significantly ($P<0.05$) higher live weight (2191.78g), dressed weight (1541.11g) and dressing percentage (75.16%) compared to the other treatment groups. However, there were no significant ($P>0.05$) differences in all haematological and serum biochemical indices across the treatments except for albumin, creatinine, aspartate aminotransferase, alkaline phosphatase and total cholesterol. Percent

apparent nutrient digestibilities were also insignificant except for crude fibre and crude protein. Crude fibre digestibility (87.12%) was better in the treatment receiving 200g *Allium cepa* addition level compared to the control (82.99%). The proximate compositions of meat were significant ($P<0.05$) except ash across the treatment means. The meat quality characteristics were also insignificant. There was a reduction in ceacal and ileal microbial populations of *Allium cepa* treated group compared to the control. In the second experiment, the treatment group fed *Allium cepa* based diet (200g/100kg) with 45g Bactofort® addition had better ($P<0.05$) final weight (2575.00g), weight gain (2529.80g), and FCR (1.89) compared to the rest of the treatment groups. Carcass parameters were all significant ($P<0.05$) except for percentages of organs weight and dressing percentage. Treatment groups fed 0 and 60g Bactofort® addition to the *Allium cepa* based diet (200g/100kg) had significantly ($P<0.05$) higher total cholesterol (402.86 and 401.56mg dl^{-1}) and low-density lipoproteins (263.08 and 250.08mg dl^{-1}) compared to the other treatment groups. There were significant ($P<0.05$) differences in all digestibility parameters. The net profit return was better in the treatment group fed 45g Bactofort® addition levels to the *Allium cepa* based diet (200g/100kg). Moreover, gut microbial populations of *coliform, salmonella* and *E. coli* were lower in the treatment group with 45g Bactofort® addition level. It can be concluded that 200g/100kg dietary onion powder improved performance, meat quality and modulates gut microbiota in broiler chickens while Bactofort® addition at 45g/100kg *Allium cepa* based diet, similarly enhance performance, nutrient digestibility and cost efficiency in broiler production.

CHAPTER ONE

1.0 INTRODUCTION

Cost-effective poultry meat production is reliant on many vital factors. Securing optimum digestibility and assimilation of nutrients for improvement of broiler performance is certainly one of the most important elements. In this respect, the gastrointestinal tract needs special attention, because any impairment of the secretion of enzymes or disturbance of the microbiological equilibrium in the gut can negatively affect the digestibility of the feed, resulting in reduced growth rate or impaired feed conversion of growing birds. Various feed additive concepts, called eubiotics have been proposed to improve the nutrient utilization and to maintain gut health, which ultimately should result in improved performance (Wenk, 2002). Eubiotics as described by Broz and Paulus (2015) are groups of some feed additives (such as probiotics, prebiotics, essential oils e.t.c) which are used for the purpose of maintaining intestinal eubiosis (optimal balance of microflora in the gastrointestinal tract), thereby resulting in an improved health status and performance of farm animals.

Prebiotics are non-digestible feed components that beneficially affect the host by selectively altering the composition and metabolism of the gut microbiota (Huyghebaert *et al.*, 2011). Prebiotics may provide energy for the growth of favourable endogenous bacteria in the gut, such as bifidobacteria and lactobacilli, thus improving the host microbial balance (Das *et al.*, 2012). Prebiotics are found naturally in a variety of foods and can also be synthesized enzymatically. Commonly used prebiotics are oligosaccharides i.e., fructo-oligosaccharides (FOS), mannan oligosaccharides (MOS), lactulose, inulin (Brijesh *et al.*, 2013). Inulin is present in significant quantities in vegetables such as onions, artichokes, asparagus, leeks,

and garlic. A substantial amount of FOS is also found in suc vegetables and some cereals such as barley, and wheat (Espinosa-Martos *et al.,* 2006; Judprasong *et al.,* 2011).

The genus Allium includes about 550 species. A few of these are important as food plants and as drugs in human medicine, notably onion (*Allium cepa L.*) and garlic (*Allium sativum L.*). Onion is a bulbous plant widely cultivated in almost every country of the world with China, India and United States leading in production (Ebesunun *et al.,* 2007). Most of the plant parts contain compounds with proven antibacterial, antiviral, anti-parasitic, antifungal properties and have antihypertensive, hypoglycemic, antithrombotic, anti-hyperlipidemic, anti-inflammatory and anti-oxidant activity (Lampe, 1999). Administration of onion extract in rabbits significantly reduced serum, liver and aorta triglycerides and serum and liver proteins as reported by Sebastian *et al.* (1979). Aji *et al.* (2011) observed the beneficial influence of onion bulbs on growth performance of broiler chickens.

Probiotics are single or mixed culture of living microorganisms which when administered in adequate numbers exert health benefits for the host by improving the host intestinal microbial balance, enhancing of colonization resistance against pathogens and improving the immune responses (Brisbin *et al.*, 2010; Cencic and Chingwaru, 2010; Das *et al.*, 2012). The species of microorganisms currently being used in probiotic preparations are varied, and lactose fermenting bacteria (LAB) i.e., *Lactobacillus bulgaricus, Lactobacillus acidophilus, Lactobacillus casei, Lactobacillus helveticus, Lactobacillus lactis, Lactobacillus salivarius, Lactobacillus plantarum, Streptococcus thermophilus, Enterococcus faecium, Enterococcus faecalis, Bifidobacterium spp*., are the most common types of bacteria used as probiotics (Khaksefidi and Rahimi, 2005; Kabir, 2009). Recently, the emphasis has been on selection and preparation of mixed strains of microorganisms as probiotics (Chateau *et al.*, 1994).

Khaksefidi and Rahimi (2005) reported lower numbers of *Coliform* and *Campylobacter* in the gut of broiler chickens fed probiotics (mixed strains). Competition with pathogenic *E. coli* has also been documented (Watkins *et al.*, 1982), and an increase in production of antibodies at the systemic and local (intestinal) level (Haghighi *et al.*, 2006). The combination of prebiotics and probiotics (symbiotic) has not been well studied, but their beneficial effects might be additive or even synergistic (El-banna *et al*., 2010).

1.1 Justification

Antibiotic feed additives have been used in the poultry industry for many years to improve the productivity in terms of weight gain and feed conversion ratio by helping to control infections in the gut mucosa. However, the use of dietary antibiotics has resulted in common problems such as the development of drug-resistant bacteria (Van Boeckel *et al.,* 2015), drug residues in the body of the birds and imbalance of normal micro flora (Andremont, 2000; Kabir, 2009). As a consequence, it has become necessary to develop alternatives using either beneficial microorganisms or non-digestible ingredients that enhance the growth of beneficial micro organisms. Intensive studies have been conducted to find alternatives and to solve this problem, some components such as probiotics, prebiotics, organic acids and phytogenic feed additives are introduced instead of antibiotics (Patterson and Burkholder, 2003; Ricke, 2003). The beneficial influence of onion bulbs on growth performance of broiler chickens as a substitute for antibiotics has also been reported (Aji *et al*., 2011). Factors such as tolerance to bile and low gastrointestinal pH are needed to be considered in using any probiotic material. Resistance to bile and acidic gastrointestinal conditions are the important characteristic that enables Lactose-fermenting bacteria to survive and grow in the

intestinal tract (Jin *et al.*, 1998). It has been suggested that probiotics and prebiotics are much more efficient when used in combinations than singly (Alloui *et al*., 2013)

1.2 Aim and Objectives of the Experiments

The aim of this study was to evaluate the effect of dietary addition of Onion (*Allium cepa*) and Onion with Bactofort® on performance of broiler chickens. The specific objectives were to determine:

1. The growth performance, carcass characteristics, nutrient digestibility and haematological profile of broilers fed graded levels of *Allium cepa*
2. The meat quality characteristics of broilers fed graded levels of *Allium cepa*
3. The growth performance, carcass characteristics, nutrient digestibility and haematological profile of broilers fed *Allium cepa* based diets with Bactofort®
4. The economic evaluation of broilers fed the *Allium cepa* based diets with Bactofort®

1.3 Research Hypotheses

1.3.1 Experiment 1

H_O: There were no significant differences between growth performance, carcass characteristics, nutrient digestibility, haematological profile and meat quality characteristics of broilers fed graded levels of onion (*Allium cepa*).

H_A: There were significant differences between growth performance, carcass characteristics, nutrient digestibility, haematological profile and meat quality characteristics of broilers fed graded levels of onion (*Allium cepa*).

1.3.2 Experiment 2

H_O: There were no significant differences between growth performance, carcass characteristics, nutrient digestibility, haematological profile and economic parameters of broilers fed *Allium cepa* based diet with Bactofort®.

H_A: There were significant differences between growth performance, carcass characteristics, nutrient digestibility, haematological profile and economic parameters of broilers fed *Allium cepa* based diet with Bactofort®.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Need for Feed Additives in Poultry Production

The challenges of food insecurity and hunger in developing African countries like Nigeria have caught the attention of experts and governments worldwide (Emaikwu *et al*., 2011). Population growth, urbanization, nutritional education, and income improvements were the main drivers of increased demand for foods of animal origin in developing countries (Abdullah *et al*., 2011). The sufficient supply of animal protein is most critical in the global food basket crisis. As a result, growing demand had led to a rise in the production of foods of animal origin (animal protein) all around the globe, especially from poultry (FAO, 2010; Mammo, 2012; Heise *et al.,* 2015). The increased demand for animal protein could be satisfied especially by the production of broilers, as these products have seen the greatest increase in production in recent years (FAO, 2011; Heise *et al.,* 2015). However the poultry industry has been threatened by a lot of factors, one of which is the continued increasing cost of production due to the high cost of feeding which constitutes over 70% cost of production (Felix, 2013). Use of antibiotics in animal nutrition has been beneficial for the improvement of growth performance and prevention of diseases (Snel *et al.,* 2002). However, contemporary biosecurity threats arising from the increasing resistance of pathogens to antibiotics and the accumulation of antibiotic residues in animal products and the environment (Snel *et al.,* 2002; Van Boeckel *et al.,* 2015) elicit a call for a worldwide ban on antibiotic usage. As a result, it is extremely important for the highly intensive broiler production sector of the poultry industry to achieve performance optimization and minimization of economic losses while ensuring the safety of broiler meat via the control

and elimination of foodborne pathogens. Part of a global solution to the use of antibiotics is safe and natural alternatives that can answer producers and consumer needs to serve the growing needs of the poultry industry making the focus of present-day nutritionist on natural biological ingredients such as probiotics, prebiotics, vitamin and mineral premixes (Linge, 2005; Sirita and Anurag 2017).

2.2 Role of Natural Feed Additives in Improving Broiler Production

Feed additives are important materials that can improve the efficiency of feed utilization and animal performance. Modern animal production requires the use of safe and effective additives to stimulate feed consumption and destroy harmful microorganisms of the diet in addition to being used as gastrointestinal manipulators to increase animal productivity. Attempt to use natural materials such as medicinal plants could be widely accepted as feed additives (Aboul-Fotouh *et al.,* 2000). There are a number of foods or feed components that provide beneficial roles (for growth and health) beyond ordinary nutrition, leading to the development of the concept of natural feed materials. These feed additives also help in protecting the host against infectious diseases (Cencic and Chingwaru, 2010). Natural feed additives may range from isolated nutrients (vitamin, mineral, amino acids, fatty acids, etc.), herbal products (polyphenols, herbs, spices, etc.) to dietary supplements such as probiotics, prebiotics, synbiotics, organic acids, antioxidants, enzyme, etc (Das *et al.*, 2012). Among the factors that may be responsible for gut health and performance in chickens, commensal microbiota in the gut seem to have pivotal roles as they may help to direct the development of gut structure and morphology, modulate the immune responses, offer protection from luminal pathogens as well as aiding digestion and utilization of the nutrients (Rinttila¨ and Apajalahti, 2013).

2.2.1 Prebiotics

Prebiotic is a selectively fermented ingredient that allows specific changes, both in the composition and/or activity in the gastrointestinal microflora that confers benefits upon host well being and health (Gibson *et al.,* 2004). Roberfroid (2007) revisited this concept in human nutrition and concluded that only two dietary non-digestible oligosaccharides, namely inulin and FOS fulfil all the criteria necessary for prebiotic classification among the materials he tested. However, trans-galactooligosaccharides, glucooligosaccharides, glycooligosacchrides, lactulose, lactitol maltooligosaccharides, xylooligosaccharides, stachyose, raffinose, and sucrose thermal oligosaccharides have also been investigated (Gibson *et al*., 2004). For a food or feed ingredient to be classified as a prebiotic it must fulfil the following criteria:

1. Neither be hydrolyzed, nor absorbed in the upper part of the gastrointestinal tract.
2. Must be palatable
3. Be selectively fermented by one or a limited number of potentially beneficial bacteria commensal to the colon, e.g. bifidobacteria and lactobacilli, which are stimulated to grow and or become metabolically activated.
4. Prebiotics must be able to alter the colonic micro flora towards a healthier composition, for example by increasing numbers of saccharolytic species while reducing putrefactive microorganisms (Roberfroid, 2007).

2.2.2 Probiotics

The term "probiotics" comes from the Greek words "pro" (in favour) and "biotic" (life). Thus probiotics are live microorganisms that may beneficially affect the host upon ingestion by improving the balance of the intestinal microflora (Patterson and Burkholder, 2003).

Probiotics display several important ways of action, an antagonistic action towards pathogen bacteria by modification of gut pH, direct antimicrobial effect by secretion of products which inhibit their development, such as bacteriocins, organic acids and hydrogen peroxide, production of short chain fatty acids (SCFA) in the intestine, regulation of the immune system of the host, normalization of gut microbiota, and different metabolic effects (Ferreira *et al.*, 2011). Another mode of action is competitive exclusion which represents colonization ability and adhering competition in the intestinal mucous membranes to prevent adhesion and invasion of pathogens, through inhibition of their colonization and replacement of already adhered ones; competing for available nutrient substances and growth factors (Patterson and Burkholder, 2003; Ana *et al.*, 2015).

2.2.3 Synbiotics

Synbiotics refer to nutritional supplements combining probiotics and prebiotics in a synergistic form. The principal reason for using a synbiotic is the conception that a probiotic, without its prebiotic substrate, does not survive well in the digestive system. Without the necessary source of nutrients for the probiotic, it will have a more important intolerance for oxygen, low pH, and temperature. In the last few years, studies on synbiotics have started to appear, with the main role on applications against diseases (Kolida and Gibson, 2011). As prebiotics furnish better conditions for probiotics to expand, the colonies of these "beneficial" bacteria are maintained. Studies have shown that by using the benefits of prebiotics and probiotics, the number of desirable bacteria in the digestive system increases, and as a result, the positive effects on health status can be observed. Such positive influences of synbiotics are obtained in two ways:

1. By improving the viability of probiotics and

2. By delivering specific health benefits (Bhupinder and Saloni, 2010).

2.2.4 Phytobiotics

Phytogenic feed additives (often called phytobiotics) are commonly defined as plant-derived compounds incorporated into diets to improve the productivity of livestock through amelioration of feed properties, promotion of the animals' production performance, as well as improving the quality of food derived from those animals (Windisch *et al.,* 2008). However some terms are commonly used to classify the vast variety of phytogenic compounds, mainly with respect to origin and processing, such as herbs (flowering, non woody, and non persistent plants), spices (herbs with an intensive smell or taste commonly added to human food), essential oils (volatile lipophilic compounds derived by cold expression or by steam or alcohol distillation), or oleoresins (extracts derived by non aqueous solvents).

2.3 Onion as Feed Additive

Onion is a very tasty and versatile vegetable linked to various health benefits. Onions have a unique combination of three families of compounds that are believed to have salutary effects on human health such as fructans, flavonoids and organosulfur compounds. Fructans are small carbohydrate molecules that help maintain gastrointestinal health by sustaining beneficial bacteria. Similar to garlic, inulin accounts for 10% of the total fibre content of onions, while FOS makes up around 6% (Kumar *et al.*, 2015). FOS strengthens gut flora, helps with fat breakdown and boosts the immune system by increasing nitric oxide production in cells (Kolida *et al.*, 2002; Roberfroid, 2005). Onions are also rich in the flavonoid quercetin, which gives onions antioxidant and anticancer properties. Furthermore,

onions have antibiotic properties and may provide benefits for the cardiovascular system (Kumar e*t al*., 2015; Suleria *et al.*, 2015).

2.4. Effect of Onion on Growth Performance of Broiler Chickens

2.4.0 Effect of Onion on Body Weight Gain of Broiler Chickens

The plant materials, herbal products and spices have been used in animal feed as digestion stimulants and growth promoters (Frankic *et al.*, 2009). Goodarzi *et al.* (2014) reported that although a higher body weight gain was recorded in broiler chickens receiving 30g/kg fresh onion supplementation, it did not differ with the other dietary treatments during the starter phase. However, it differed significantly in the finisher phase. Kim *et al.* (2015) reported that the final body weight and weight gain of the group fed non-medicated control diet were significantly lower than those fed medicated control diet and 0.3% or 0.5% onion extract groups. In another study with onion and garlic (25, 50 and 100mg dissolved powder inclusion levels), Aji *et al.* (2011) reported a significantly higher body weight gain in broilers fed onion and garlic compared to those fed control diet. However, in an experiment conducted to investigate the impact of onion extract on the performance of broilers, no significant difference was observed in broiler chickens fed onion extract (at 1 and 2%), antibiotic and control diets during the starter phase. Moreover, broilers receiving 1% onion extract in drinking water had higher daily weight gain compared to the control group but similar to those receiving 2% onion extract or antibiotic during the finisher period (Goodarzi and Nanekarani, 2014). Body Weight and cumulative feed intake were not affected by quercetin dietary supplementation from hatching to six weeks of age as reported by Goliomytis *et al*. (2014).

However, Yusrizal and Chen (2003) observed that inulin or FOS at 10g/kg of diet improved body weight gain in broiler chickens. Xu *et al.* (2003) also observed improvements in body weight gain when 4g/kg of FOS was added to the basal diet. Moreover, Rebolé *et al*. (2010) reported that the body weight gain of broilers fed diet containing concentration of inulin at 10g/kg was significantly higher than those fed control, enzyme or enzyme plus inulin supplementations but similar to those receiving 20g/kg dietary inulin supplementation during starter and finisher phases. Biggs *et al.* (2007) reported no difference using inulin or FOS at concentrations of 4 and 8g/kg. Rehman *et al.* (2008) also observed no positive effect of including dietary inulin at 10g/kg on growth performance of broiler chickens.

2.4.1 Effect of Onion on Feed Intake of Broiler Chickens

Kim *et al.* (2015) observed no significant difference in feed intake and feed efficiency of broilers fed antibiotic medicated, none medicated, 0.3 and 0.5% onion extract dietary treatments. It was also reported that the average daily feed intake (ADFI) of broilers supplemented with 30g fresh onion/kg was higher ($P<0.05$) compared to the control and birds supplemented with antibiotic (Goodarzi *et al.*, 2014). Aji *et al.* (2011) reported no difference ($P>0.05$) in feed intake of broiler chickens fed dissolved onion powder up to 50mg inclusion level but significantly higher ($P<0.05$) than the control at 100mg inclusion level. ADFI of broilers supplemented with 1% onion extract in drinking water was greater ($P<0.05$) compared to control, but similar to that of other treatments during starter and finisher phases ($P>0.05$) as reported by Goodarzi and Nanekarani (2014).

2.4.2 Effect of Onion on Feed Conversion of Broiler Chickens

Goodarzi *et al.* (2014) reported that broilers fed 10 or 30g fresh onion/kg diet had lower feed conversion ratio (FCR) compared to broilers fed dietary antibiotic during the starter period

(P<0.05) but FCR of broilers did not differ during the finisher period. Feed conversion ratio of broiler chickens fed dissolved garlic and onion powder (at 25, 50 and 100mg inclusion levels) did not differ from their respective control (basal) diets (Aji *et al.*, 2011). In another research with onion extract, Goliomytis *et al*. (2014) reported increasing but no significant FCR values in broilers fed increasing dietary levels of quercetin up to 1g/kg dietary inclusion. In a study conducted to investigate the effect of onion extract in drinking water on performance of broiler chickens, Goodarzi and Nanekarani, (2014) observed a significant difference(P<0.05) in FCR between broilers fed onion extract compared to control group. However, other groups receiving 2% onion extract and antibiotic were not significant (P>0.05). Furthermore, Rebolé *et al*. (2010) conducted a research with three varying levels of inulin and two levels of enzyme supplementations and reported no significant difference in FCR among the treatment (P>0.05) groups.

2.4.3 Effect of Onion on Carcass Characteristics of Broiler Chickens

Aji *et al.* (2011) reported that there was no significant difference in carcass yield of broiler chickens fed onion and garlic (at 25, 50 and 100mg orally) and control (basal diet). Similarly, carcass yield and the relative weights of edible parts were not affected by dietary treatments of antibiotic, control, 0.3 and 0.5% onion extract inclusions (Kim *et al.*, 2015). Moreover, Goodarzi and Nanekarani, (2014) observed that except for abdominal fat, carcass yield and relative organs weight were not significantly affected by dietary treatments of both onion extracts, antibiotic and the control (P<0.05). Yusrizal and Chen (2003) observed a decrease in abdominal fat pad weight of broiler chickens fed inulin at 10g/kg of diet.

2.4.4 Effect of Onion on Haematological Parameters of Broiler Chickens

Haematological indices have been shown to be major indices of physiological, pathological and nutritional status of an organism and changes in the constituent compounds of blood when compared to normal values could be used to interpret the metabolic stage of an animal, as well as the quality of feed the animal consumed (Ologhobo *et al.,* 2008). Jimoh *et al*. (2012) conducted a research on varied dietary levels of garlic powder (0, 0.5, 1, 1.5, 2, and 2.5g/kg) and reported no significant (P>0.05) difference in haematological parameters of broiler chickens. In a similar research, Onyimonyi *et al.* (2012) also reported no significant (P>0.05) differences in haematological parameters of birds fed graded levels (0, 0.25, 0.50 and 0.75g/kg) of garlic powder for a period of eight weeks.

Normal ranges for some blood parameters are shown in Table 2.1

Table 2.1: Hematological Diagnostic Values for Domestic Fowl

Parameters	Units-International Standard	Normal Ranges
PCV	%	30-49
Hb	g/dl	10.2-15.1
WBC	$X10^9/L$	1.9-9.5
RBC	$X10^{12}/L$	2.5-3.9

Source: Jaime (2005).

2.4.5 Effect of Onion on Serum Biochemical Parameters of Broiler Chickens

Kim *et al.* (2015) reported that the levels of serum cholesterol ester and phospholipid of broilers fed diets with onion extract were not affected by dietary treatments. However, the concentrations of serum-free cholesterol and triacylglycerol were significantly decreased in

groups fed diets with onion extract relative to non medicated control groups. Goodarzi *et al.* (2013) observed that broilers fed diets with 3% onion had significantly higher HDL and lower blood triacylglycerol levels than those fed control diets. It has also been reported that administration of onion extract in rabbits significantly reduced serum, liver and aorta triglycerides and serum and liver proteins (Sebastian *et al.*, 1979). Suresh and Srinivasan (1997) also stated that 3% onion powder reduced blood lipids, lipid peroxides and cholesterol. Al-Homidan (2005) observed reduced serum cholesterol ($P<0.05$) in an experiment with onion on broilers. However, Yusrizal and Chen (2003) observed a decrease in serum cholesterol concentration of broiler chickens fed inulin at the level of 10g/kg of diet. Roberfroid (2005) also reported that animals fed a diet supplemented with 10% inulin or oligofructose, tend to have lower triglycerides (36% reduction compared to the control).

2.4.6 Effect of Onion on Nutrient Digestibility of Broiler Chickens

Hernandez *et al.* (2004) reported that plant material supplementation improved apparent digestibility of nutrients. In agreement with this findings, Abo Omar and Kamal (2012) evaluated the effect of feeding graded levels (0, 0.2 and 0.4%) of garlic powder (GP) on performance of broiler chickens showed an improvement ($P<0.05$) in apparent digestibility of DM, CP and EE in GP treatments compared to that in the control diet.

2.4.7 Effect of Onion on Intestinal Microbial Population of Broiler Chickens

Goodarzi *et al.* (2014) reported that *Lactobacilli spp.* population in birds supplemented with onion at the level of 30g/kg were significantly higher, and *E. coli* loads were lower than other groups (control and 10g/kg groups) at six weeks of age. Antimicrobial activity of onion extract against vibrio cholera has also been reported to had reduced the *E. coli* loads (Hannan *et al.*, 2010). Kaplan and Hutkins (2000) screened a selection of twenty-eight lactic

acid bacteria and *bifidobacteria* for their ability to ferment inulin and oligofructose on MRS agar. Twelve of sixteen Lactobacillus strains and seven of eight Bifidobacterium strains tested were able to ferment the substrates. Many *Lactobacilli* and bifidobacteria *species* were able to excrete natural antibiotics, which could have a broad spectrum of activity (e.g., lactocins, helveticins, curvacins, nisin, or bifidocin). For the *Bifidobacteria*, some species were able to exert antimicrobial effects on various Gram-positive and Gram-negative intestinal pathogens including *Salmonellae, Campylobacters, and E. coli* (Gibson and Wang, 1994; Nabizadeh, 2012).

2.4.8 Effect of Onion on Meat Quality Characteristics of Broiler Chickens

The textures of meat, as well as its visual appearance, were the main attributes that attract consumers to purchase quality poultry meats (Yang and Jiang, 2005). Kim *et al.* (2015) reported no significant differences in pH, colour and cooking loss of breast meats in broiler chickens fed dietary onion extract levels (0.3 and 0.5%) compared to the controls (positive and negative). Jang *et al.* (2011) reported that dietary quercetin and methoxylated quercetin extracted from onion did not influence the pH and meat colour in chicken thigh meats after slaughter. In a similar study, Goliomytis *et al.* (2014) reported that dietary supplementation of quercetin did not affect pH, cooking loss, tenderness, and intramuscular fat concentration ($P>0.05$) of broiler chickens.

2.5.0 Impact of Probiotics on Broiler Chickens

2.5.1 Growth Performance

Majority of the probiotic products are based mainly on *Lactobacillus spp* with or without *Bifidobacterium spp*, although other organisms such as *Streptococcus faecium, Bacillus*

subtilis and yeast were also used (Chim-anage *et al.*, 2008). In a study involving the dietary inclusion of five bacteria species of probiotics in broiler diets, Mountzouris *et al.* (2010) reported that probiotics had a significant effect on growth responses, apparent digestibility coefficients and caecal microbial composition of broiler chickens. It has also been reported that supplementation of 0.1 and 0.2% of mixed probiotics (containing *L. acidophilus, B. subtilis* and *Saccharomyces cerevisiae*) significantly improved weight gain and feed conversion ratio of broilers (Kim *et al.,* 2002). According to Ryu *et al.* (2003), supplementation of 0.1 to 0.3% mixed probiotics containing *L. acidophilus, B. subtilis, S. cerevisae* to broiler chicken diets improved weight gain and feed conversion ratio as well as feed intake. Talebi *et al.* (2008) conducted a research to investigate effects of a probiotic Primalac® (*L. acidophilus, L. casei, E. faecium and B. bifidium*) on performance and immune responses to vaccination against Newcastle disease and infectious bursal disease in broiler chickens. They reported a significantly higher increase in body weight gain and lower feed conversion ratio in broilers fed Primalac® compared to vaccinated and unvaccinated groups but similar to vaccinated plus Primalac® group. However, Olnood *et al.* (2015) conducted an experiment to ascertain the effects of feeding probiotics (multiple strains) on growth performance, gut development and microbial population of broiler chickens and documented that there were no significant effects on body weight gain, feed intake and feed conversion ratio when probiotic candidates were added to the feed during both starter and finisher phases of the experiment. Similarly, Biernasiak and Slizewska (2009) observed non-statistical ($P>0.05$) differences in body weight gain, feed intake and feed conversion ratio of broiler chickens fed diets containing mixed strains probiotic, antibiotics and control. In line with these findings, Ergun *et al.* (2000) reported that mixed

strain probiotics Protexin™ (*Streptococcus salivarius spp. Thermophilus, Lactobacillus (L) delbruckii sub spp. bulgaricus, L. acidophilus, L. plantarum, L. rhamnosus, Bifidobacterium bifidum, Enterococcus faecium, Candida pintolopesii, and Asperigillus oryzae*) had no effect (P>0.05) on feed intake and growth performance of broiler chickens. Moreover, Thyagarajan *et al.* (2013) reported insignificant differences in body weight gain, feed efficiency and percent livability of broiler chickens fed experimental diets containing two probiotic cultures (Bio-green A®; *Streptococcus faecalis, Clostridium butyricum, Bacillus mesentricus* and Yucca extract and Bio-green B®; *Streptococcus faecalis, Clostridium butyricum, Bacillus mesentricus*, Yucca extract and *Lactobacillus spp*) and a non probiotic group. In contrast to that, research results from Anjum *et al.* (2005) showed that weight gain, feed conversion ratio and economic efficiency of broiler chicks fed Protexin™ supplemented diets were significantly higher compared to those fed the control diet. However, differences in feed intake among the treatment groups were not significant. Similarly, results of other researchers with probiotics on broiler chickens showed that probiotics significantly improved body weight gain, feed conversion ratio (Ahmad, 2004), bone ash and bone breaking strength (Panda *et al*., 2006).

Khan *et al.* (2011) conducted a research to assess the effect of administering different probiotics (Biovet®, yoghourt and Protexin®) in drinking water on performance, blood biochemistry and immune response of broiler chickens. They found out that supplementation of probiotics significantly increased body weight gain and decreased feed conversion ratio of broilers compared with control in both starter and finisher phases. Mortality rate was also lower for probiotic-supplemented groups. However, body weight gain and feed conversion ratio of birds within probiotic treatments were similar. Moreover,

Yin *et al*. (2014) reported that there were significant differences in final body weight, daily weight gain and feed conversion ratio of broiler chickens fed multi-strain probiotic treatments compared to the control group.

2.5.2 Carcass Characteristics

There were reports that probiotics supplementation in broiler nutrition had positive effects on carcass traits of broiler chickens (Kabir, 2009). Moreover, Kioumarsi *et al.* (2012) conducted a study to investigate the effect of three probiotics (Protexin®, Primalac® and Calciparine®) on carcass and internal organs of broiler chickens. The results showed that there were significant differences in carcass parameters (dress weight, dressing percentage, breast muscle thigh and drumstick) and internal organs (heart, gizzard, liver, abdominal fat and Bursa of Fabricius) of broiler groups fed probiotics compared to the control group. An experiment was also carried out to determine the effects of a probiotic (Protexin®) and an antibiotic (zinc bacitracin), used alone or in combination in broiler rations, on live weight gain, feed consumption, feed efficiency, carcass yield and edible visceral organ weights. The findings showed that supplementation of probiotic, with or without antibiotic, had no significant effect on carcass yield and edible visceral organ weights of broilers (Ergun *et al*., 2000). Moreover, an insignificant difference in meat composition, dressing percentage and empty intestine and gizzard weights was observed among broiler chickens fed diets containing multi-strain probiotic and a control (Anjum *et al.*, 2005). Similar to Anjum *et al.* (2005) report, Khan *et al.* (2011) also documented that meat yield characteristics and organ traits of broilers fed diets containing different probiotics (Biovet®, yoghourt and Protexin®) had non-significant difference compared to the control. However, abdominal fat was significantly reduced by probiotic supplementation. In another study, the relative weights of

the major digestive organs (gizzard, ileum, duodenum and jejunum) and immune organs (liver, pancreas, spleen and Bursa of Fabricius) were not affected by probiotic treatments compared with the controls (Olnood *et al.*, 2015). Biernasiak and Slizewska (2009) also reported that the relative carcass weight, liver, pancreas and abdominal fat, as well as sections of the gastrointestinal tract of broiler chickens, fed control, antibiotic and probiotic (multi-strain) were statistically insignificant.

2.5.3 Haematological Parameters

Probiotics supplementation in broiler nutrition has been reported to have positive effects on haemato-biochemical parameters of broiler chickens (Kabir, 2009). Khan *et al.* (2011) reported that packed cell volume (PCV), white blood cells (WBC), red blood cells (RBC), haemoglobin (Hb) and lymphocytes of broiler chickens fed diets supplemented with probiotics were not significantly different compared to that of the control. However, Kumar *et al.* (2015) have documented that probiotics supplementation (either single or mixed strain) did not have influence on haematological parameters of broiler chickens. Rahman *et al.* (2013) conducted a research to evaluate the effects of probiotics (Microguard®) supplementation on growth performance, haematological and biochemical parameters of broiler chickens. They reported that hemoglobin concentration and packed cell volume were significantly increased in probiotic-treated birds compared to the control. Zhang and Kim (2009) reported that the concentration of red blood cells, white blood cells, and lymphocyte of broiler chickens fed experimental diets containing multi-strain probiotic were statistically similar compared to those fed control and an antibiotic diets.

2.5.3 Serum Biochemical Parameters

Panda *et al*. (2006) conducted a research to find out the effect of supplementing probiotic (*Lactobacillus sporogenes*) on performance and serum biochemical profile of broiler chickens. They reported that probiotics supplementation at 100mg per kg diet significantly lowered total cholesterol, very low-density lipoprotein and triglycerides concentrations in the serum of broiler chickens. However, Kumar *et al.* (2015) stated that probiotics supplementation did not have influence on biochemical parameters (total protein, albumin, globulin and glucose levels) of broiler chickens except blood cholesterol level. Khan *et al.* (2011) also reported that probiotic inclusion in broiler diet had a significant effect on cholesterol levels of probiotic treated birds compared to the control. Moreover, Bostanabad and Salmanzadeh, (2014) reported that there were no significant treatment effects on serum cholesterol, triglyceride, and total protein concentration of geese fed diets containing mixed strains of probiotic (Protexin®) compared to the control. Rahman *et al.* (2013) reported that serum alanine aminotransferase (AST) and aspartate aminotransferase (ALT) levels of broiler chickens fed diets containing probiotics were significantly lower compared to the control but similar to those fed enzyme or combination of both (enzyme and probiotic). Fatima *et al.* (2013) conducted a study to determine the efficacy of comparing probiotic (Protexin®) and antibiotic on growth performance, immunological and biochemical parameters in *Salmonella enteritidis* challenged broiler chicks and reported that AST and lactate dehydrogenase (LDH) enzymes activities increases at both first and second week post challenge with *S. enteritidis* compared with probiotic, antibiotics and negative control groups. However, ALP enzyme activity and blood glucose level were insignificantly different. Total protein and globulin (G) were significantly lower in both probiotic and

negative control groups either at first or second week compared to the positive group. Meanwhile, albumin (A) and A/G ratio were insignificant among all the treatment groups. Ashayerizadeh *et al.* (2009) reported that there were no significant differences in total protein, albumin, globulin, low-density lipoprotein(LDL), high-density lipoprotein (HDL) and glucose levels of broiler chickens fed diets containing probiotic (Primalac®), prebiotic (Biolex-MB), antibiotic (flavomycin), symbiotic (Primalac® + Biolex-MB) and a control. However, triglycerides and cholesterol were significantly lower in probiotic-treated group compared to control and antibiotic but similar with prebiotic and symbiotic groups.

2.5.4 Nutrient Digestibility

Kumar *et al.* (2015) conducted a study to evaluate the effect of dietary supplementation of combination of probiotics on the performance, immune response and nutrient digestibility of broiler chickens. They reported that probiotics supplemented group showed significantly ($p<0.05$) higher crude protein and dry matter digestibility coefficients than the control group. The coefficients of apparent ileal nutrient digestibility of DM, crude protein, and nitrogen-free extract were not affected by dietary supplementation of multi-strain probiotics (Zhang and Kim, 2009).

2.5.5 Intestinal Microbial Population

Microbial populations in the gastrointestinal tracts of poultry played a key role in normal digestive processes and in maintaining animal health (Falaki *et al*., 2011). Probiotics have been used for improving immunity to infections with *salmonella* (Perdigón *et al*., 1990), *coccidiosis* (Dallout *et al*., 2003) and *Escherichia coli* (Medici *et al*., 2005). Probiotics have also been reported to stimulate production of natural antibodies (Haghighi *et al*., 2006) and to reduce lung damage (Racedo *et al*., 2006). Olnood *et al.* (2015) reported

that there was no significant difference in count of total anaerobic bacteria, LAB, *Lactobacilli, Enterobacteria* and *C. perfringens* in the digesta of the gizzard, ileum and caeca of birds fed diets containing positive control (basal), negative antibiotic control, and probiotic (*L. johnsonii, L. crispatus, L. salivarius* and *Lactobacillus sp*.) treatments, except that the anaerobes and LAB tended to be higher in birds fed probiotics. Meanwhile, the number of *Enterobacteria* in the gizzard varied significantly ($P<0.05$), with *L. salivarius* and *L. johnsonii* giving a lower count than the controls. However, all the isolates significantly ($P<0.05$) reduced *enterobacterial* counts in the ceaca compared with the negative control. Moreover, Zhang and Kim (2009) have reported an increasing ($P<0.05$) *Lactobacillus* and a decreasing ($P< 0.05$) *E. coli* counts in birds fed probiotic (*L. acidophilus, B. subtilis and C. butyricum.*) treatments, compared with those fed positive control. The probiotic-treated groups were similar to the negative (antibiotic) control. Further study also indicated a significant increase of ceacal *Lactobacillus* concentration in broilers supplemented with probiotic treatment group (Falaki *et al*., 2011; Yin *et al*., 2014). Falaki *et al.* (2011) reported no significant difference in total aerobic count in the small intestine of broilers fed on diet with or without probiotic supplementation. However, the coliforms counts in the ileum of broilers fed diets containing probiotic reduced significantly.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The study was conducted at the Poultry Unit of the Skills Acquisition and Entrepreneurship Development Centre, National Agriculture Extension and Research Liaison Services (NAERLS), Ahmadu Bello University, Zaria, located within the Northern Guinea Savannah Zone of Nigeria at latitude 11^0 09' 06" N and longitude 7^0 38' 55" E, at an altitude of 706m above sea level (GPS 2016) . The area has an average annual rainfall of 1100mm, which usually starts late April or early May to mid-October. The peak of the rainy season is between July and August, followed by the Harmattan period of cool and dry weather which lasts from November to February. This is then followed by hot – dry weather from Marh to May. The mean relative humidity during Harmattan period and wet season are 21 and 72%, while mean maximum temperature varies from 26 to 35^{o}C depending on the season (Institute for Agricultural Research Meteorological Unit, 2016).

3.2.1 Source of Experimental Materials

A total of two hundred and forty (240) Ross 308 strain commercial broiler chicks were sourced from a reputable hatchery in Ibadan. Maize, soya bean cake, groundnut cake and other feed ingredients were procured from feed mill at Samaru market while Bactofort® was obtained from a reputable probiotic marketer in Kaduna. Onion (*Allium cepa*) was procured from Makarfi market, it was then sliced, sun dried for 10 days, ground and stored in an airtight plastic container until when it was needed for the experiment. A small portion (10g) of the ground onion sample was weight and analysed in triplicate for proximate compositions (Table 4.1) according to AOAC (2008) method. Bactofort® is a probiotic blend

of a fungal species (*Saccharomyces cerevisiae*) at 5 trillion cells/kg, and three other bacterial species comprising of *Lactobacillus acidophilus* at 77 billion *cfu*/kg, *Enterococcus faecium* at 44 billion *cfu*/kg and *Bacillus subtilis* at 2.2 billion *cfu*/kg of the mixture.

3.2.1 Experimental Diets

Five experimental diets were formulated for both experiments. Diet 1 served as the control while diets 2, 3, 4 and 5 contained 100, 200, 300 and 400g/100kg of dried *Allium cepa* for the first experiment (Table 3.1) while Bactofort® levels of 0, 15, 30, 45 and 60g were incorporated to the best *Allium cepa* level (200g inclusion level) per 100kg diet for experiment one represented as diet 1, 2, 3 4 and 5 respectively in the second experiment (Table 3.2).

3.3 Experimental Design and Management of Birds

Two hundred and forty (240) day old Ross mixed sex broiler chicks were allotted into five different dietary treatments comprising of a control and four levels of *Allium cepa* (100, 200, 300, and 400g/kg) with three replicates of 16 chicks per pen each in a completely randomized design (CRD) in the first experiment. The second experiment also followed the same design with supplementation of 0, 15, 30, 45 and 60g Bactofort® levels to the best *Allium cepa* level (200g/kg diet) obtained from the first experiment using growth performance parameters. Feed and water were given *ad-libitum* to the birds throughout the experimental period. Vaccination against New castle and gumboro diseases and all other medications were also given as prescribed by Veterinary Teaching Hospital Ahmadu Bello University, Zaria for the study area. Each of the experiments lasted for 8 weeks (0 - 4 weeks starter phase and 5 - 8 weeks finisher phase for the first experiment and 0 – 8 weeks for the second experiment).

Table 3.1: Ingredients Composition and Calculated Analysis of Experimental Diets (for Experiment One)

Ingredients (Kg)	Composition (%)	
	Starter (0-4 weeks)	Finisher (5-8 weeks)
Maize	57.70	63.50
Groundnut cake	9.00	14.00
Soya cake	29.00	18.00
Limestone	0.50	0.50
Bone meal	3.00	3.00
Common Salt	0.25	0.25
Premix**	0.25	0.25
Lysine	0.05	0.25
Methionine	0.25	0.25
Total	**100.00**	**100.00**
Calculated Analysis		
ME Kcal/kg	2901	2957
Crude protein %	22.07	20.09
Ether extract%	4.68	4.46
Crude fibre%	4.22	3.73
Calcium%	1.04	1.03
Lysine%	1.17	1.12
Met. + Cys. %	0.91	0.84
Available P%	0.52	0.51

Met = Methionine; P=Phosphorus; ME= Metabolizable Energy; Cys= Cystine **Biomix premix supplied per kg of diet: Vit. A, 10,000 I.U; Vit.D_3, 2000 I.U; Vit E, 23 mg;Vit. K, 2mg: Vit.B_1, 1.8; Vit. B_2, 5.5mg; Niacin, 27.5mg; Pantothenic acid, 7.5mg; Vit. B_{12}, 0.015mg: Folic acid, 0.75mg; Biotin, 0.06mg; Choline chloride, 300mg; Cobalt, 0.2mg; Copper, 3mg; Iodine, 1 mg; Iron, 20 mg; Manganese, 40 mg; Selenium, 0.2 mg; Zinc, 30mg; Antioxidant, 1.25mg. Onion powder was added at 0,100,200,300 and 400g/100kg diet (for treatment 1,2,3,4 and 5 respectively) at both starter and finisher phases. Feed cost/kg was ₦110, ₦110.3, ₦110.6, ₦110.9 and ₦111.2 for treatment 1,2,3,4 and 5 respectively.

Table 3.2: Ingredients Composition and Calculated Analysis of Experimental Diets (for Experiment Two)

Ingredients (Kg)	Composition (%)	
	Starter (0-4 weeks)	Finisher (5-8 weeks)
Maize	56	57
Maize offal	1.7	8
Groundnut cake	9	12.60
Soya cake	29	18
Limestone	0.5	0.5
Bone meal	3	3
Common Salt	0.25	0.30
Premix**	0.25	0.25
Lysine	0.05	0.10
Methionine	0.25	0.25
Total	**100.00**	**100.00**
Calculated Analysis		
ME Kcal/kg	2904	2928
Crude protein %	22.60	20.32
Ether extract%	3.66	3.99
Crude fibre%	3.63	3.78
Calcium%	1.37	1.36
Lysine%	1.15	0.98
Met. + Cys. %	0.87	0.80
Available P%	0.58	0.57

Met = Methionine; P=Phosphorus; ME= Metabolizable Energy; Cys= Cystine **Biomix premix supplied per kg of diet: Vit. A, 10,000iu; Vit.D_3, 2000 iu; Vit E, 23 mg;Vit. K, 2mg: Vit.B_1, 1.8; Vit. B_2, 5.5mg; Niacin, 27.5mg; Pantothenic acid, 7.5mg; Vit. B_{12}, 0.015mg: Folic acid, 0.75mg; Biotin, 0.06mg; Choline chloride, 300mg; Cobalt, 0.2mg; Copper, 3mg; Iodine, 1 mg; Iron, 20 mg; Manganese, 40 mg; Selenium, 0.2 mg; Zinc, 30mg; Antioxidant, 1.25mg; Onion powder,200g/100kg diet. Bactofort® was added at 0,15,30,45 and 60g/100kg diet for treatment 1,2,3,4 and 5 respectively. Feed cost/kg was ₦125.46, ₦125.94, ₦126.43, ₦126.96, and ₦127.38 for treatment 1,2,3,4 and 5 respectively

3.4 Data Collection and Analysis

3.4.1 Measurement of Growth Performance

Feed consumption and body weight of the birds were recorded weekly. Mean initial body weights of the birds were calculated at the onset of the experiment while mean final body weights were also calculated at the end of the experiment. Body weight gain was then calculated as the difference between the final weight and the initial weight using the formula below:

$$\text{Mean body weight gain (g)} = \text{Mean final body weight} - \text{Mean initial body weight.}$$

Feed conversion ratio was also calculated as the ratio between feed intake and body weight gain using the following formula.

$$\text{Feed conversion ratio (FCR)} = \frac{\text{feed intake}}{\text{body weight gain}}$$

3.4.2 Haematological and Serum Biochemical Analysis

At the end of 8th week of the experiment, two blood samples (2 ml each) were collected from the wing vein of one bird per each replicate (making a total of 30 samples). The blood samples were collected in a well-labelled tubes; 15 samples in a non ethylene-diamine tetra-acetic acid (EDTA) containing tubes which were used to determine serum biochemical parameters such as albumin, globulin, urea, creatinine, total cholesterol etc., while the other 15 samples in EDTA tubes which were used to determine the haematological parameters; packed cell volume (PCV), heamoglobin (Hb), red blood cells (RBC), white blood cells (WBC) using Automated Haematological Analyser (cell-Dyn 1700®, Abbott Park, Illinois, U.S.A) in the Teaching Hospital, Faculty of Medicine, Ahmadu Bello University, Shika, Zaria.

3.4.3 Carcass Analysis

At the end of 8th week of the experiment, 3 birds having representative mean weights were selected from each replicate (9 birds per treatment). The birds were fasted overnight, weighed, slaughtered, and eviscerated. Parameters such as live weight, slaughter weight, carcass weight, dressed weight, organ weights and weight of the prime cuts were recorded. Prime cuts and organ weights were expressed as percentages of dressed weight and live weight respectively.

3.4.4 Digestibility trial

A nutrient digestibility trial was carried out at the end of the finisher phase of the experiment; one bird was selected from each replicate pen making a total of three (3) birds per treatment. The birds were housed in individual layer cages with wire bottoms. Trays were placed under each cage for faecal collection. Three days adjustment period was allowed and water was given throughout the experiment. The birds were given a known amount (120g) of feed daily for seven days. Feed consumed was measured by weighing the left over feed daily and subtracting it from amount of feed provided. Faecal output was collected for 7 days then dried and mixed thoroughly. Contaminations such as down feathers were carefully removed. Faecal samples were subsequently dried in an oven at 80°C and the sample was analysed for proximate composition in the Biochemical Laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria using the methods described by Association of Official Analytical Chemist (A.O.A.C, 2008). The percentage apparent digestibility was calculated using the equation below;

$$\text{Apparent Digestibility (\%)} = \frac{\text{Nutrient intake} - \text{Nutrient output}}{\text{nutrient intake}} \times 100$$

Where;

Nutrient intake (g) =Feed intake x Nutrient in diet

Nutrient output (g)=Faecal output x Nutrient in faeces.

3.4.5 Microbial Analysis

At the end of the experiment a homogeneous sample of ileal and ceacal content (from 3 birds/pen) was pooled in a separate sterile flask as representing samples from each pen. Samples were transported to the microbiological laboratory of the Department of Microbiology, Ahmadu Bello University Zaria for microbial analysis. Ten grams (10g) of each representative sample was weighed aseptically using a sterile forceps and transferred into a flask containing 90ml of 0.1% sterile peptone water. The contents were shaken thoroughly to allow dispersion of the organisms. With pre-sterilized pipettes, serial dilutions were done serially to 10^{-3}. From each of 10^{-3} dilution, 0.1ml of the dilution was transferred aseptically to the pre-poured plates of plate count. Each dilution was streaked on plate count agar-PCA for total aerobic bacteria count, MacConkey agar for *E. coli*, Eosin methylene blue agar for *coliform*, and Salmonella-Shigella agar for *Salmonella* respectively, a spreader was used to spread the inocula on the surface of the culture media. All the inoculated plates were inoculated at 35^{o}C for 24hours. Following the incubations, standard plate counting techniques were used for aerobic bacteria, *coliform*, *E. coli* and *salmonella* counts according to the technique prescribed by Yardimci and Kenar (2008). At the end of all colonies count, the results were expressed as colony forming unit per gram (cfu/g) using the formula below:

$$\text{Colony forming units (cfu/g)} = \frac{\text{total number of colonies counted x dilution factor}}{\text{volume of the inocula}}$$

3.4.6 Meat Quality Evaluation

At the end of the first experiment which lasted for eight (8) weeks, three birds were randomly selected from each treatment. They were sacrificed by cutting their jugular veins and allowed to bleed for five minutes. They were eviscerated and an average sample of 250g breast meat was collected from each treatment bird. The samples were boiled for 25minutes in aluminium pots of same sizes containing equal quantity of water using gas cooking stoves at the National Agricultural Extension and Research Liaison Services (NAERLS) canteen's kitchen. The boiled samples were cut into an average size of about 10g on a plate and offered to a test panel. Thirty (30) semi-trained panellists were used in the assessment procedure. They were asked to chew on the boiled meat samples from each treatment (0, 100, 200, 300 and 400g *Allium cepa* addition levels tagged A, B, C, D and E) and score for texture (base on hedonic scale of 1 = very tough, 2= moderately tough, 3= neither soft nor tough, 4 = moderately soft, 5 = very soft), colour, flavour, aroma and general acceptability (on hedonic scale of 1= dislike, 2= dislike moderately, 3= neither like nor dislike, 4= like moderately, 5 = like very much). Bottled water was served to each panellist to rinse their mouth with after each sample chew in order to avoid carry-over effect of flavour amongst the treatment samples.

3.4.6.1 Cooking Loss Evaluation

Raw breast meat sample of about 60g weighed from the various treatments were cut, wrapped in a “Santana” polyethene bag, boiled for about 30 minutes and cooled to room temperature for the determination of meat cooking loss according to the method demonstrated by Kim *et al.* (2015). Cooking loss was measured by calculating the difference in weight of the raw meat before and after boiling.

3.4.6.2 Meat pH and Proximate Composition Determination

A digital pocket-sized pH meter (pHep® with pH measuring capacity of 0.0 - 14.0pH and an accuracy of ±0.1pH) was used to measure the pH of the meat. Raw breast meat sample from each of replicate bird was placed under the glass rod of the pH meter until a constant pH value was achieved. The pH values were recorded for analysis. Another fresh raw breast meat samples (100g from each replicate) were collected and analysed for proximate composition (CP, CF, EE, DM, Ash and NFE) according to the method of A.O.A.C (2008).

3.4.7 Statistical Analysis

Data obtained from the experiments were subjected to the Analysis of Variance (ANOVA) using the General Linear Model procedure of Statistical Analysis System (SAS) (2008). Significant differences among treatment means were compared using Dunnett's Test in the SAS package.

Statistical Model of the Experiment

$Y_{ij} = \mu + T_i + e_{ij}$

Where;

Y_{ij} = Dependent variable

μ = Overall mean

T_i = fixed effect of treatment at varying levels of eubiotic inclusion

e_{ij} = random residual effect

CHAPTER FOUR

4.0 RESULTS

4.1 Experiment One

4.1.1 Proximate composition of onion (*Allium cepa*)

The result of the proximate composition of onion (*Allium cepa*) was presented in Table 4.1. The dry matter, crude protein, crude fibre, ether extract nitrogen free extract and ash had proximate percentage values of 88.58, 16.50, 12.83, 8.68, 55.18 and 6.81% respectively which were obtained from averages of three different determinations.

4.1.2 Growth Performance of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa* during Starter Phase (0 - 4weeks)

Table 4.2 shows growth performance results of broiler chickens fed dietary *Allium cepa* during the starter phase. There were no significant (P>0.05) difference in all the parameters measured which comprised of body weight gain, daily weight gain, total feed intake, daily feed intake and feed conversion ratio (FCR). Moreover, there was insignificant (P>0.05) difference in final body weight of birds amongst the treatment means (0, 100, 200, 300 and 400g *Allium cepa* addition levels) with 200g addition level having the highest value (405.63g) while 300g had the lowest (391.49g). Furthermore, high percentage mortality was recorded among birds on 300g *Allium cepa* treatment level (2%). However, there was no mortality in birds fed diets containing 0, 100, 200 and 400g dietary *Allium cepa* levels.

4.1.3 Growth Performance of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa* during Finisher Phase (5 - 8 weeks)

The result of growth performance of broiler chickens fed dietary *Allium cepa* treatment levels is presented in Table 4.3. The result indicated that birds on *Allium cepa* treatment

Table 4.1: **Proximate Composition of Onion (*Allium cepa*)***

Parameters	**(%)**
Dry Matter	88.58
Crude Protein	16.50
Crude Fibre	12.83
Ether Extract	8.68
Nitrogen Free Extract	55.18
Ash	6.81

*Values were averages of three (3) determinations.

Table 4.2: Effect of *Allium cepa* Addition in the Diet of Broiler Chickens on Growth Performance During Starter Phase (0 - 4wks)

Parameters	Levels of *Allium cepa* Addition (g)					SEM
	0	100	200	300	400	
Initial body weight (g)	39.85	39.83	39.82	39.85	39.85	-
Final body weight (g)	404.91	394.60	405.63	391.49	404.95	8.03
Body weight gain (g)	365.06	354.77	365.82	351.64	365.10	24.89
Daily weight gain (g)	13.03	12.67	13.06	12.55	13.03	1.37
Total Feed Intake(g)	696.14	694.37	699.18	672.77	707.22	23.57
Daily Feed Intake(g)	24.86	24.79	24.97	24.02	25.25	0.84
F C R	1.92	1.96	1.92	1.93	1.95	0.17
Mortality (%)	0	0	0	2	0	-

FCR = Feed Conversion Ratio, SEM**:** Standard error of means.

Table 4.3: Effect of *Allium cepa* Addition in the Diet of Broiler Chickens on Growth Performance During Finisher Phase (5-8wks)

Parameters	Levels of *Allium cepa* Addition (g)					SEM
	0	100	200	300	400	
Initial body weight (g)	676	675.96	675.15	676.29	675.42	-
Final body weight (g)	2121.53^{d}	2189.39^{b}	2223.25^{a}	2191.37^{b}	2137.47^{c}	0.63
Body weight gain (g)	1445.53^{e}	1513.43^{c}	1548.10^{a}	1515.08^{b}	1462.05^{d}	0.46
Daily weight gain (g)	51.62^{e}	54.05^{c}	55.28^{a}	54.11^{b}	52.21^{d}	0.02
Total feed Intake(g)	3126.91	3298.97	3189.60	3342.91	3197.87	122.20
Daily feed Intake(g)	111.67	117.82	113.91	119.38	114.20	4.36
F C R	2.16	2.17	2.06	2.20	2.18	0.08
Cost/kg gain (₦)	237.95	240.43	227.87	244.69	243.22	12.27
Mortality (%)	10	2	2	0	2	-

^{abcde} Means within the same row with different superscript differ significantly (P<0.05), g/d**:** gram per day, FCR = Feed Conversion Ratio, SEM**:** Standard error of means.

groups (100g, 200g, 300g and 400g) had significantly (P<0.05) higher final body weight, body weight gain, and daily weight gain compared to the control. The final body weights were 2121.53, 2189.39, 2223.25, 2191.37 and 2137.47g for 0, 100, 200, 300, and 400g *Allium cepa* addition groups respectively while body weight gain and daily weight gain were 1445.53, 1513.43, 1548.10, 1515.08, 1462.05g and 51.62, 54.05, 55.28, 54.11, 52.21g for birds fed diet containing 0, 100, 200, 300, and 400g *Allium cepa* addition levels respectively. However, there were no significant (P>0.05) differences in initial body weight, total feed intake, daily feed intake, feed conversion ratio (FCR) and cost per kg gain across treatments. Birds fed 300g *Allium cepa* diet had the highest (3342.91g) total feed intake while those in 0g treatment group recorded the lowest (3126.91g). FCR were 2.16, 2.17, 2.06, 2.20, and 2.18 for 0, 100, 200, 300 and 400g *Allium cepa* added levels accordingly while feed cost/kg gain were 237.95, 240.43, 227.87, 244.69 and ₦243.22 for 0, 100, 200, 300 and 400g *Allium cepa* treatments respectively. However, percentage mortality was higher (10%) in birds on treatment receiving 0g *Allium cepa* with 2% each in treatments receiving 100, 200 and 400g *Allium cepa* addition levels. Birds receiving 300g *Allium cepa* addition recorded zero mortality.

4.1.4 Carcass Characteristics of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

Table 4.4 shows carcass characteristics of broiler chickens fed dietary graded levels of *Allium cepa* addition. There were significant (P<0.05) differences in live weight, dressed weight and dressing percentage. The live weight and dressed weight ranged from 2015.33 to 2191.33g and 1348.22 to 1541.11g with birds receiving 200g *Allium cepa* addition level having the highest live weight and dressed weight while those on 100g having the lowest

Table 4.4: Carcass Characteristics of Broiler Chickens Fed Graded Levels of *Allium cepa*

Parameters	Levels of *Allium cepa* Addition (g)					
	0	100	200	300	400	**SEM**
Live weight (g)	2049.78[b]	2015.33[b]	2191.33[a]	2104.56[b]	2120.78[b]	61.43
Dressed weight (g)	1348.22[b]	1444.33[b]	1541.11[a]	1424.67[b]	1440.33[b]	59.01
Dressing percentage (%)	71.13[b]	73.67[b]	75.16[a]	72.80[b]	72.91[b]	1.48
Prime cuts weight (expressed as percentages of dressed weight)						
Drumstick	15.65	14.99	15.68	15.31	15.00	0.35
Breast	27.09[b]	27.38[b]	28.65[b]	27.13[b]	30.21[a]	1.44
Thigh	18.13	18.25	18.57	17.50	18.31	0.54
Back	17.72	17.77	17.06	18.04	18.02	0.75
Organs weight (expressed as percentages of live weight)						
Heart	0.49	0.50	0.52	0.50	0.50	0.03
Gizzard	2.43	2.37	2.13	2.26	2.29	0.21
Liver	2.49	2.18	2.21	2.34	2.17	0.16
Abdominal fat	0.94	0.75	0.60	0.60	0.46	0.34

[ab] Means within the same row with different superscript differ significantly ($P<0.05$), SEM**:** Standard error of means.

live weight and those receiving 0g had the lowest dressed weight. Moreover, dressing percentages across the treatments were 71.13, 73.63, 75.16, 72.80 and 72.91% for 0, 100, 200, 300 and 400g *Allium cepa* addition levels respectively. However, there were no significant (P>0.05) differences in birds organ weights (visceral) across the treatment means. Abdominal fat percentages were 0.94, 0.75, 0.60, 0.60 and 0.46% for 0, 100, 200, 300 and 400g *Allium cepa* dietary levels respectively. Furthermore, prime cut weights such as drumstick and thigh were not significantly (P>0.05) different across all the treatment means and had percentage weight ranges of 14.99 to 15.68% and 17.50 to 18.57% accordingly. However, breast weight differed significantly (P<0.05), in birds receiving 400g *Allium cepa* addition and had higher weight compared to all other treatments (0, 100, 200 and 300g *Allium cepa* addition levels).

4.1.5 Haematological parameters of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

The result for the effect of graded levels of dietary *Allium cepa* addition on haematological characteristics of broiler chickens is presented in Table 4.5. Packed cell volume (PCV) and haemoglobin (Hb) values were 36.73, 37.67, 37.57, 36.87, 34.43% and 11.37, 11.03, 11.67, 11.33, 11.47gdl^{-1}for 0, 100, 200, 300 and 400g *Allium cepa* dietary levels correspondingly. There were no significant (P>0.05) difference in all haematological parameters (PCV, Hb, WBC, RBC) across the dietary treatments (0, 100, 200 and 300g *Allium cepa* addition levels).

Table 4.5: Effect of *Allium cepa* Addition in the Diet of Broiler Chickens on Haematological parameters

Parameters	Levels of *Allium cepa* Addition (g)					SEM	Normal range[£]
	0	100	200	300	400		
PCV (%)	36.73	37.67	37.57	36.87	34.43	6.74	30 – 49
Hb (g dl^{-1})	11.37	11.03	11.67	11.33	11.47	1.74	10– 15.1
RBC ($x\ 10^{12}L^{-1}$)	2.63	2.54	2.66	2.62	2.74	0.43	2.5 – 3.9
WBC ($x\ 10^{9}L^{-1}$)	10.42	9.51	11.68	10.44	11.21	1.35	1.9 – 9.5

PCV**:** Packed Cell Volume, Hb**:** Haemoglobin, RBC**:** Red Blood Cells, WBC**:** White Blood Cells, [£] = Jaime, (2005), SEM**:** Standard error of means.

4.1.6 Serum Biochemical Parameters of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

Table 4.6 shows serum biochemical parameters of broiler chickens fed graded levels of *Allium cepa*. Serum albumin content of broilers receiving 0g *Allium cepa* (control) was significantly ($P<0.05$) lower compared to that of birds receiving 100 and 300g *Allium cepa* dietary levels but similar ($P>0.05$) to that of birds receiving 200 and 400g *Allium cepa* dietary levels. However, there was no significant ($P>0.05$) difference in globulin and total protein among all dietary treatments. The serum creatinine values were 0.31, 0.35, 0.62, 0.39 and 0.40mg dl^{-1} for birds on 0, 100, 200, 300 and 400g *Allium cepa* dietary levels respectively, while uric acid were 2.97, 4.17, 3.20, 3.50 and 4.03mg dl^{-1} for 0, 100, 200, 300 and 400g *Allium cepa* dietary levels respectively. Liver enzymes: aspartate aminotransferase (AST) and alkaline phosphatase (ALP) were significantly ($P<0.05$) different except alanine aminotransferase (ALT) which was not significant ($P>0.05$) across the treatments. Furthermore, there were significant differences in total cholesterol among the treatment means with birds on 300g *Allium cepa* having significantly ($P<0.05$) lowest value (139.34mg dl^{-1}) compared to 0g *Allium cepa* addition level (184.83mg dl^{-1}). However, there were no significant differences in triglycerides, high-density lipoprotein (HDL), low-density lipoprotein (LDL) and glucose across all the treatment groups.

4.1.7 Apparent Nutrient Digestibility by Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

The result of the effect of feeding graded levels of *Allium cepa* on apparent nutrient digestibility of broiler chickens is presented in Table 4.7. Apparent crude protein (CP) digestibility of broilers receiving 200g dietary *Allium cepa* differed significantly ($P<0.05$) from that of birds receiving 300g *Allium cepa* but similar ($P>0.05$) to those of birds

Table 4.6: Serum Biochemical Parameters of Broiler Chickens Fed Grade Levels of *Allium cepa*

Parameters	Levels of *Allium cepa* Addition (g)					SEM
	0	100	200	300	400	
T. Protein (g dl^{-1})	3.87	4.57	4.43	4.77	4.63	0.57
Albumin (g dl^{-1})	0.45^{c}	2.15^{ab}	0.90^{abc}	2.02^{ab}	1.02^{abc}	0.45
Globulin (g dl^{-1})	3.40	2.33	3.53	2.73	3.73	0.56
Uric acid (mg dl^{-1})	2.97	4.17	3.20	3.50	4.03	0.79
Creatinine (mg dl^{-1})	0.31^{b}	0.35^{b}	0.62^{a}	0.39^{ab}	0.40^{ab}	0.08
AST (U L^{-1})	61.67^{c}	85.00^{abc}	64.00^{c}	124.33^{ab}	125.33^{abc}	23.18
ALT (U L^{-1})	56.67	53.33	44.00	41.67	54.33	5.41
ALP (IU L^{-1})	362.00^{c}	408.77^{bc}	522.73^{ab}	604.13^{a}	611.93^{a}	40.21
T. Cho. (mg dl^{-1})	184.83^{b}	155.96^{ab}	153.15^{ab}	139.34^{a}	154.27^{ab}	12.39
Triglyceride(mg dl^{-1})	76.73	83.27	82.60	90.20	72.73	6.86
HDL (mg dl^{-1})	81.67	72.87	70.87	71.13	68.53	4.89
LDL (mg dl^{-1})	70.30	58.03	65.74	56.13	65.13	8.19
Glucose (mg dl^{-1})	127.30	102.20	91.03	94.23	128.23	14.17

^{abcd} Means within the same row with different superscript differ significantly ($P<0.05$), LDL: low density lipoprotein, HDL: high density lipoprotein, AST: aspartate aminotransferase , ALT: alanine aminotransferase, ALP: alkaline phosphatase, T. protein: total protein, T. cho.: total cholesterol, SEM**:** Standard error of means.

Table 4.7: Effect of *Allium cepa* Addition in the Diet of Broiler Chickens on Apparent Nutrient Digestibility

Parameters (%)	Levels of *Allium cepa* Addition (g)					SEM
	0	100	200	300	400	
Dry Matter	76.91	77.82	80.25	77.07	78.02	2.10
Crude Protein	85.66[ab]	85.24[ab]	86.65[a]	83.93[b]	85.76[ab]	1.33
Crude Fibre	82.99[b]	83.80[ab]	87.12[a]	86.29[ab]	85.20[ab]	1.77
Ether Extract	92.50	92.76	93.06	89.99	91.73	0.70
Ash retention	81.45	82.41	84.13	82.17	82.73	1.80
Nitrogen Free Extract	69.82	72.35	74.88	70.77	72.12	2.71

[ab] Means within the same row with different superscript differ significantly ($P<0.05$), SEM**:** Standard error of means.

receiving 0, 100, 300 and 400g *Allium cepa* dietary levels. Moreover, there was a significant ($P<0.05$) difference in apparent crude fibre (CF) digestibility with groups fed 200g *Allium cepa* dietary level having higher means (87.12%) compared to that of the control (82.99%) but similar ($P>0.05$) to that fed 100 (83.80%), 300 (86.29%), and 400g (85.20%) *Allium cepa* dietary levels. However, there were no significant ($P>0.05$) differences in percentage apparent digestibility of dry matter (DM), ether extract (EE), nitrogen free extract (NFE) and percentage ash retention across all the treatments.

4.1.8 Proximate Composition of Meat of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

Table 4.8 shows the results of proximate compositions of the meat of broiler birds fed diets containing graded levels of *Allium cepa* additions. The results revealed no significant ($P>0.05$) difference in percentage ash across all the treatment means. However, there were significant differences ($P<0.05$) in percentage compositions of DM, CP, EE and NFE across all the treatments (0, 100, 200, 300 and 400g *Allium cepa* addition levels). Treatment group receiving 400g dietary *Allium cepa* addition had significantly ($P<0.05$) higher dry matter composition compared to the other treatments groups. The meat of birds receiving 400g *Allium cepa* addition level recorded the highest NFE (36.15%) which was similar to that receiving 300g while that receiving 0g Allium cepa addition had the lowest (33.44%). EE were 6.59, 6.21, 5.79, 5.63 and 5.49% for 0, 100, 200, 300 and 400g *Allium cepa* addition levels respectively.

Table 4.8: Proximate Composition of Meat of Broiler Chickens Fed Graded Levels of *Allium cepa*

Parameters (%)	Levels of *Allium cepa* Addition (g)					SEM
	0	100	200	300	400	
DM	48.62^{c}	50.64^{bc}	51.13^{b}	50.88^{b}	54.59^{a}	1.07
CP	47.16^{ab}	47.22^{ab}	47.87^{a}	46.29^{bc}	45.54^{c}	0.46
CF	0.00	0.00	0.00	0.00	0.00	-
EE	6.59^{c}	6.21^{bc}	5.79^{ab}	5.63^{a}	5.49^{a}	0.26
NFE	33.44^{c}	34.24^{b}	34.30^{b}	35.75^{a}	36.15^{a}	0.27
ASH	12.53	12.24	12.01	12.75	12.75	0.42

^{abc} Means within the same row with different superscript differ significantly (P<0.05), SEM**:** Standard error of means.

4.1.9 Meat Quality Characteristics of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

The result of meat quality characteristics and meat sensory evaluation of broiler chickens fed diets containing graded levels of *Allium cepa* is presented in Table 4.9. The results showed no significant differences in all parameters (texture, colour. Aroma, flavour, pH, cooking loss and general acceptability of the meat) measured across all the treatments as shown on the table.

4.1.10 Ceacum and Ileal Microbial Population of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

Figures 4.1 to 4. 4 shows the results of the ileal and ceacal microbial population of broiler chickens fed graded levels of *Allium cepa.* The results showed a decrease in *E. coli, Salmonella spp.* and *coliform* counts in treatments receiving graded levels of *Allium cepa* (100, 200, 300 and 400g *Allium cepa* dietary levels) compared to the control.

Figure 4.1 showed the results of the ileal and ceacal total aerobic bacterial population of broiler chickens fed graded levels of *Allium cepa*. The total bacterial count of the ileal and ceacal contents were 2.86×10^5, 6.00×10^4,1.8×10^5, 2.13×10^5, 2.80×10^5 and 6.17×10^5, 2.67×10^5, 1.03×10^5, 2.47×10^5, 6.00×10^4 for 0, 100, 200, 300 and 400g *Allium cepa* addition levels respectively. There were higher total aerobic bacterial counts in the control compared to all other treatments.

The results of the ceacal and ileal coliform microbial counts were presented in Figure 4.2. The ileal and ceacal coliform counts were 2.66×10^5, 1.73×10^5,1.8×10^5, 2.00×10^5, 2.46×10^5 and 9.79×10^5, 4.13×10^5, 3.87×10^5, 5.67×10^5, 3.67×10^5 for 0g, 100g, 200g, 300g and 400g *Allium cepa* addition levels respectively. There were reductions in coliform counts as *Allium cepa* increased across the treatments.

Table 4.9: Meat Quality Characteristics of Broiler Chickens Fed Graded Levels of *Allium cepa*

Parameters	Levels of *Allium cepa* Addition (g)					SEM
	0	100	200	300	400	
Texture*	3.47	3.60	3.60	4.1	4.20	0.98
Taste$^{\beta}$	3.73	3.67	3.90	3.60	3.67	0.86
Aroma$^{\beta}$	3.77	4.0	3.77	3.60	3.50	0.85
Colour$^{\beta}$	3.43	3.40	3.30	3.50	3.76	0.92
General acceptability$^{\beta}$	3.70	3.50	3.83	3.67	4.0	0.92
Cooking loss (%)	23.00	23.00	23.00	22.67	22.00	1.71
Raw meat pH	5.75	5.65	5.70	5.70	5.70	0.10

Hedonic scale $^{\beta}$ = (1= dislike very much, 2= dislike moderately, 3= neither like nor dislike, 4= like moderately, 5 = like very much), * = (1 = very tough, 2= moderately tough, 3= neither soft nor tough, 4 = moderately soft, 5 = very soft), SEM**:** Standard error of means.

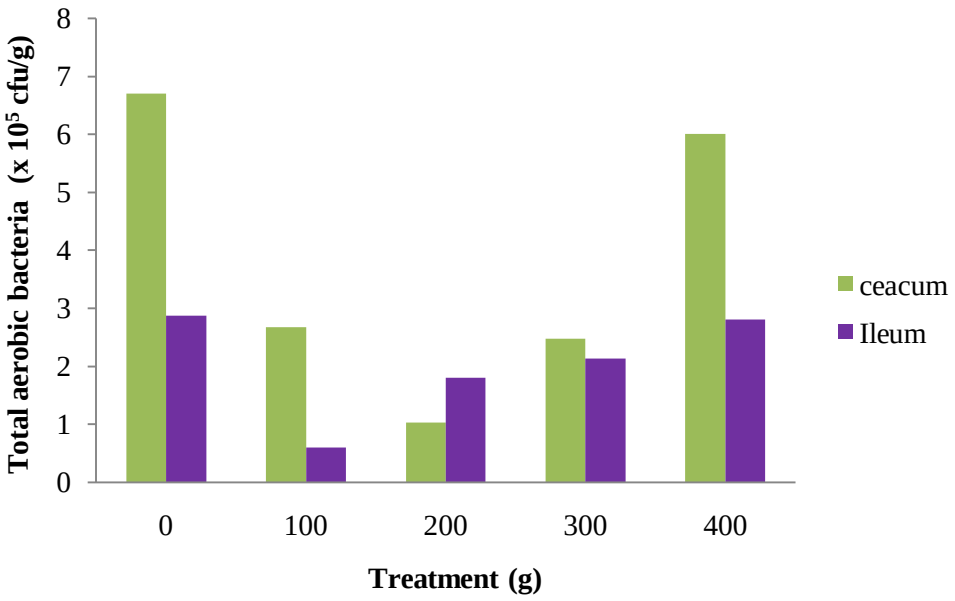


Figure 4.1: Effect of *Allium cepa* Addition in the Diet of Broiler Chickens on Population of Gut Total Aerobic Bacteria

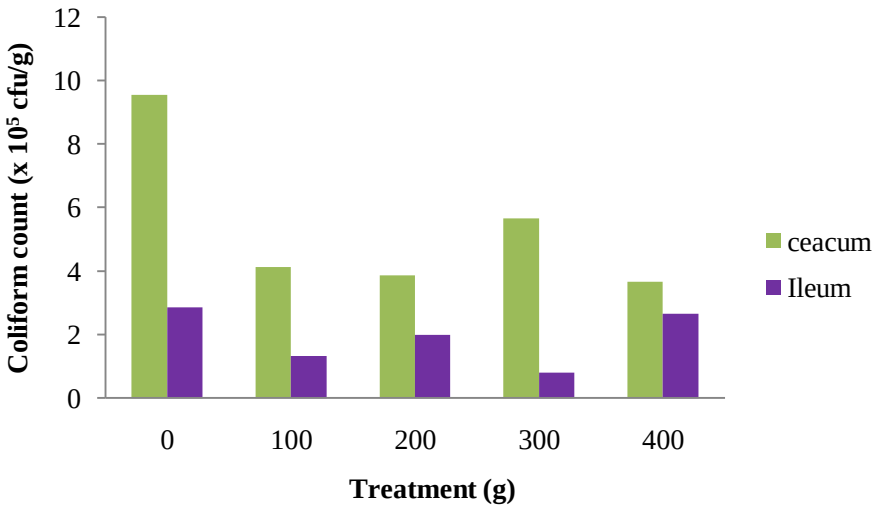


Figure 4.2: Effect of *Allium cepa* Addition in the Diet of Broiler Chickens on the Population of Gut *Coliform* Bacteria

Figure 4.3 showed the results of the ileal and ceacal *Salmonella spp* bacterial population of broiler chickens fed graded levels of *Allium cepa*. *Salmonella spp.* microbial counts of the ileum and ceacum were 2.00×10^4, 0.00×10^4, 0.00×10^4, 0.00×10^4, $0.00\times10^4$and 2.50×10^5, 2.33×10^5, 2.66×10^4, 5.30×10^4, 0.00×10^5 for 0, 100, 200, 300 and 400g *Allium cepa* addition levels accordingly. *Salmonella spp* were not detected in the ileum of birds receiving 100, 200, and 300g *Allium cepa* levels. Furthermore there was a total absence of *Salmonella spp* in the gut of birds receiving 400g *Allium cepa.*

The results of the ceacal and ileal *E. coli* microbial counts were presented in Figure 4.4. The broiler chickens fed on 0, 100, 200, 300 and 400g, *Allium cepa* levels had ileal and ceacal *E. coli* microbial population counts of 2.33×10^5, 1.66×10^5, 6.00×10^4, 0.00×10^4, $0.00\times10^4$and 6.87×10^5, 2.63×10^5, 1.60×10^5, 2.63×10^5, 3.67×10^5 correspondingly. No *E. coli* bacteria were detected at ileum of broiler chickens fed 300 and 400g *Allium cepa*.

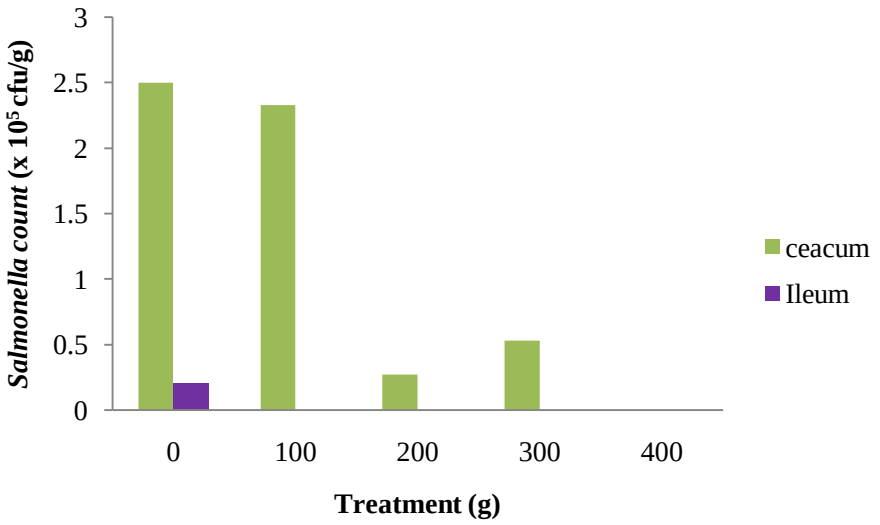


Figure 4.3: Effect of *Allium cepa* Addition in the Diet of Broiler Chickens on the Population of Gut *Salmonella* Bacteria

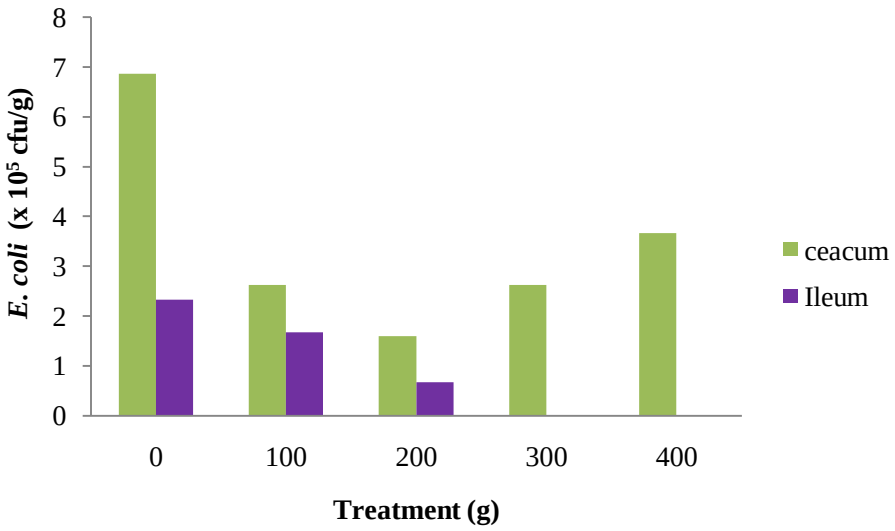


Figure 4.4: Effect of *Allium cepa* Addition in the Diet of Broiler Chickens on the Population of Gut *E. coli* bacteria

4.2 Experiment Two

4.2.1 Growth Performance of Broiler Chickens Fed *Allium cepa* based Diets (200g) Containing Graded Levels of Bactofort® (0 - 8weeks)

Table 4.10 shows the growth performance of broiler chickens fed graded levels of Bactofort® + 200g onion. There were significant differences (P<0.05) in final body weight, body weight gain, daily weight gain, total feed intake, daily feed intake and feed conversion ratio. Treatment groups receiving 45g Bactofort® + 200g onion addition level had highest final body weight (2575.00g) and weight gain (2529.80g) compared to the other treatment groups and birds on 60g Bactofort® + 200g onion treatment group recorded the highest (P<0.05) total feed intake of 4999.40g while those on 0g Bactofort® + 200g onion recorded the lowest (4347.45g). FCR was significantly (P<0.05) lowest in treatment group receiving 45g Bactofort® + 200g onion addition level compared to the rest of the treatment groups. However, treatment groups receiving 0, 15 and 30g Bactofort® + 200g onion addition levels were similar (P>0.05) but significantly different (P<0.05) from those receiving 60g Bactofort® + 200g onion. Moreover, mortality was higher in the treatment group fed 15g Bactofort® + 200g onion compared to the other groups.

4.2.2 Carcass Characteristics of Broiler Chickens Fed *Allium cepa* based Diets (200g) Containing Graded Levels of Bactofort®

The result of the effect of graded levels of Bactofort® + 200g onion addition on carcass characteristics of broiler chickens is presented in table 4.11. The results show significant differences (P<0.05) in live weight, dressed weight and weight of the prime cuts (breast, thigh and drumstick) among the treatment groups. Treatment group fed 45g Bactofort® + 200g onion level had significantly (P<0.05) higher live weight (2454.00g) while those fed

Table 4.10: Effect of Bactofort® + 200g onion Addition in the Diet of Broiler Chickens on Growth Performance (0-8wks)

Parameters	Levels of Bactofort® Addition (g)					SEM
	0	15	30	45	60	
Initial body weight (g)	45.20	45.18	45.20	45.19	45.19	-
Final body weight (g)	1815.46^{d}	1821.04^{d}	1942.50^{c}	2575.00^{a}	2390.42^{b}	43.34
Body weight gain (g)	1770.25^{d}	1775.86^{d}	1897.31^{c}	2529.80^{a}	2345.22^{b}	43.34
Daily gain (g/d)	31.61^{d}	31.71^{d}	33.88^{c}	45.17^{a}	41.87^{b}	0.77
Total Feed Intake(g)	4347.45^{c}	4507.56^{c}	4514.37^{c}	4780.48^{b}	4999.40^{a}	93.21
Daily feed Intake(g/d)	77.63^{c}	80.49^{c}	80.61^{c}	85.36^{b}	89.67^{a}	1.65
F C R	2.45^{c}	2.53^{c}	2.38^{c}	1.89^{a}	2.13^{b}	0.09
Cost/kg gain (₦)	307.37	318.63	300.88	239.84	271.32	-
Mortality (%)	2	4	2	2	2	-

^{abcd} Means within the same row with different superscript differ significantly ($p<0.05$), g/d**:** gram per day, FCR = Feed Conversion Ratio, SEM**:** Standard error of means.

Table 4.11: Carcass Characteristics of Broiler Chickens Fed *Allium cepa* Based Diet (200g) Containing Graded Levels of Bactofort®

	Levels of Bactofort® Addition (g)					
Parameters	0	15	30	45	60	**SEM**
Live weight (g)	1710.00^{d}	1717.33^{d}	1837.33^{c}	2454.00^{a}	2277.67^{b}	46.26
Dressed weight (g)	1180.67^{c}	1205.00^{bc}	1316.33^{b}	1752.67^{a}	1639.67^{a}	59.01
Dressing percentage (%)	74.37	75.07	76.41	76.08	76.46	1.48
Prime cuts weight (express as percentages of dressed weight)						
Drumstick	14.09^{b}	14.50^{b}	15.24^{a}	14.68^{ab}	14.41^{b}	0.35
Breast	24.79^{b}	26.87^{ab}	28.73^{a}	28.98^{a}	28.12^{a}	1.44
Thigh	16.58^{b}	17.34^{ab}	16.67^{b}	17.81^{a}	16.89^{ab}	0.54
Back	22.57	21.97	23.57	25.71	25.30	1.87
Organs weight (express as percentages of live weight)						
Heart	0.58	0.62	0.61	0.58	0.57	0.03
Gizzard	2.71	2.40	2.63	2.36	2.36	0.21
Liver	2.55	2.57	2.45	2.30	2.32	0.16
Abdominal fat	1.56	1.73	1.41	1.40	1.87	0.34

^{abcd} Means within the same row with different superscript differ significantly ($p<0.05$), SEM**:** Standard error of means.

0g Bactofort® + 200g onion level recorded the lowest (1710.00g). Dressed weight was significantly higher in the treatment group fed 45g Bactofort® + 200g onion compared to those fed 0, 15 and 30g Bactofort® + 200g onion but similar to the group fed 60g Bactofort® + 200g onion. There were no significant differences in dressing percentage and percentages of organ weights among the treatment means. However, there were significant differences in percentages of breast, drumstick and thigh weights among the treatment groups. Treatment group fed 45g Bactofort® + 200g onion had significantly ($P<0.05$) higher percentage breast weight (28.89%) compared to the control which recorded the lowest (24.79%) but similar to the other treatment groups.

4.2.3 Haematological Parameters of Broiler Chickens Fed *Allium cepa* based Diets (200g) Containing Graded Levels of Bactofort®

Table 4.12 shows the results of haematological parameters of broiler chickens fed diets containing graded levels of Bactofort® + 200g onion. There were no significant differences in all parameters measured and all measurements were within the normal range except WBC in which all the values were outside the normal range.

4.2.4 Serum Biochemical Parameters of Broiler Chickens Fed *Allium cepa* based Diets (200g) Containing Graded Levels of Bactofort®

The effect of feeding graded levels of Bactofort® + 200g onion on serum biochemical parameters of broiler chickens is presented in Table 4.13. There were significant differences in the following parameters measured: AST, ALT, total cholesterol, HDL and LDL. AST and ALP values were 56.83, 65.06, 80.86, 84.20, 67.13 UL^{-1} and 99.77, 93.07, 93.40, 101.05, 96.37 UL^{-1} respectively. However, the treatment group fed 45g Bactofort® + 200g

Table 4.12: Haematological Characteristics of Broiler Chickens fed *Allium cepa* Based diets (200g) Containing Graded Levels of Bactofort® addition

Parameters	Levels of Bactofort® Addition (g)					SEM	Normal range[£]
	0	15	30	45	60		
PCV (%)	38.26	36.46	35.20	37.96	38.86	1.65	30 – 49
Hb (g dl^{-1})	11.32	11.53	11.30	11.33	11.60	0.48	10– 15.1
RBC ($x\ 10^{12}L^{-1}$)	2.66	2.50	2.46	2.69	2.40	0.16	2.5 – 3.9
WBC ($x\ 10^{9}L^{-1}$)	11.02	10.28	10.39	11.16	11.63	0.58	1.9 – 9.5

PCV**:** Packed Cell Volume, Hb**:** Haemoglobin, RBC**:** Red Blood Cell, WBC**:** White Blood Cell, [£] = Jaime, (2005), SEM**:** Standard error of means.

Table 4.13: Serum Biochemical Parameters of Broiler Chickens Fed *Allium cepa* Based Diets (200g) Containing Graded Levels of Bactofort®

	Levels of Bactofort® Addition (g)					
Parameters	0	15	30	45	60	SEM
T. Protein (g dl^{-1})	6.10	6.13	6.20	6.13	6.05	0.17
Albumin (g dl^{-1})	1.53	1.50	1.56	1.60	1.53	0.08
Globulin (g dl^{-1})	4.76	4.63	4.73	4.53	4.43	0.18
Uric acid (mg dl^{-1})	2.77	2.78	2.30	2.50	2.39	0.90
Creatinine (mg dl^{-1})	0.36	0.42	0.38	0.39	0.40	0.12
AST (U L^{-1})	56.83^{c}	65.06^{bc}	80.86^{a}	84.20^{a}	67.13^{abc}	8.65
ALT (U L^{-1})	5.33^{b}	6.23^{ab}	7.10^{ab}	7.90^{a}	5.43^{b}	0.92
ALP (IU L^{-1})	99.77	93.07	93.40	101.05	96.37	5.66
T. Cho. (mg dl^{-1})	402.86^{b}	367.93^{a}	387.33^{a}	386.46^{a}	401.56^{b}	11.97
Triglyceride(mg dl^{-1})	128.77^{d}	171.57^{c}	256.57^{b}	223.23^{a}	251.23^{b}	8.49
HDL (mg dl^{-1})	109.0^{ab}	113.73^{bc}	118.50^{c}	118.60^{c}	101.23^{a}	4.67
LDL (mg dl^{-1})	263.08^{b}	219.88^{a}	217.52^{a}	223.22^{a}	250.08^{b}	13.54
Glucose (mg dl^{-1})	77.57	91.66	78.03	80.63	81.73	9.32

^{abcd}**:** Means within the same row with different superscript differ significantly ($P<0.05$), LDL: low density lipoprotein, HDL: high density lipoprotein, AST: aspartate aminotransferase , ALT: alanine aminotransferase, ALP: alkaline phosphatase, T. protein: total protein, T. cho.: total cholesterol, SEM**:** Standard error of means.

onion had significantly ($P<0.05$) higher (7.90 UL^{-1}) ALT value compared to those fed 0g(5.33 UL^{-1}) and 60g(5.43 UL^{-1}) Bactofort® + 200g onion but similar to those fed 15g (6.23 UL^{-1}) and 30g (7.10 UL^{-1}) Bactofort® + 200g onion. Triglyceride values were 128.77, 171.57, 256.57, 223.23 and 251.23 mg dl^{-1} while HDL were 109.00, 113.73, 118.50, 118.60 and 101.23 mg dl^{-1}. However, total cholesterol and LDL were significantly lower in treatment groups fed 15, 30, and 45g Bactofort® + 200g onion compared to those fed 0g and 60g Bactofort® addition levels.

4.2.5 Apparent Nutrient Digestibility by Broiler Chickens Fed *Allium cepa* based Diets Containing Graded Levels of Bactofort®

Table 4.14 shows the result of apparent nutrient digestibility of broiler chickens fed *Allium cepa* based diets containing graded levels of Bactofort®. There were significant differences in all digestibility parameters measured. Percentage DM and CP digestibility were 68.89, 61.91, 65.05, 75.50, 73.71% and 77.80, 74.18, 76.02, 80.48, 81.42% for 0, 15, 30, 45 and 60g Bactofort® + 200g onion respectively. Percentage apparent digestibilities of CF were 80.40. 77.17, 74.25, 80.47 and 83.11% while EE were 85.59, 85.58, 87.74, 90.15 and 89.72% for 0, 15, 30, 45 and 60g Bactofort® addition levels accordingly. Furthermore, treatment group fed diet containing 0, 45 and 60g Bactofort® addition level had significantly higher ($P<0.05$) NFE digestibility coefficient compared groups fed 15g and 30g Bactofort® + 200g onion.

4.2.6 Economic Evaluation of Broiler Chickens Fed *Allium cepa* based Diets Containing Graded Levels of Bactofort®

The results of the effect of feeding graded dietary levels of Bactofort® on the economic performance of broiler chickens is presented in Table 4.15. There was an increase in feed

Table 4.14: Effect of Bactofort® + 200g onion Addition in the Diet of Broiler Chickens on Apparent Nutrient Digestibility

	Levels of Bactofort® Addition (g)					
Parameters (%)	0	15	30	45	60	SEM
Dry Matter	68.89^{abc}	61.91^{c}	65.05^{bc}	72.50^{ab}	73.71^{a}	3.87
Crude Protein	77.80^{ab}	74.18^{c}	76.02^{b}	80.48^{ab}	81.42^{a}	2.70
Crude Fibre	80.40^{ab}	77.17^{bc}	74.25^{c}	80.47^{ab}	83.11^{a}	2.08
Ether Extract	86.59^{b}	85.58^{c}	87.74^{ab}	90.15^{a}	89.72^{ab}	1.63
Ash	79.58^{abc}	75.92^{c}	77.02^{bc}	80.84^{ab}	82.99^{a}	2.20
Nitrogen Free Extract	59.45^{ab}	50.07^{b}	53.91^{b}	64.90^{a}	65.83^{a}	5.06

^{abc} Means within the same row with different superscript differ significantly (P<0.05), SEM**:** Standard error of means.

Table 4.15: Effect of Dietary Bactofort® + 200g onion Addition on Economic Parameters of Broiler Chickens

	Levels of Bactofort® Addition (g)				
Parameters/bird	0	15	30	45	60
Feed Cost /kg (₦)	125.46	125.94	126.42	126.90	127.38
Average feed intake (g)	4347.45	4507.56	4514.37	4780.48	4999.40
Average feeding cost (₦)	545.43	567.68	570.71	606.64	636.82
Other Expenses (₦)	364.12	364.12	364.12	364.12	364.12
Total Expenses (₦)	909.55	931.80	934.83	970.76	1000.94
Average final weight (g)	1815.46	1821.04	1942.50	2575.00	2390.42
Cost of chicken/kg (₦)	600	600	600	600	600
Average yield cost (₦)	1089.28	1092.62	1165.50	1545.00	1434.25
Net profit (₦)	179.73	160.82	230.67	574.24	433.31

Net profit = Average yield cost – Total expenses, Average yield cost = cost of chicken/kg *x* average final weight/kg

cost/kg, average feeding cost and total expenses as Bactofort® levels were increased across the treatment groups. Moreover, average yield cost and net profit also increase with increasing levels of Bactofort® + 200g onion. Feed cost/kg and average feeding cost were 125.46, 125.96, 126.42, 126.90, ₦127.38 and 545.43, 567.68, 570.71, 606.64, ₦636.82 correspondingly. Total expenses were 909.55, 931.80, 934.83, 970.76 and ₦1000.74 while average yield costs were 1089.28, 1092.62, 1165.50, 1545.00 and ₦1434.25. However, treatment groups fed diets containing 45g Bactofort® addition level had the highest net profit of ₦574.24 while the lowest (₦179.73) was recorded in treatment group fed 0g Bactofort® addition level.

4.2.7 Ceacal and Ileal Microbial population of Broiler Chickens Fed *Allium cepa* based Diets (200g) Containing Graded Levels of Bactofort® (0 – 8weeks)

Figures 4.5 – 4.8 showed results of the effect of feeding graded levels of Bactofort® on gut microbial loads of broiler chickens. The result showed that treatment groups fed diets containing 45 and 60g Bactofort® + 200g onion addition levels had decreased microbial loads of *coliform, E. coli* and *Salmonella spp.* compared to the other treatment groups.

Figures 4.5 showed the results of the total bacterial count of the ileal and ceacal contents which were 1.38×10^6, 1.70×10^6,1.76×10^6, 1.63×10^6, 1.64×10^6 and 2.24×10^6, 2.13×10^6, 2.01×10^6, 1.46×10^6, 2.46×10^6 for birds fed on 0, 15, 30, 45 and 60g Bactofort® + 200g onion accordingly.

The results of the ileal and ceacal coliform counts were presented in Figure 4.6. The values were 8.0×10^4, 2.76×10^5, 1.56×10^5, 3.30×10^4, 7.33×10^4 and 1.83×10^5, 3.25×10^5, 1.65×10^5, 9.00×10^4, 8.70×10^4 for ileal and ceacal coliform counts of broiler chickens fed on 0, 15, 30,

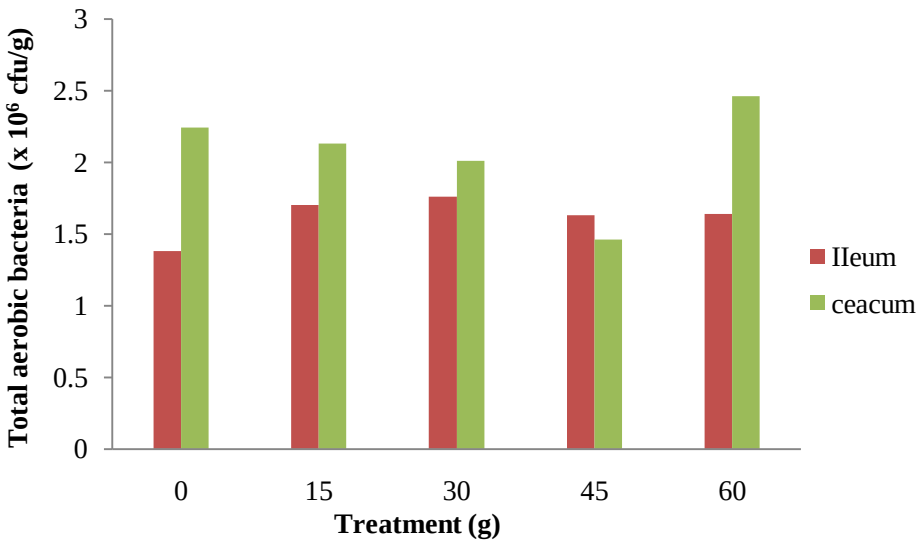


Figure 4.5: Effect of Bactofort® + 200g onion Addition in the Diet of Broiler Chickens on Population of Gut Total Aerobic Bacteria.

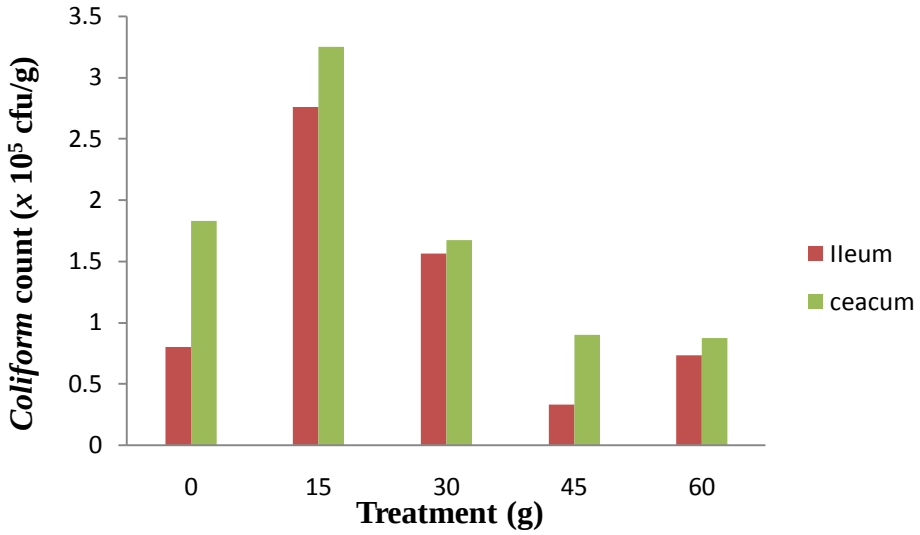


Figure 4.6: Effect of Bactofort® + 200g onion Addition in the Diet of Broiler Chickens on Population of Gut *Coliform* Bacteria

45 and 60g Bactofort® + 200g onion addition levels respectively. Broiler chickens Fed on 45g + 200g onion had lower coliform counts compared to the treatments.

Figures 4.7 showed the results of the *E. coli* bacterial count of the ileal and ceacal contents of broiler chickens Furthermore, *E. coli* microbial counts of the ileum were 1.80×10^5, 2.10×10^5, 3.46×10^4, 1.20×10^5, and 5.00×10^4 while ceacum were 2.06×10^5, 5.73×10^5, 1.33×10^5, 0.00×10^5, and 1.05×10^5 for 0, 15, 30, 45 and 60g Bactofort® + 200g onion levels correspondingly.

The results of the ileal and ceacal *Salmonella* microbial counts were presented in Figure 4.8. Broiler chickens fed on 0, 15, 30 and 60g Bactofort® + 200g onion levels had higher ileal and ceacal *Salmonella* microbial loads compared to those fed on control diet.

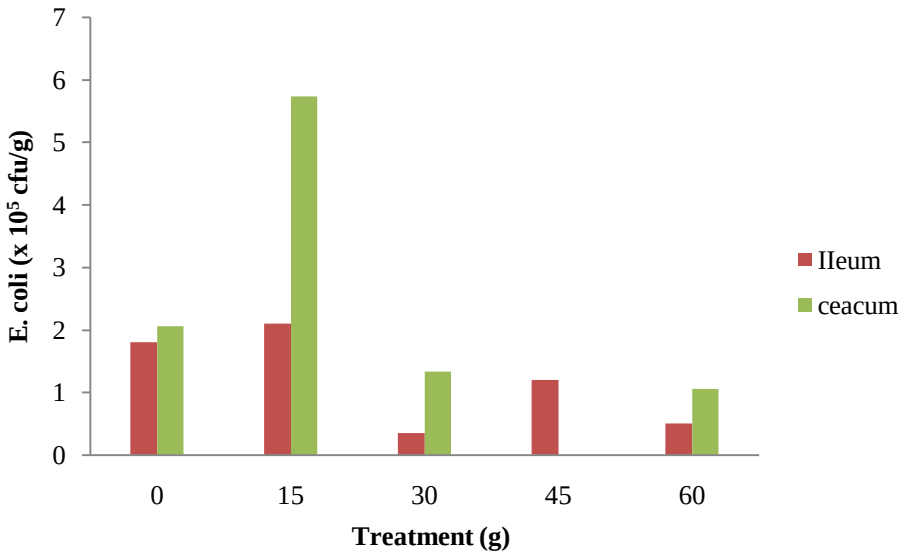


Figure 4.7: Effect of Bactofort® + 200g onion Addition in the Diet of Broiler Chickens on Population of Gut *E. coli* Bacteria

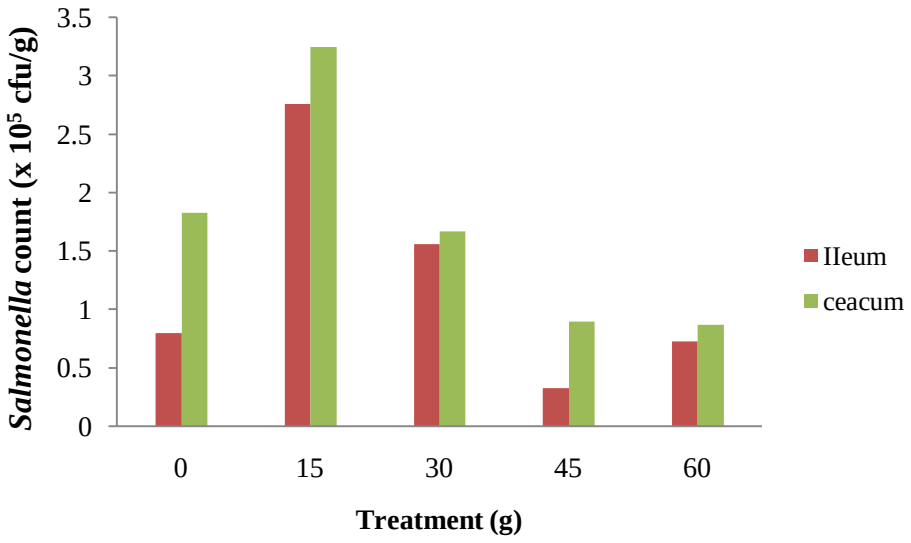


Figure 4.8: Effect of Bactofort® + 200g onion Addition in the Diet of Broiler Chickens on Population of Gut *Salmonella* Bacteria

CHAPTER FIVE

5.0 DISCUSSION

5.1 Experiment One

5.1.0 Proximate composition of onion (*Allium cepa*)

The values of dry matter and nitrogen free extract were lower than those reported by Nwinuka *et al.* (2005), Bello *et al.* (2013) and Lawan and Matazu (2015) (92.59 and 76.71%, 91.22 and 65.16% and 84.48 and 88.84% respectively). However the proximate compositions of crude fibre, crude fibre, ether extract and ash were higher than the values reported those authors except for ether extract which was lower than reported by Bello *et al.* (2013) and ash which was lower than the values of Nwinuka *et al.* (2005). The variations observed the proximate compositions of onion compared to the results of other authors could be attributed certain factors such as the growing condition of the plant, soil management practice, geographical location, varietal difference, method of laboratory analysis, and so forth.

5.1.1 Growth Performance of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa* During Starter Phase (0 - 4weeks)

The insignificant difference observed in this experiment was in agreement with the result obtained by Goodarzi *et al.* (2014) who reported non-significant difference in performance of broiler chickens fed two levels (10 and 30g kg^{-1}) of fresh onion bulbs during starter phase. However, the higher percentage mortality observed in treatment receiving 300g *Allium cepa* addition level compared to other treatments was incidental rather than treatment effects.

5.1.2 Growth Performance of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa* During Finisher Phase (5 - 8weeks)

The higher final body weight, weight gain and daily weight gain in treatments receiving *Allium cepa* compared to the control were in line with the findings of Aji *et al.* (2011) and Goodarzi *et al.* (2014) who reported that broiler chickens fed diet containing onion had better ($P<0.05$) weight gain and daily weight compared to their controls. The improvement in weight observed in this study could be attributed to the influence of certain compounds (such as inulin and FOS) present in the onion. Furthermore, the high percentage mortality recorded in the control group (0g *Allium cepa* addition level) compared to those fed graded levels of *Allium cepa* may be as a result of disease infection. The post-mortem result pointed to Newcastle disease as the possible cause of the mortality.

5.1.3 Carcass Characteristics of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

The trend of higher live weight, dress weight and dressing percentage observed in birds fed 200g dietary *Allium cepa* compared to the other treatments may be related to the higher weight gain and better feed conversion ratio observed in that treatment group compared to rest of the treatment groups during finisher phase which could also be as result of influence of onion addition. Moreover, the insignificant but numerically decreasing abdominal fat percentage observed in this study conformed with the finding of Goodarzi *et al.* (2014) and Kim *et al.* (2015) who reported similar trends in abdominal fat percentages of broiler birds fed fresh onion bulb and onion extract respectively. This could be attributed to the anti-hyperlipidemic properties of onion (Lampe, 1999).

5.1.4 Haematological Parameters of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

Haematological parameters are important pointers to the normal health and nutritional status of animals (Ologhobo *et al.,* 2008). The insignificant differences observed in haematological parameters across all the treatment groups were in agreement with the reports of Onyimonyi *et al.* (2012) and Jimoh *et al*. (2012) who recorded a non significant difference in haematological indices of broiler chickens fed graded levels of *Allium sativum*. However, all haematological indices measured in this study were within the normal ranges of haematological reference values reported by Jaime (2005) for broilers except white blood cells. This may be related immunological response to fight against the Newcastle disease that was said to have infected the birds.

5.1.5 Serum Biochemical Parameters of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

The total cholesterol reduction in treatment groups fed *Allium cepa* addition levels compared to the control group was in line with the findings of Suresh and Srinivasan (1997) and Al-Homidan (2005) who reported that inclusion of onion in diabetic rat diet and broiler diet reduced serum cholesterol compared to the control. However, the cholesterol lowering effect of dietary onion observed in this study may be related to the liver's decrease in cholesterol secretion as stated by Kim *et al.* (2015). Inulin-type fructans were reported to have the tendency of stimulating the liver to synthesize bile acid from cholesterol thereby reducing serum cholesterol levels (Beylot, 2005).

5.1.6 Apparent Nutrient Digestibility by Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

The significant difference recorded in percentage apparent crude fibre digestibility in treatment groups fed graded level of *Allium cepa* over control may be attributed to ceacal fermentation of inulin and FOS content by *Bifidobacterium* and *Lactobacillus spp* which are the host dominant beneficial microbes in the ceacum (Das *et al.*, 2012).

5.1.7 Proximate Composition of Meat of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

The observed percentage reduction of EE in treatments receiving graded levels of *Allium cepa* compared to the control corroborates with the reduction in percentage abdominal fat, serum total cholesterol, LDL and HDL recorded in the study and these could be related to the lipid-lowering activities of compounds (inulin and FOS) contained in the onion.

5.1.8 Meat Quality Characteristics of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

According to Yang and Jiang (2005), physiochemical characteristics such as texture and visual appearance were the vital attributes that attract consumers in sourcing for a good quality meat. The statistical insignificant difference observed across all the treatment groups were in conformity with the findings of Jang *et al.* (2011); Goliomytis *et al*. (2014) and Kim *et al.* (2015) who reported that dietary supplementation of onion extract had no significant ($P>0.05$) effect on pH, colour and cooking loss of breast meat in broiler chickens.

5.1.9 Ceacal and Ileal Microbial Population of Broiler Chickens Fed Diets Containing Graded Levels of *Allium cepa*

The reduction in pathogenic microbial population (*E. coli, Salmonella spp.* and *coliform*) observed in treatments containing graded levels of dietary *Allium cepa* compared to the

control is in line with the findings of Goodarzi *et al.* (2014) who reported that fresh dietary *Allium cepa* inclusion at 30g/kg had significantly reduced *E. coli* counts in broiler chicken gut. However, the reduction in pathogenic microbial load in *Allium cepa* treated diet may be attributed to the influence of inulin and FOS on beneficial microbial populations (Kaplan and Hutkins, 2000; Gibson *et al.*, 2004; Das *et al.*, 2012) through competitive exclusion. This could also add to the better performance and nutrient digestibility showcased by *Allium cepa* treatment groups compared to control group in the experiment.

5.2 Experiment Two

5.2.1 Growth Performance of Broiler Chickens Fed *Allium cepa* based Diets (200g) Containing Graded Levels of Bactofort® (0 - 8weeks)

The significant difference observed in final body weight, weight gain, daily gain and FCR in this study was in contrast with the findings of Ergun *et al*. (2000), Biernasiak and Slizewska (2009) and Olnood *et al.* (2015) who found out that feeding dietary multi-strain probiotics did not have any effect final weight, weight gain and FCR of broiler chickens. However, it agreed with the results of Kim *et al.* (2002), Ryu *et al.* (2003), Anjum *et al.* (2005), Mountzouris *et al.* (2010), Khan *et al.* (2011) and Yin *et al*. (2014) who reported that multi-strain probiotics had effect on final weight, weight gain and FCR of broiler chickens. These could be attributed to the beneficial effect of Bactofort® through either competitive exclusion (Patterson and Burkholder, 2003), secretion of microbial products such as bacteriocins, organic acids and hydrogen peroxide, or production of SCFA in the gut (Ferreira *et al.*, 2011) thereby allowing for optimum nutrient digestion, assimilation and utilization, thus improving birds' performance. Moreover, the higher feed intake observed with increase Bactofort® levels may be attributed to higher palatability of the feed as a result of Bactofort®

addition. The mortality observed may be as a result of Newcastle disease as suggested by the post-mortem result.

5.2.2 Carcass Characteristics of Broiler Chickens Fed *Allium cepa* based Diets (200g) Containing Graded Levels of Bactofort®

The higher final body weight and dressed weight recorded in the treatment receiving 45g Bactofort® addition compared to the other treatments (0g, 15g, 30g and 60g Bactofort® addition levels) may be attributed to the influence of Bactofort® as shown in growth performance which is in line with the reports of Kabir (2009) and Kioumarsi *et al.* (2012) who documented beneficial effect of probiotics on carcass characteristics of broiler chickens. However, the lack differences observed in percentage organ weights (liver, heart, abdominal fat and gizzard) were similar to the findings of Biernasiak and Slizewska (2009) and Olnood *et al.* (2015) who reported that addition of multi-strain probiotics had no effect on internal organ weights of broiler chickens. Moreover, the difference in prime cut weights did not follow a particular trend but treatment groups fed 45g Bactofort® + 200g onion had higher weight values for breast, back and thigh except for drumstick whose weight was highest at 30g addition level.

5.2.3 Haematological Parameters of Broiler Chickens Fed *Allium cepa* based Diets (200g) Containing Graded Levels of Bactofort®

The statistical insignificant difference in haematological parameters recorded in this study concurred with the reports of Kumar *et al.* (2015) who found that probiotic supplementation with either single or mixed strain (Zhang and Kim, 2009) did not have any effect on haematological parameters of broiler chickens. Apart from white blood cells, all parameters were within the normal ranges of blood haematological diagnostic values reported by Jaime

(2005). The slightly higher white blood cell values seen in the study may be as a result of the immune system of the birds fighting the disease (Newcastle) that set in the flock.

5.2.4 Serum Biochemical Parameters of Broiler Chickens Fed *Allium cepa* based Diets (200g) Containing Graded Levels of Bactofort®

The results obtained in this study tallied with the findings of Kumar *et al.* (2015) who reported that probiotics supplementation did not have influence on biochemical parameters (total protein, albumin, globulin and glucose levels) of broiler chickens. In addition, the higher values of AST and ALT were in line with the records of Fatima *et al.* (2013) who reported that multi-strain probiotic (Protexin®) fed to broiler chickens challenged with *Salmonella enteritidis* increased AST values compared to the control. However, the lower values of total cholesterol and low-density lipoprotein observed in treatment groups fed 15, 30 and 45g Bactofort® + 200g onion addition levels compared to the control and 60g addition level was in line with the findings of Khan *et al.* (2011) who reported that probiotic inclusion in broiler diet lowered both total cholesterol and low-density lipoproteins. This could be attributed to the microbial composition of Bactofort® as suggested by Santoso *et al.* (2001) that certain microflora present in the gastrointestinal tract of birds could impair cholesterol and bile acid absorption.

5.2.5 Apparent Nutrient Digestibility by Broiler Chickens Fed *Allium cepa* based Diets (200g) Containing Graded Levels of Bactofort®

The higher percentage of apparent dry matter, crude protein, crude fibre, ether extract and nitrogen-free extract digestibility's observed in the treatment group fed 60g Bactofort® addition level compared to the group fed 15g Bactofort® + 200g onion could be related to the lower pathogenic microbes (*Salmonella spp, E. coli,* and *coliform*) documented in this study. However, this was also in consonance with the mortality observed in the study.

5.2.6 Economic Evaluation of Broiler Chickens Fed *Allium cepa* based Diets (200g) Containing Graded Levels of Bactofort®

The increase in feed cost/kg, average feeding cost and total expenses across the treatment groups could be attributed to the cost of Bactofort® + 200g onion addition which increased with increase in feed intake and addition levels. However, the higher average yield cost and net profit observed in treatment groups fed the diet containing 45g Bactofort® + 200g onion over other treatment groups in this study were in line with the findings of Anjum *et al.* (2005) who showed that economic efficiency of broiler chickens fed diets supplemented with multi-strain probiotic (Protexin™) was higher compared to those fed control diet. This could be attributed to the better feed conversion ratio and nutrient digestibility obtained in this study.

5.2.7 Ceacal and Ileal Microbial Populations of Broiler Chickens Fed *Allium cepa* Based Diets (200g) Containing Graded Levels of Bactofort®

The reduction in microbial loads of *coliform* were in agreement with the results of Falaki *et al.* (2011) who reported that inclusion of probiotics in broiler diets decreased bacterial counts of *coliform*. However, a reduction in *E. coli* bacterial loads in the gut of broiler chickens fed diets containing multi-strains probiotics reported by Zhang and Kim (2009) was in lined with the finding of this study. Furthermore, the reduction of *Salmonella spp* microbial loads observed in groups fed diet containing 45g Bactofort® + 200g onion over other treatment groups in this study were in line with the findings of Perdigón *et al*. (1990) who reported a reduction *Salmonella spp* counts of broilers fed diets containing probiotics. The reduction in microbial loads of *coliform, E. coli* and *Salmonella spp* observed in this study may be related to the ability of probiotic in modulating the gastrointestinal tract of the

birds through competitive exclusion thereby drastically reducing the populations of pathogenic microbes in the gut.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

Profitable broiler production depends on certain important factors amongst which securing optimum digestibility and assimilation of nutrients which is a dictate of gut health (through maintenance well balanced intestinal microbiota) is a focal point. Some natural feed additives such as onion (*Allium cepa*) are known to contain certain compounds (such fructans e.g. inulin and FOS) which are helpful in maintaining gut health.

Two different experiments were conducted to evaluate the effect of adding dietary *Allium cepa* and *Allium cepa* with Bactofort® on performance, carcass characteristics and microbial load of broilers chickens. In the first experiment, onion powder was added at 0 (control), 100, 200, 300 and 400g per 100kg dietary treatments. *Allium cepa* addition did not significantly affect broiler performance during the starter phase, but it did in the finisher phase and also reduced mortality. However, haematological indices were not affected while serum biochemical parameters were also not affected except for total cholesterol, creatinine, albumin, alanine phosphatase and aspartate aminotransferase. Apparent nutrient digestibility of crude fibre also differed significantly from the control. Meat quality parameters such as colour, texture, flavour, aroma, general acceptability, pH, cooking loss were not affected by *Allium cepa* additions but the proximate compositions differed. Microbial loads of *coliform, E. coli and Salmonella spp* were reduced in *Allium cepa* treatments compared to the control. Meanwhile, in the second experiment, a multi-strain probiotic (Bactofort®) was added to the best *Allium cepa* treatment (200g) at 0, 15, 30, 45 and 60g per 100kg dietary treatment levels. Bactofort® + 200g onion addition at 45g/100kg improved the performance of broiler

chickens compared to the rest of the treatment groups (0, 15, 30 and 60g addition levels). Carcass parameters such as live weight, dress weight and percentages of prime cuts were positively affected except for percentages of organ weights. Haematological parameters (PCV, Hb, RBC and WBC) were similar across the dietary treatments while serum biochemical values of total protein, albumin, globulin, creatinine, uric acid, ALP and glucose were also not significant except AST, ALT, total cholesterol, triglycerides, HDL and LDL. Moreover, apparent nutrient digestibility values were significantly different. There was an increase in net profit of birds in the treatment group fed 45g Bactofort® + 200g onion level compared to other treatment groups. They also had lower gut microbial loads of *coliform, E. coli* and *Salmonella spp* compared to the other treatment groups.

6.2 Conclusions

It could be concluded that:

1. Addition of dried *Allium cepa* at 200g/100kg diet improved growth performance, carcass characteristics and nutrient digestibility without any adverse effect on blood indices of broiler chickens
2. Dietary *Allium cepa* did not have any adverse effect on meat quality characteristics but rather reduced blood and carcass lipid contents of broiler chickens
3. Bactofort® addition at 45g/100kg *Allium cepa* based diet (200g) improved growth performance, carcass characteristics, blood indices and reduced gut microbial loads in broiler chickens
4. Addition of Bactofort® at 45g/100kg in *Allium cepa* based diet (200g) increased the net profit per bird by ₦395.51.

6.3 Recommendations

It could be recommended that poultry farmers should add:

1. Dried powdered *Allium cepa* in broiler diet at 200g/100kg to ensure better performance.
2. Dietary Bactofort® at 45g/100kg in *Allium cepa* based diet (200g/100kg) for greater performance and higher net farm returns from broiler enterprise

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