RESPONSE OF BROILER CHICKENS FED DIETS CONTAINING VARIOUS FIBROUS FEEDSTUFFS TREATED WITH *Zymomonas mobilis*

BY

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JULY, 2018

DECLARATION

I hereby declare that this thesis has been written by me and is a record of my own research work. It has not been presented in any previous application for a higher degree of this or any other university. All citations and sources of information are clearly acknowledged by means of references.

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Augustine Adelaja Alade

Date……………………………..

CERTIFICATION

We certify that this thesis titled "Response of Broiler Chickens Fed Diets containing Various Fibrous Feedstuffs Treated with *Zymomonas mobilis*" is the outcome of the research carried out by A. A. Alade in the Livestock Science and Sustainable Environment Programme, World Bank Africa Centre of Excellence for Agricultural Development and Sustainable Environment.

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ABSTRACT

The fibrous nature of agro-industrial by-products (AIBPs) limited their utilization in poultry production. Studies were conducted to evaluate the response of broiler chickens fed diets containing various fibrous feedstuffs treated with *Zymomonas mobilis* (ZT). Pure strains of *Z. mobilis* extracted from fresh palm wine was used to ferment soyabean hull (SBH), cassava sifting (CS), sawdust (SD) and corn cobs (CC). Four experiments were conducted and each study lasted for 56 days. Two hundred and forty (240) day old broiler chicks were randomly allotted to 5 treatments of 3 replicates with 16 birds each in a Completely Randomized Design for each study. Five diets containing untreated and treated SBH, CS, SD, and CC were formulated to replace wheat offal at 0, 50 and 100% at starter and finisher phases. Data on growth response, apparent nutrient digestibility, blood parameters, carcass yield and organ weight of broiler chickens were collected. Data were subjected to one-way Analysis of Variance, significant means were separated by Duncan's Multiple Range Test at ($p<0.05$). The results showed that 100% ZTSBH increased ($p<0.05$) feed conversion ratio and 100% UTSBH increased ($p<0.05$) protein efficiency ratio at the starting phase while 50% UTSBH increased PER at the finishing phase. The 100% UTSBH and 100% ZTSBH significantly increased ($p<0.05$) crude protein, crude fibre digestibility at the finishing phase. Birds fed 50% UTSBH had highest ($p<0.05$) values for Packed cell volume, haemoglobin and red blood cell at the finishing phase. The 100% UTCS increased ($p<0.05$) the FCR at the starter phase. The 100% UTCS and 100% ZTCS had highest ($p<0.05$) values of CF digestibility at both phases. The starting birds on 100% ZTCS had highest ($p<0.05$) values for PCV and Hb but had highest ($p<0.05$) values of white blood cell at the finishing phase. The CS based diets increased ($p<0.05$) dressing percentage, breast, thigh, drumsticks of the birds. Broiler birds on 50% ZTCS had highest ($p<0.05$) gross profit and the rate of return on investment. The treated SD based diets promoted ($p<0.05$) PER and positively influenced ($p<0.05$) the CF and fibre fractions digestibility of the broiler chickens at the finishing stage. Broiler chicks fed SD based diets had increased ($p<0.05$) total protein, cholesterol and creatinine at the finishing stage. Broiler chickens on 100% ZTCC had lowest ($p<0.05$) values of FCR at both phases. The 50% ZTCC improved ($p<0.05$) CF and fibre fractions digestibility at the finishing phase. The finishing birds on 50% UTCC had highest ($p<0.05$) values of PCV, Hb and total protein. The UTCC and ZTCC improved ($p<0.05$) the breast, thigh and drumstick of the broiler chickens. The 100% ZTCC had highest values ($p<0.05$) for liver and kidneys. The 100% ZTCC increased ($p<0.05$) the gross profit, rate of return on investment and economic efficiency. The studies concluded that replacement of wheat offal with 50% UTCS and 50% UTSD, 100% UTCC and 100% ZTSBH, 100% ZTCS, 100% ZTSD and 100% ZTCC in the ration of broiler chicks promoted FCR, PER, PCV, Hb, RBC and carcass traits.

DEDICATION

This research work is dedicated to the Almighty God who made it possible for the completion of the work.

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CHAPTER ONE

1.0 INTRODUCTION

The cost of conventional protein and energy sources like groundnut, fish meal, soya beans, maize, sorghum and wheat for monogastric animal production has been on the increase in some developing countries since the last decade. This was as a result of competition with man over few available cereals, grains and legumes with resultant scarcity and increase in price. It is not economical to use these feedstuffs for poultry production (Opara, 1996, Oduguwa *et al.,* 2004 and Esonu *et al*., 2004). Aside this, feed accounts for 65-75% of all the cost of production of non-ruminant animals (Esonu *et al.*, 2002). The escalating cost of the conventional feedstuffs motivated the nutritionists to search for alternative feedstuffs (Adeniji, 2001). This has led to sourcing of locally available and cheap plant materials to formulate a balanced ration for monogastric animals (Esonu, 2008).

The increased demand for animal protein due to rapid population growth in the developing countries like Nigeria has placed a higher demand on animal protein. The shortage of animal protein among average Nigerians demands a logical solution such as an increase in the production and consumption of poultry products (FAO, 1997). Fasuyi and Aletor (2005) reported that per capita consumption of animal protein had been on the decline for the past decades. This was due to inadequate supply of animal products from livestock industry (Abeke, 2005). Available statistics indicated that Nigeria ranked high amidst countries where the intake of protein is low. It is estimated on the average that Nigerians consumed about 7g of protein per day instead of 28g/head/day recommended by FAO (Uchegbu *et al.*, 2007).

Poultry meat is favoured over beef because of its higher protein and lower caloric content in addition to other favourable meat qualities such as tenderness (Dafwang, 2002). Broiler meat is generally accepted and rapidly consumed by practically every groups in Nigeria (Okon, 1983). In many countries, per capita consumption of poultry meat has expanded directly in proportion to the increase in the availability of poultry meat at an affordable price (FAO, 1966). Agriculturists and nutritionists have generally agreed that developing the poultry industry of Nigeria is the fastest means of bridging the protein-deficiency gap presently prevailing in the country (Amos, 2006). It is also a promising source of additional income and quick returns from investment (Kekocha, 1994). There had been inadequate supply of good quality feeds throughout the year due to seasonal fluctuations in supply of convectional ingredients. This is a major problem preventing optimum performance of poultry birds in the developing countries.

Animal nutritionists are currently focusing on cheap but suitable alternative feedstuffs especially crop residues and industrial by–products, to sustain livestock industry in Nigeria (Alhasan, 1985). The evaluation of these unconventional feed resources besides other strategies would reduce pressure on the demand for conventional feed resources thereby ensuring attainment of feed security for poultry (Fajimi *et* a*l*., 1993). Recent innovations in animal nutrition have led to the use of by-products as animal feed ingredients thus solving the problem of risk to environmental hazards giving rise to cheaper feedstuffs. The incorporation of these by-products in livestock feeds is a form of recycling of biological waste which will reduce pollution in developing countries (Owen and Jayasuriya, 1989). This will consequently lead to reduced cost of poultry products, increased profit for poultry producers and increased availability of cheaper poultry products for consumers (FAO, 2012).

A large quantity of unconventional feedstuffs abounds in Nigeria which is suitable as poultry feed ingredients (Ologhobo, 1992). The lignocellulosic materials (rice hull, sawdust, corn husk, corn cobs, wood-chips, barks, rice-straw, etc.,) are by-products of industries and farms. Efforts are being made by animal scientists to explore the possibilities of utilizing them as alternative feed resources. However, the enrichment of the lignocellulosic materials has become important for the nutrition of the Nigerian livestock industry (Anigbogu, 2011). Corn cobs can be defined as the waste products of maize grain shelling. They littered the surroundings, street, markets and constitute public nuisance. They can block drainage canals and cause flooding (Ndubuisi *et al.*, 2008). The corn cobs carry the grains, husks, shanks and silks which are harvested from the farmlands. Alokan (1998) reported that corn cob is perhaps the most prominent cereal crop by-product in Nigeria. Several million tons of corn cobs that had no immediate use to humans accumulate on farm processing units contributing to land and air pollution as sizeable percentage are burnt to provide space for other useful purposes and ashes used as fertilizer in crop farming (Oladeinde, 2000).

Soyabean hull is a by-product derived from dehulled soyabean seeds before being processed to soya milk or soyabean meal. Soybean hull, due to their high fibre contents, are known to be poorly digested by monogastric animals, but normally well digested by ruminant animals (Chee *et al*., 2005). Esonu (1998) reported that soybean hull has estimated feeding value of 74 – 80% of that of maize when included in moderate to high quality of maize based broiler finishers' diets. However, much has not been done in assessing and establishing its uses as a feed stuff for livestock especially broiler chicken.

Cassava sifting is derived from the processing of cassava flour. This by-product of flour processing industry is not useful to man. It is a waste and even constitute nuisance in waste disposal of these industries (Odunsi, 2017). There is evidence in literature that cassava peels and cassava waste product ensue during the processing of cassava tubers could be utilized to a great extent in the feeding of poultry and pigs (Ewane, 1996).

Sawdusts are small discontinuous particles or small fragments of wood produced during sawing of logs of timber into saleable sizes. Sawdust is a by-product of sawmilling industries which is produced in very large quantities in most developing nations, as a result of ever rising demand for building materials and furniture (El-Ladan and Olofin, 2013). The small fragments flow from the cutting edges of the saw blade to the floor during sawing operation, therefore, they are considered as a nuisance and waste to man and its environment (Olusola and Omojola, 2013). However, researches have identified sawdusts as raw materials for the production of biogas, packaging fillers, as lagging materials (Ogunleye and Awogbemi, 2007; Ogunleye and Awogbemi, 2012).

Agbim and Omaliko (1993) observed that there was a great concern about the accumulation of sawdust, and its attendant environmental hazard. A general attribute of this and other wastes, is the large quantity generated and the high costs of effective disposal, especially if long hauls are undertaken (El-Ladan and Olofin, 2013). For most sawmilling industries, the best and most popular means of disposing sawdust is by open-air burning, although a little percentage is used as fuel, poultry litter and other purposes (Ebhodage, 1993). Studies in the management of sawdust as waste are not new in Nigeria, but most of these studies have had their focus on utilizing the waste as a soil amendment material, with promising results. Ibrahim (2003) attempted a study on exploring the potentials of sawdust as a livestock feed, and reported encouraging results.

Zymomonas mobilis is a bacterium belonging to the genus Zymomonas that is known for its bio-ethanol production efficiency (Seo *et al*., 2005, Gunasekaran and Chandra, 1999), with activities that surpass yeast in some aspects. It is generally found in African palm wine and Mexican pulque. It is a rod-shaped gram-negative bacterium. It is 2-6µm long and 1-1.4µm wide but can vary significantly (Yanase *et al*., 2005; Cazetta *et al*., 2007). Its ability to efficiently ferment carbohydrates using the Entner-Doudoroff pathway makes it an attractive option for life-enzyme for animal feed (Onyejekwe, 2010).

1.1 **Justification**

Agro-industrial by-products (AIBPs) refer to the by-products derived in the industry during the processing of the main products. They are less fibrous, more concentrated, highly nutritious and less costly compared to crop residues (Aguilera, 1989). Therefore, the feeding of AIBPs will help to decrease feeding cost in developing country like Nigeria. The utilization of wheat offal as a major dietary fibre source in most parts of poultry producing areas of Nigeria has escalated its price, thereby necessitating a search for a cheaper and locally available alternative (Lamidi *et al*., 2008).

In the past, agro-industrial by-products such as brewers spent grains, wheat and maize offals and molasses were either being burnt or improperly disposed on land or in the water bodies which resulted in environmental pollution (Onyeonagu and Njoku, 2010). It is necessary to alleviate the negative impact of indiscriminate disposal of these organic materials in the environment by diverting them for livestock feeding, biofertilizer production, bioenergy generation, etc. (Kivaisi *et al*., 2010). Soyabean hulls are poorly being digested by non-ruminant animals due to their high fibre contents (Dourado *et al*., 2011) but, they have potential as alternative feed ingredient for poultry birds (Chee *et al*., 2005). In order to enhance their utilization and other high fibre non-conventional feedstuffs, nutritionists have resorted to using exogenous enzyme supplementation (Esonu *et al*., 2010) to improve the nutritive value of feedstuffs (Adeola and Olukosi, 2009). Corn cob is currently being thrown away after processing of maize. In order to stop this trend, it is better to incorporate this fibrous feedstuff into non-ruminant diets. The militating problem affecting the use of corn cob in chicken diet is the constituent high fibre content which can be improved by fermentation. The utilization of corn cob will reduce the attendant competition between man and animals especially in monogastric animal nutrition (Oke *et al*., 2007). The use of fermentation procedures to improve the nutritive value, utilization of fibrous feeds as well as the generation of high protein had been reported by Cantner (1995) and Rajagopal (1977).

Sawdust is a lignocellulosic material that is burnt away annually in industrial sites resulting in pollution thereby aggravating the existing environmental hazards. Millions of tons of these lignocellulosic materials, which are wasted every year are found around industrial sites such as sugar mills and sawmills (Pidjen and Bender, 1975). However, there is scarce information concerning the utilization of sawdust by chickens (Oke and Oke, 2007), these authors suggested biological and chemical treatment of sawdust in order to improve its digestibility by broiler chickens.

Zymomonas mobilis has hetero-fermentative ability to produce gas from glucose, fructose and sucrose. It has a shorter fermentation time (300 – 400%) than yeast, and higher ethanol yield of 92 – 94% efficiency, high level of ethanol tolerance, non-toxic, locally available and its ability to be genetically and mutationally altered (Jeon *et* al., 2005). The treatment of fibrous feedstuffs with *Zymomonas mobilis* microbes is proposed to breakdown the polysaccharide and lignin contents into simpler carbohydrates, which the poultry birds can utilize for better productivity. Also, the utilization of degraded fibrous feedstuffs for farm animals will reduce the cost of production, encourage production of cheap animal protein for Nigerians, increase foreign reserve and greatly reduce environment hazards/pollution (Anigbogu and Onyejekwe, 2010). Therefore, little information is available on the effect of feeding *Zymomonas mobilis* fermented fibrous feedstuffs on growth reponse of broiler chickens hence this study will be carried out to determine the effects of untreated and treated fibrous feedstuffs on growth performance, apparent nutrient digestibility, haematological and serum metabolites and sensory evaluation of meat of broiler chickens.

1.2 **Broad objective**

To evaluate the response of broiler chickens fed diets containing various fibrous feedstuffs (soyabean hull, cassava sifting, sawdust and corn cobs) treated with *Zymomonas mobilis*.

1.2.1 **Specific objectives**

(i) To assess the growth response of broiler chickens fed diets containing various fibrous feedstuffs treated with *Zymomonas mobilis*.

(ii) To determine the apparent nutrient digestibility of broiler chickens fed diets containing various fibrous feedstuffs treated with *Zymomonas mobilis*.

(iii) To determine the haematological and serum chemistry of broiler chickens fed diets containing various fibrous feedstuffs treated with *Zymomonas mobilis*.

(iv) To determine the carcass yields and relative organ weight of broiler chickens fed diets containing various fibrous feedstuffs treated with *Zymomonas mobilis*.

(v) To determine the viscosity of ileal digesta of broiler chickens fed diets containing various fibrous feedstuffs treated with *Zymomonas mobilis*.

(vi) To determine the sensory evaluation of meat obtained from broiler chickens fed diets containing various fibrous feedstuffs treated with *Zymomonas mobilis*.

(vii) To evaluate the economy of feed conversion of feeding the experimental diets to broiler chickens.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition and Classification of Fibre

Mc Donald *et al*. (2002) refer to fibre as cell walls of plant tissue that mostly consist of lignin, cellulose as well as hemicelluloses. It is also the composition of plant cell that is resistant against enzymes in the small intestine. In chemical viewpoint, fibre is illustrated as non-starch polysaccharides. Non-Starch Polysaccharides (NSP) covers a large variety of polysaccharide molecules excluding alpha-glucans (starch). The classification of NSP was based on the methodology that was utilized for extraction and isolation of polysaccharides. The residue remaining after a series of alkaline extractions of cell wall materials was called cellulose and the fraction of this residue solubilised by alkali was called hemicelluloses (Choct, 1997).

The composition of crude fibre differs in different plants in the plant taxa (Varastegani and Dahlan, 2014). Neutral Detergent Fibre (NDF) refers to the insoluble portion of the Non-Starch Polysaccharide plus lignin, and Acid Detergent Fibre (ADF) refers to a portion of insoluble NSP comprised largely, but not exclusively, of cellulose and lignin. However, NSP falls into three main groups, namely, cellulose, non-cellulosic polymers and pectic polysaccharides (Bailey, 1973). Polysaccharides are polymers of monosaccharides joined through glycosidic linkages and are defined and classified in terms of the following structural considerations; identity of the monosaccharides, monosaccharide ring forms, positions of the glycosidic linkages, configurations of the glycosidic linkages, sequence of monosaccharide residues in the chain and presence or absence of non-carbohydrate substituents (Choct, 1997). Mc Nab and Boormann (2002) classified non-starch polysaccharides into two types of soluble and insoluble NSP.

Dietary fibre is made of diverse polymers with variability in physiochemical properties that result in differences in ion exchange capacity, viscosity, bulking, and fermentation in the gastrointestinal tract when included in the diet. Although, it may not be easy to measure dietary fibre but the physiological effects of fibre can be explained by differentiating them into soluble and insoluble components (Mertens, 2003; Newman *et al*. 1992). Insoluble dietary fibre is not degraded by microbial fermentation and could increase faecal output. In poultry intake, excretion and degradation of fibre (NDF, ADF or CF) vary among different species. Ning *et al*. (2003) reported that intake, excretion and degradation of dietary fibre were high for five and seven months old emus compared to turkeys and chickens of a similar age. The authors suggested that the difference could be attributed to the well-developed ceca in the emus as opposed to turkeys and chickens. The results also showed that most fibre degradation was reported to occur in the ceca. Wang *et al*. (2007) reported that NDF and ADF degradation was better in the ceca compared to ileum and rectum portions of the GIT. Degradation of fibre also increases with age in poultry. Emus, turkeys and chickens of seven months degraded NDF and ADF much better than the five month old birds (Ning *et al*., 2003).

2.2 Structure and Composition of Cellulosic Biomass

Cellulose is the most abundant component of plant biomass which is found in nature almost exclusively in plant cell walls but can be produced by some animals such as tunicates and a few bacteria. There was variation in the composition and anatomical structure of cell walls in the plant taxa, they had high cellulose content in the range of approximately 35 – 50% of plant dry weight (Lynd *et al*., 1999). Cellulose fibres are embedded in a matrix of other structural biopolymers, primarily hemicelluloses and lignin, which comprise 20% - 35% and 5% - 30% respectively of plant dry weight (Lynd *et al.*, 1999; Marchessault and Sundararajan,1993; Van Soest,1994).

Although cellulose forms a distinct crystalline structure, cellulose fibres in nature are not purely crystalline. The degree of departure from crystalline is variable and has led to the notion of a "lateral order distribution" of crystallinity, which portrays a population of cellulose fibres in statistical term as a continuum from purely crystalline to purely amorphous, with all degrees of order in between (O'Sullivan,1997).

2.3 **Hemicelluloses and lignin**

Hemicelluloses are branched polymers of xylose, arabinose, galactose, mannose and glucose. These polymers bind bundles of cellulose fibrils to form microfibrils, which enhance the stability of the cell wall. They also cross-link with lignin, creating a complex web of bonds that provide structural strength but also challenge microbial degradation. Lignin is a complex polymer of phenyl propane units, which are cross-linked to each other with a variety of different chemical bonds. Thus complexity has thus far proven to be as resistant to detailed biochemical characterization as it is to microbial degradation (Jacobus, 2001).

2.4 **Nutritional and Biological Effects of Dietary Fibre**

The use of feed ingredients high in dietary fibre in poultry nutrition has generally been discouraged due to the negative effects on nutrient utilization and performance such as decrease in body weight gain and feed conversion. Feeding animals diets high in dietary fibre, especially soluble fibre alters the rate of faecal passage, microbiota, metabolites and efficacy of digestion (Bach Knudsen, 2001). Commensal bacteria in the large intestine utilize fibre as a source of energy. An increase in the energy supply increases microbial metabolism and microbial population growth. Bacteria produce short chain fatty acids such as acetate, butyrate, and propionate during the metabolism causing increased bacterial populations. This results in further production of short chain fatty acids (Walugembe, 2013).

There has been limited inclusion of dietary fibre in poultry diets, particularly chickens, due to its negative effects on nutrient digestion. Villamide and San Juan (1998) reported the true metabolizable energy (TME) of sunflower seed meal with variations in NDF and ADF has a negative correlation with NDF, ADF, CF, hemicelluloses, cellulose and lignin. Soluble fibre is known to increase viscosity in the small intestine (Choct *et al*., 1996), and subsequently inhibits digestion and absorption. The rate of digesta passage is reduced, thereby decreasing feed intake and creates favourable conditions for proliferation of microbes in the intestine (Smiths and Annison, 1996; Choct *et al*., 1996; Langhout, 1998). Large amounts of fermentation were observed in some experiments when chickens were fed diets containing soluble NSP (such as non-starch, non-NDF polysaccharides including peptic substances, β-glucans, fructans and gums (Choct *et al*., 1996; Langout, 1998 and Hall, 2003). Hence, the ability of micro-organisms to ferment dietary fibre is correlated to the amount and type of dietary fibre components in the diet. Diets that are high in insoluble fibre (cellulose, hemicellulose and lignin) contain low energy, birds increase feed consumption to compensate for the reduced nutrient concentration in the feed (Hill and Dansky, 1954). Feed ingredients high in insoluble fibre cause an increase in the bulk of the digesta that eventually leads to fast digesta passage through the GIT, unless the animal has a large digestive system capacity. This effect has been reported to improve digestibility (Krogdahl, 1986; Rogel *et al*., 1987a, b).

Insoluble fibre in monogastric diets has for long been considered as diluents of nutrients (Edwards, 1995). The little or no degradation of insoluble fibre in chickens results in increased bulk of digest in the intestinal tract. This makes its effect on microbial population quite insignificant (Krogdahl, 1986; Choct *et al*., 1996 and Langout, 1998). Some experiments have shown that as long as insoluble fibre is included in poultry diets at moderate concentrations, performance of the birds will not be affected despite the fact that the nutrient concentrations of the diets is reduced (Hetland and Svihus, 2001; Hetland *et al*., 2002). Hughes and Duncan (1972) reported that fibre in the diet of chicken will influence the behaviour of the birds by reducing cannibalism because the birds spent more time in eating than pecking each other.

2.5 **Fibre Requirement of poultry**

The latest researches precisely recommend 3 – 4% crude fibre for poultry for a greater period while 5% crude fibre could be applied for layers. However, poultry-feed manufacturers and poultry producers believe that fibre content must be kept below 7% in poultry feed. Fibre is thought to decline chicken production and growth that is it decreases the effectiveness of feed utilization (Varastegani and Dahlan, 2014).

However, according to a recent survey, the welfare of chicken may be improved due to the fibre in the feed. First, chickens that were fed with lower quantities of fibre suffered from cannibalism more than those that were fed with diets of higher fibre. This may be due to the longer period they need to digest the high-fibre feed because they were given more feed. Secondly, fibre ingredients in laying hens' diet could decrease the emission of ammonia in their manure. In order to provide energy for good-bacteria, fibre in the chickens' digestive tract replaces some of the nitrogen. The increase in bacterial metabolism changes ammonia into ammonium which is less volatile for chickens' health (Varastegani and Dahlan, 2014).

2.6 **Utilization of lignocellulosic materials as livestock feeds**

The lignocellulosic materials (rice hull, sawdust, corn husk, corn cob, wood-chips, barks, rice-straw, etc.) are by-products of industries and farms. They could be used to reduce the gap between feed unavailability and requirement of nutrients in the production of ruminant animals. Efforts are being geared towards exploring the possibilities of their use as alternative feed resources (Anigbogu, 2011). The lignocellulosic materials are abundant and poorly utilized as livestock feed because they are high in tannin and oxalate compounds with indigestible fibres which could result to toxicity, poisoning and poor productivities among the farm stocks. The high levels of anti-nutritional factors interact with protein and minerals to form insoluble complexes. They contain high levels of potential digestible carbohydrates for livestock, but when fed undegraded, they are largely indigestible to ruminants and other herbivores. This is because the structural characteristics of the wastes are composed of lignin, hemicelluloses and cellulose which form a close, physical and chemical complex known as lignocelluloses (Anigbogu, 2011).

2.6.1 **Utilization of soyabean hull in livestock feeds**

The soyabean hull is a good source of carbohydrates but it has some drawbacks. Its use is limited in livestock feeding due to its high fibre contents. Soyabean hull had been reported in literature to contain about 10 - 12% crude protein (CP), 43% crude fibre (CF), 1 - 2% ether extract (EE), and 4 - 5% crude ash (Kornegay, 1978; Mitaru *et al*., 1984). The soyabean hull's amino acid patterns as percentage of total CP were similar to those of soyabean meal (Kornegay, 1981; NRC, 1998). A digestible energy content of the hull, 2,070kcalkg,$^{-1}$ was lower than that of wheat bran, 2,420kcalkg^{-1} (NRC, 1998). However, Soybean hull contains 22.75% crude protein, 18.15% crude fibre, 14.60%, ether extract, 8.00% ash and 20.90% NFE (Esonu *et al*., 1997, Esonu, 1998 and Preston, 1989). In other to enhance its utilization and other high fibre non–conventional feedstuffs, nutritionists have resorted to using exogenous enzyme supplementation, (Annison and Choct., 1991; Scheiderier and Abudabos, 1998;

Acamovic, 2001; Ofongo *et al*. 2008; Aderolu *et al*. 2007). Enzyme activity is basic to digestion of feed components and release of nutrients in the gastrointestinal tract and the main rationale for the use of exogenous enzyme is to improve the nutritive value of feed stuffs (Adeola and Olukosi, 2009). Faulkner *et al*. (1994) evaluated soybean hulls and corn as sources of supplemental creep feed for nursing beef calves. They concluded that a highly digested fiber source such as soybean hulls can successfully replace corn as a creep feed source when economically feasible. Soybean hulls can replace part of the roughage in dairy cow diets, and provided higher energy without causing acidosis that usually occurs with high energy feeds such as maize grain (Blasi *et al*., 2000). Shriver *et al*. (2003) observed that fibre addition (10% soybean hulls) to a low protein diet had little effect on overall nitrogen balance or growth performances, but increased volatile fatty acid concentrations in barrows. They also observed that supplementing soybean hulls to a low protein diet had minor effect on carcass traits. However, the average back fat decreased, and the10th-rib fat depth was numerically reduced by adding the hulls. It has been reported that feeding 10% soybean hulls to fattening gilts or barrows (above 85kg) had positive effects on growth rate, feed conversion ratio, and carcass characteristics (DeCamp *et al*., 2001). Chee *et al*. (2005) reported that the soybean hulls can be included up to 10 and 12% for growing or finishing pig diets, respectively, replacing the wheat bran on a weight basis without any adverse effects on palatability of diets and animal performances. Also, Esonu *et al*. (2005) reported that inclusion of up to 20% soyabean hull improved the feed cost/dozen eggs in laying hens while cellulolytic enzyme supplementation at 30% dietary level of soyabean hull meal in layer diet could not significantly affect the performance of laying hens. Esonu *et al*. (2010) reported that 30% dietary level of soybean hull meal with/without Safzyme® supplementation could be used in laying birds diets without any deleterious effects on birds.

2.6.2 **Utilization of sawdust in livestock diets**

About 147.2 million metric tons of the fibre solids are found in the world (USDA, 1997), the global output of wheat straw residue and rice straw were estimated at 709.2 and 673.3 metric tonnes. In addition, the total global output of non-wood fibres was about 61 metric tonnes (Atchison, 1995). Badejo and Giwa (1985) gave the estimated volume of sawdust in 1981 to be 1.72 million metric tonnes m^3. Owonubi and Badejo (2000) reported that wood wastes increased to 3.87 million metric tonnes m^3 in 1993. Out of these wood waste estimates, sawdust accounts for about 10 – 20%. Since agricultural wastes are available at no or low cost, they can be improved, processed and supplemented to reduce feed insecurity in poultry nutrition. There are two ways of improving the usefulness of high fibrous residues such as sawdust for livestock; a) modification of sawdust biologically, chemically or physically to increase the ability of the rumen microbes to degrade them, b) supplementing them so as to create conducive condition in the rumen to ensure that the fibres are broken down at high rates as possible (El-Ladan and Olofin, 2013). In animal nutrition, sawdust as cellulose is mainly used to furnish bulk, stimulate appetite and to decrease the incidence of abscesses among the farm stocks. Also, Anigbogu *et al*. (2008a) revealed that sawdust, ammoniated sawdust and biodegraded sawdust have been used in animal feeding. Gohl (1981) reported the uses of sawdust in livestock feed is an attempt to solve the problem of disposing the by-product. The major limitation in the use of sawdust as feed (which constitute about 62.10% crude fibre- lignocellulosic plant material) is the crystalline nature of the cellulose and recalcitrance of lignin (Chesson *et al*., 1983).

Efforts to improve the bioconversion of cellulosic material as feed have been made during the last decades, the chemical and physical methods of treatment have improved to some extent the availability of nutrients in feeds, but are not yet acceptable to the farmers (Igba-Shah and Miller, 1983). The recent microbial technology using efficient microorganisms and Innovation Solid-State Fermentation (SSF) technology (Anigbogu *et al*., 2009) may be appropriate for the biological conversion of sawdusts (lignocellulosic waste) to valuable feed, making enzymatic hydrolysis more accessible in the rumen (Lewis *et al*., 1996). Oke and Oke (2007) reported that up to 80 g/kg sawdust from *Daniella ogea* tree can be included in broiler chicken diets without any detrimental effect on their weight gain and reduced cost of production. The authors suggested biological and chemical treatment of this lignocellulose waste in order to improve its digestibility.

2.6.3 **Utilization of corn cobs in livestock feeds**

Corn cob is derived from the post-harvest processing of corn (maize) which account for about 30 – 40% of the weight of the dehusked maize (Adeyemi *et al*., 2008). Corn cobs had been employed in ruminant feeding as feed fillers (Umunna *et al*., 1980; Alokan, 1998), but they are not included as component of commercial non-ruminant animal feed because of its high fibre, lignin and hemicelluloses which will impair digestion and utilization (Adeyemi *et al*., 2008). Corn cobs have high percentage of lignin (45% cellulose, 35% hemicellulose and 15% lignin), low nutritive value and degradation rate (Sun and Cheng, 2002). Therefore, rumen micro flora lack enzymes for degradation of cellulose, hemicellulose and lignin which are embedded within the lignin structures. Thus, the nutritive values of corn cob depend on the availability of nutrients, lignifications and crystallinity of cellulose (Olagunju *et al*., 2013).

Adeyemi *et al*., (2008) reported that rumen filtrate fermented corn cob can replace 50% of dietary maize and can be included in practical rabbit diets at up to 25%. Also, Adedire *et al*. (2012) observed that Rhizopus fermentation improved the performance and utilization of crude fibre, phosphorus, ADF and NDF by rabbits fed corn cob and cowpea husk and it was concluded that corn cob and cowpea husk possessed the potential as fibre sources in rabbit ration. In a trial in Nigeria, pullets fed a diet containing 10% maize cobs reached maturity earlier, but birds fed 20% maize cobs did not come into lay within the time frame of the experiment. Birds fed maize cobs at 15% of the diet had nitrogen retention identical to the control (Longe and Ogedengbe, 1989). In Ghana, diets containing up to 7.5% ground maize cobs fed *ad libitum* to commercial broiler chickens did not alter growth performance, carcass yields, health and biochemical indices (Donkoh *et al*. 2003).

2.7 Production of soyabean flour

Soyabean seeds are processed to produce flour which is used for infant formula and other products. The soyabean hull is the by-product of the flour production. The flow chart of the processing is shown in figure I.

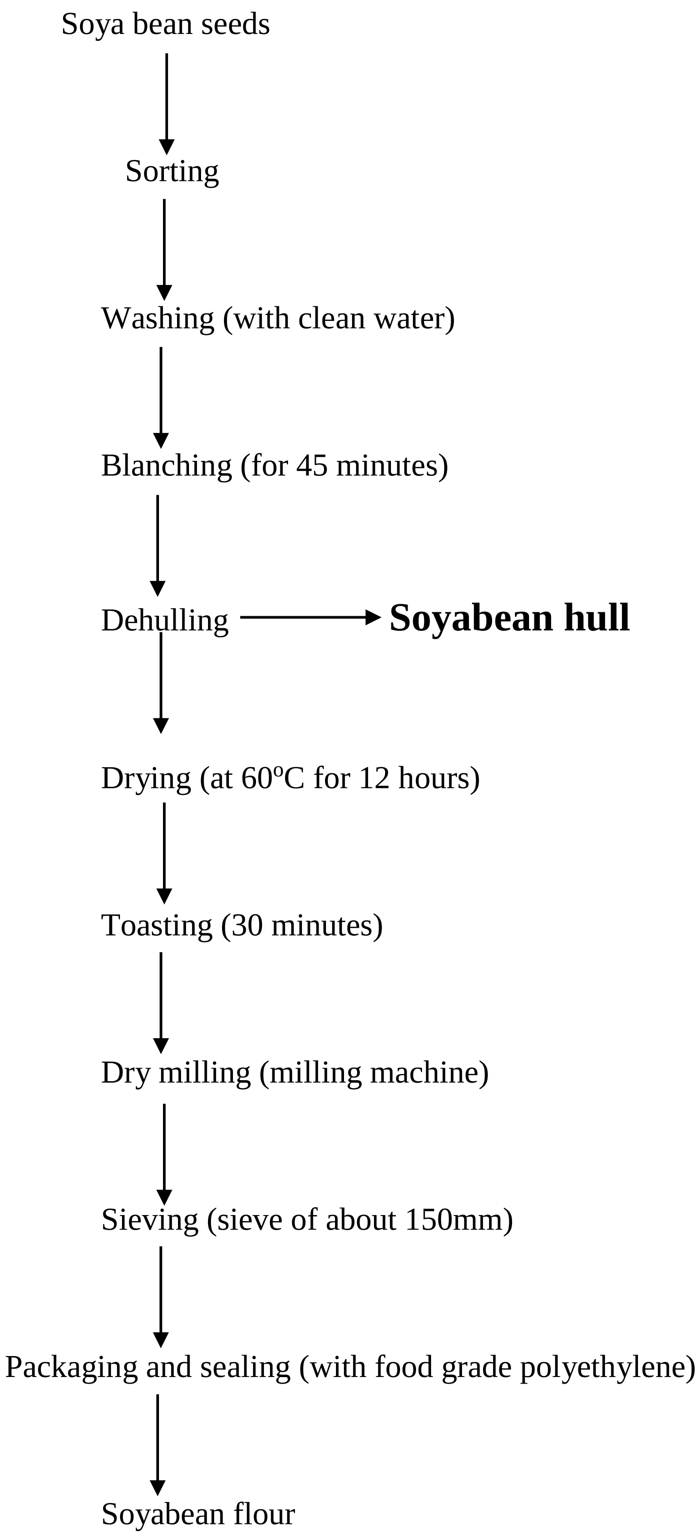

Figure I: Flow chart for the production of Soyabean flour

Source: Opara *et al*. (2012)

2.8 Processing of lumber

The processing of logs into various products result into wood waste. One of the products is sawdust which is a small discontinuous chips or small fragments of wood during sawing of logs of timber into marketable sizes. The flow chart is shown in figure II.

2.9 Processing of maize cobs

Maize shelling is the post-harvest operation which involves the removal of seeds from the cobs. It can be carried out in the field or at the the storage environment. The corn cobs derived from the the shelling of maize seeds can be crushed with hammer mill to produce ground corn cobs. The flow chart for the processing of ground corn cobs is shown in figure III.

2.10 Utilization of cassava in broiler chicken diets

Cassava (*Manihot esculenta* Crantz) can be described as a perennial woody shrub with edible roots, which grows in tropical and subtropical parts of the world. Cassava is an essential crop in developing countries, especially in sub-Saharan Africa, because it thrives well in poor soils with low rainfall, and being a perennial crop it can be harvested as required by the farmers. (Onyenwoke and Simonyan, 2014). There was more than 248 million tons of cassava produced worldwide in 2012 of which Africa accounted for 58% (IITA, 2012). Nigeria produced about 54 million metric tonnes (MT) per annum of cassava tubers (FAO, 2013), she became the highest cassava producer in the world, producing a third more than Brazil and almost double the production capacity of Thailand and Indonesia (Onyenwoke and Simonyan, 2014). Eruvbetine *et al*. (2003) reported that cassava products had been in use for a long time as an energy source to replace cereal grains in livestock feeds. Cassava has been used as an alternative energy source and its inclusion in diets for poultry has been

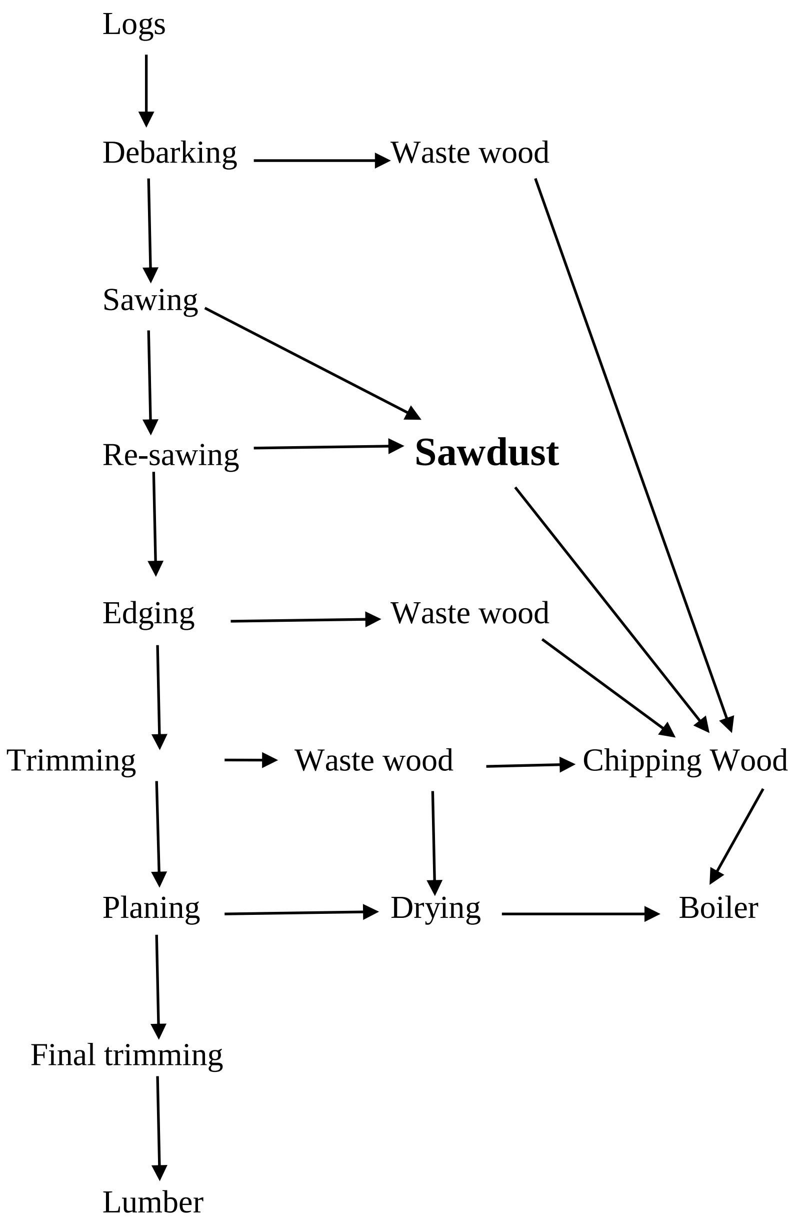

Figure II: Process-flow-diagram for sawmill operation

Source: Gopalakrishnan *et al*. (2012)

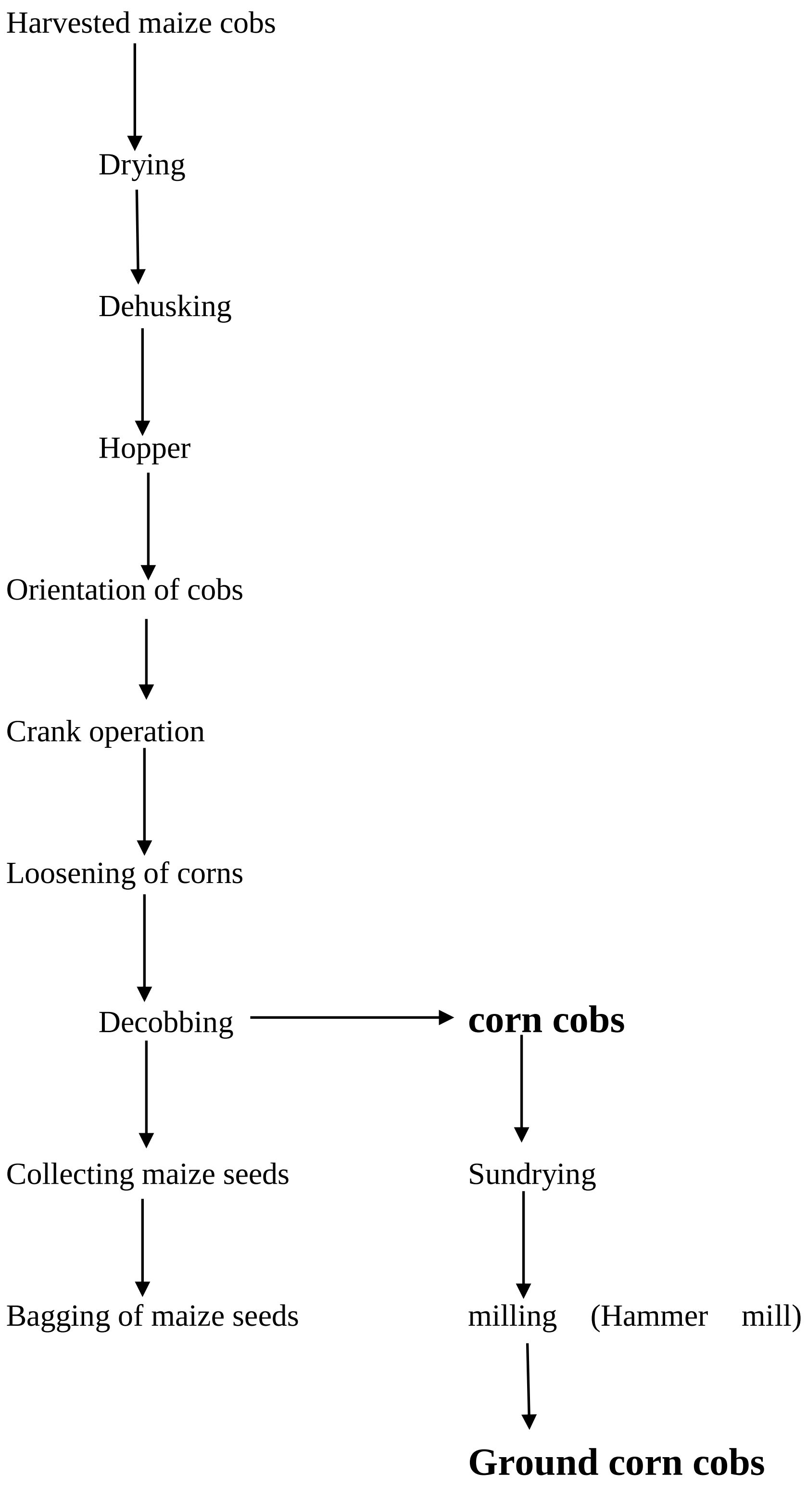

Figure III: Flow chart of maize shelling process and production of ground corn cobs

Source: Re-modified flow chart of maize shelling (Karikatti *et al*. 2015) extensively studied (Tewe and Egbunike 1992, Eruvbetine 1995, Adegbola, 1977). Eruvbetine *et al*. (2003) found that broilers could be successfully fed a substitution of 10% half cassava root and half leaf meal. Abu *et al*. (2015) found that up to 20% inclusion of cassava leaf meal and 20% cassava peelings could be used as a replacement for maize and soybean meal. Body weight reduces significantly when broilers were fed whole cassava. Akinfala *et al*. (2002) observed that replacing maize with either 12.5% or 25% whole cassava plant resulted in reduced growth rate of 13% and 19% respectively in broilers. Additionally, Gomez *et al*. (1983) found that performance of broilers fed 200 g/kg cassava root meal was similar to that of birds fed maize based diets, and Ezeh and Arene (1994) found that cassava root meal could replace up to 75% of dietary maize, resulting in a cost benefit ratio of 1.41:1 against maize. The opposite was however illustrated by Oso *et al*. (2014) in a study in which unpeeled cassava root meal was fed to broilers up to a level of 200 g/kg. It was found that live weight, weight gain, feed intake and crude protein digestibility decreased and serum glucose and cholesterol levels increased as the dietary cassava root meal level increased. Efficiency of nutrient utilisation of cassava can be improved by using microbial enzyme supplements. Midau *et al*. (2011) found that a diet containing 50% cassava peel meal supplemented with a cocktail of enzymes (Maxigrain) resulted in performance values similar to that of a 100% maize diet. Also, Bhuiyan *et al*. (2012) found that presence of carbohydrase and phytase significantly improved live weight and ME energy in birds fed diets containing cassava chips and pellets. The oil content of the cassava based diets may also influence efficiency. Kana *et al*. (2014) found that cost of feed consumed was reduced and bird growth was increased when diets containing cassava flour and fibre were supplemented with palm oil. Additionally, the efficacy of cassava in the bird likely varies with bird age. Mhone *et al*. (2008) observed a live weight of 2 kg and dressed carcass weight of 1.2 kg at week 7 when broilers were fed diets containing 20% cassava from either 2 or 6 weeks of age, but when birds were fed these diets from day old live weight and dressed carcass weight were lower.

2.11 Process of production of high quality cassava flour (HQCF)

The harvested cassava tubers were taken to the factory where processing of HQCF was carried out on the cassava tubers to bagged flour after been sifted. This was carried out within six hours. The processing of cassava to cassava sifting is divided into two main sections which are:

Wet section: Wet processing start from offloading point of cassava; the cassava tubers were deposited in the machine; the machine rolled the cassava to the 1st check point where there was check for foreign objects such as stone, nails etc. The cassava tubers moved to the dry pilling machine where the peel was separated from the tubers, the tubers then moved to root washer tumbling over one another, the root washer washed the dirt from the peeled root tubers, then moved to slicing machine, (where the root was chopped), grinding machine ground the cassava to pulp form (Odunsi, 2017).

This was then transported to 2nd check point (this is section where the operator stays to check the foreign object that escapes the 1st check point and also chopped the tubers), the chopped cassava moved to the milling machine (which is specially design to mill the cassava thereby making the cassava pulp look milky and a lot of water is involved, the milky form moved to the flour milk tank, the milky form moved to the filter press (it removed the water from the milky form of cassava to form cake, the membrane helps in reducing the water). Heat was not involved in filtering, compressed air was used, and the cassava milky form stayed for about 15 minutes in the machine, before moving to the hot dryer (Odunsi, 2017).

Dry section: The hot dryer made the compressed cassava to come out in form of cake, the anti-nutritional factor of cassava hydrogen cyanide was reduced due to the amount of heat produced in the dryer (heat reduce the amount of cyanide in cassava), the cake was milled in to powdery form by milling machine, the powdery form was allowed to cool, it is made up of flour, cassava sift 1 and cassava sift 2. The sift is the by-product of cassava flour which will account for 15% to 10% while flour was between 85% to 90% (Odunsi, 2017).

The flow chart for the industrial processing of high quality cassava to obtain cassava sifting I and II by Thai farm which is located in Ososa, Ogun state, Nigeria is shown in figure IV.

Raw materials (Cassava tubers)

↓

Raw material floor

↓

1st Hopper distribution

↓

Root peeler

↓

Root washer

↓

2nd Hopper distribution

↓

Milling

↓

Filter press

↓

Hot Drying

↓

Milling

↓

Cooling

↓

Cassava Sifting

Figure IV: Flow chart of processing of high quality cassava sifting

Source: Odunsi (2017)

2.12 **Utilization of wheat offal in the broiler chicken diets**

The processing of wheat into flour for human food has made wheat offal abundantly available in Nigeria. This by-product of the milling process has no value as human food because of the high fibre content (Christopher *et al.*, 2007). Lawal *et al*. (2012) reported that fungal degradation of wheat offal showed improved crude protein content, decreased crude fibre level and increased ash bioavailability via the depolymerisation process through solid state fermentation. done by the enzymes released by the fungus (*Aspergillus niger*) in an attempt to feed on the wheat offal. They reported that 7% degraded wheat offal can be included in the diets of broiler birds with positive results than feeding undegraded wheat offal.

Christopher *et al.* (2007) reported that maize can be replaced with about 25% wheat offal in broiler chicken diets without adverse effect on the growth, feed intake and efficiency of feed utilization, but led to a considerable reduction in feed cost. However, they concluded that 10% replacement value of maize with wheat offal resulted in optimum growth performance of the broiler chickens.

The proximate analysis of undegraded wheat offal and degraded wheat offal is shown in Table 1.

Table 1: **Proximate and detergent fibre analysis of the undegraded and degraded wheat offal (g/100 gDM)**

Parameter	Undegraded wheat offal	Degraded wheat offal
Dry matter	87.53	89.11
Crude protein	2.43	4.00
Ash	2.33	3.58
Ether extract	0.17	0.13
Crude fibre	11.60	8.35
Nitrogen free extract	84.14	86.19
Gross energy (Kcal/Kg)	4.73	5.86
Cellulose	8.12	6.55
Hemicellulose	5.33	4.23
Neutral detergent fibre	2.11	1.85
Acid detergent fibre	3.16	2.90
Acid detergent lignin	7.02	6.20

Source: Lawal *et al.* (2012)

2.13 **Fermentation of fibrous feedstuffs**

Fermentation is the enzymatic decomposition and utilization of foodstuffs, particularly carbohydrates, by microbes. Fermentation takes place throughout the gastrointestinal tracts of all animals, but the intensity of fermentation depends on microbe numbers, which are generally higher in large bowel. Thus, the large intestine is quantitatively the most important site of fermentation, except for species with fore stomachs (ruminants) (Richard, 2012). Importantly, the major end products of microbial digestion of cellulose and other carbohydrates are volatile fatty acids, lactic acids, methane, hydrogen and carbon dioxide (Stevens and Hume, 1998). Volatile or short – chain fatty acids (especially acetic, propionic and butyric acids) generated from fermentation are not only metabolized within intestinal epithelial cells, but can be absorbed by diffusion and thereby contribute fuel to systematic energy metabolism.

2.14 **Substrates used in microbial fermentation**

All solid substrates have a common feature, their basic macromolecular structure. In general, substrates for solid state fermentation (SSF) are composite and heterogeneous products from agriculture or by-products of agro-industries. This basic macromolecular structure (e. g. cellulose, starch, pectin, lignocelluloses, fibres etc.) confers the properties of a solid to the substrate. The structural macromolecule may simply provide an inert matrix (sugarcane bagasse, inert fibres, resins) within which the carbon and energy source (sugars, lipids, organic acids) are absorbed. But generally, the macromolecular matrix represents the substrates and provides also the carbon and energy source (Doelle *et al*., 1992). Each macromolecular type of substrate present different kind of heterogeneity. Lignocelluloses occur within the plant cell walls, which consist of cellulose microfibrils embedded in lignin, hemicelluloses and pectin. Each category of plant material contains variable proportion of each chemical compound. Different enzymes are required to degrade cellulose e. g., endo and exo-cellulases plus cellobiase (Senez *et al*., 1980). Pectins are polymers of galacturonic acid with different ratio of methylation and branching. Exo and endo-pectinases and demethylases hydrolyse pectin into galacturonic acid and methanol. Hemicelluloses are divided into xylans, mannans and galactans. Most of the hemicelluloses are heteropolymers containing two to four different types of sugar residues (Senez *et al*., 1980). Lignin represents between 26 – 29% of lignocelluloses, and is strongly bounded to cellulose and hemicelluloses, hiding and protecting them from the hydrolase attack. Lignin peroxidise is the major enzyme involved in lignin degradation. Effective cellulose hydrolysis requires the synergetic action of several cellulases, hemicellulases and lignin peroxidases. Lignocellulose is an abundant and cheap natural renewable material and a lot of work had been carried out on its breakdown using fungal species (Senez *et al*., 1980).

2.15 Fermentation as new tool in feed enrichment in animal nutrition

Fermentation had been used to produce amino acids, proteins, vitamins, antibiotics and certain enzymes. It can also be used to convert by-products and waste materials into livestock feeds and at the same time, lessening the pollutants in the environment. Processing is an integral part of fermentation because it is essential for destruction of pathogens, improvement in storage, handling characteristics and maintenance or enhancement of palatability together with production (CAST, 1978). Fermentation is a chemical change brought about by enzymes produced by various microorganisms. Fermented products are derived from enzymatic fermentation of organic substrates. Yeast, mould or bacteria can be utilized in a controlled aerobic or anaerobic process to produce alcohols, acids, vitamins, B-complexes or antibiotics. Ensiminger (1991) reported that two fermentation processes which are of practical importance in livestock feeding (i) ensiling (ii) improvement of the nutritional value of feeds either by fermenting the feedstuff or by fermenting other materials that may be used as feed additives to supplement the original feeds. Fermented foods often are actually more nutritious than their unfermented counterparts. This can come about in at least three different ways (Wilson *et al*., 1980). Microorganisms not only are catabolic, breaking down more complex compounds but they are metabolic and synthesize several complex vitamins and other growth factors, for examples, industrial production of riboflavin, vitamin B12 and the precursors of vitamin C is largely by special fermentation processes (Kofi, 1991). The second important way by which fermented foods can be improved nutritionally is through the liberation of nutrients locked into plant structures and cells by indigestible materials (Pederson, 1963). The milling processes do much to release nutrients from such items by physical rupturing cellulosic and hemicellulosic structures surrounding the endocellulosic structures around the endosperm (in case of certain grains) which is rich in digestible carbohydrates and protein. Fermentation especially by certain mould break down indigestible protective coatings and cell walls both chemically and physically Pederson (1971). The third way by which fermentation can enhance nutritional value especially of plant materials involve enzymatic splitting of cellulose, hemicelluloses and related polymers which goes on naturally in the rumen of the cow through the enzymatic action of protozoa and bacteria (Frazier, 1976).

2.16 Bacterium *Zymomonas mobilis* as potential benefit in Livestock feed

The bacterium *Zymomonas mobilis* is isolated from fresh palm-sap. Palm wine is an alcoholic beverage obtained from the fermentation of the sugary sap of various palm species in Nigeria. It is usually obtained from *Raphia vinifera*, *Raphia hookeri* and *Elaeis guineensis* by methods described by Bassir (1968), Faparusi (1966) and Okafor

(1972). Raphia palms usually yield more sap than oil palms although raphia palms can only be tapped once in its life because its terminal inflorescence is destroyed during tapping (Okafor, 1977). Bassir (1962), Faparusi (1966) and Okafor (1977) had reported the presence of various microorganisms such as bacteria and yeasts which are responsible for the fermentation of palm wine. The types of bacteria present in palm wine depend on the stage of fermentation and the composition of the sap. *Zymomonas mobilis* was identified as the only Zymomonas species present in palm wine obtained from the three different ecological sites. It was gram-negative, catalase positive, anaerobic, plump rods with an unusual width. Its hetero-fermentative activity leads to the production of gas from glucose, fructose and sucrose while maltose and arabinose are not fermented. Some isolations were motile, but oxidase and urease are negative. These observations were similar to those reported by Swings and De Ley (1977) on *Zymomonas mobilis* isolated from different sources. *Zymomonas mobilis* was used to ferment the juice of agave plant to produce pulque (an alcoholic beverage) (Talaro and Talaro, 1999; Ingraham and Ingraham, 2004). In Mexico, bacterium *Zymomonas mobilis* was used to traditionally produce distilled spirit tequila from the fermentation of juices from the agave plant (Ingraham and Ingraham, 2004; Nester *et al*., 2004). Although, alcohol production is common with yeasts, it is rare among bacteria (Ingraham and Ingraham, 2004). Yeasts are utilized to make most beverages but Zymomonas species are the most important alcoholic fermenters of the bacterial group in plant saps and juices. Zymomonas are facultative anaerobes with both respiratory and fermenting capabilities. They are harmless and beneficial to man and cattle. The fermentation products of Zymomonas are used in the treatment of various diseases such as enteric metabolic disorders, gynaecological infections (Swings and De Ley, 1977).

2.17 Benefits of *Zymomonas mobilis* over other micro-organisms

Zymomonas mobilis has shorter fermentation time (300-400%) than yeast with higher ethanol yield (92 - 94% verse 88 – 90% for yeast). It can convert sugar mixtures to ethanol with 90 – 95% efficiency as reported in the University of Energy Efficiency and Renewable Energy report, United States of America (Ichita, 2006).

2.18 Poultry Industry in Nigeria

Commercial poultry production in Nigeria began in the early 60's. Halbrook (1962) reported that there were about 30 million chickens in Nigeria as the time of the report with no commercial poultry farms but only two government poultry units at Riyom and Mando Roads. Smaller indigenous birds were crossed with larger imported breeds in the southern part of the country. The poultry industry started earlier especially when the then Regional Governments introduced the farm settlement schemes which educated farmers on agriculture. The reports described the Eastern Region's Poultry Programme as the best in the 60's. It was complete in every respect with both plans and action on providing a supply of chickens, making feeds available, arranging vaccinations, training and follow up field services on extension and marketing (Halbrook, 1962).

The development of poultry as a business had been described by many as more promising than any other livestock business for Nigeria. Halbrook (1962) was of the view that poultry development programmes will pay more for the country than any other animal production programme and there is a great potential for it. Poultry are among the most adequate domesticated animals and there are only few places on the globe where climatic conditions make the keeping of poultry flock impossible (Thaman, 1968). Nowadays poultry production has developed and occupies a place of pride among the livestock enterprises due to its rapid monetary turnover (Laseinde, 1994). This has made the enterprise attractive and popular among small, medium as well as large scale poultry farmers. The poultry industry has become a diverse industry with a variety of business interests such as egg production, broiler production, hatchery and poultry equipment business (Oluyemi and Roberts, 1979).

2.19 Nutrient Requirement of Broiler chickens

Olomu (1995) reported the nutrient requirement of broiler chickens at starter and finisher phases. It is presented in Table 2.

Table 2: Nutrient requirements of broiler chickens

Nutrients	Weeks 0 – 4	Weeks 6 – 9
MetabolizableEnergy (Kcal/Kg)	3000.00	3000.00
Crude Protein (%)	24.00	20.00
Arginine (%)	1.30	1.10
Glycine + Serine (%)	1.30	1.10
Histidine (%)	0.54	0.45
Isoleucine (%)	1.20	1.00
Lysine (%)	1.20	0.95
Methionine (%)	0.55	0.40
Methionine + Cystine (%)	0.75	0.65
Phenylalanine (%)	0.87	0.75
Phenylalanine + Tyrosine (%)	1.62	1.38
Threonine (%)	0.70	0.55
Tryptophan (%)	0.20	0.18
Valine (%)	1.22	1.04
Calcium (%)	1.25	1.00
Total Phosphorus (%)	0.85	0.70
Available Phosphorus (%)	0.55	0.45
Sodium (%)	0.25	0.25
Potassium (%)	0.45	0.45
Manganese (mg)	60.00	60.00
Magnesium (mg)	550.00	550.00
Iron (mg)	95.00	95.00
Copper (mg)	10.00	10.00
Zinc (mg)	40.00	40.00
Selenium (mg)	0.20	0.20
Iodine (mg)	0.40	0.40

Source: Olomu (1995)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of the Experiment

The research was carried out at the Poultry Unit, Directorate of University Farms (DUFARMS), and Animal Nutrition Laboratory, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The former is located on Latitude 7^{o} 13^{1} 35.48''N., Longitude 3^{o} 26^{1} 12.38''E with an elevation of 415 feet and high altitude of 700 feet while the latter is on Latitude 7^{o} 13^{1} 57.53''N., Longitude 3^{o} 26^{1} 12.38''E with an elevation of 473 feet and high altitude of 1141 feet (Google Earth, 2014). It is located in rainforest vegetation zone which has humid climatic condition with a mean annual rainfall of 1,037mm and mean temperature and humidity of 34.7^{o}C and 83% respectively.

3.2 Test Ingredients

The fibrous industrial by-products used in this study were:

i) Soyabean hull (SBH)

ii) Cassava sifting (CS)

iii) Sawdust (SD)

iv) Corn cobs (CC)

The soyabean hull was collected from Nestle Plc., Agbara Estate, Ogun State, Nigeria.The soyabean hull was milled using grinding machine because of its slippery nature and stored on pallets.

Cassava sifting was collected from Thai Farm International Limited, Ososa near Ijebu-Ode, Ogun State, Nigeria. The corn cobs were collected from the maize shelling unit of the Obasanjo farm Nigeria, Ltd., Igboora, Nigeria. The corn cobs were crushed using hammer mill and screened using 3.5mm sieve before storage on pallets. The sawdust was collected at the Lafenwa sawmill, Lafenwa, Abeokuta, Ogun State, Nigeria.

3.3 Preparation of *Zymomonas mobilis* innoculum and incorporation in the feed

Pure strains of *Zymomonas mobilis* used in this study was extracted from fresh palm wine. The *Z. mobilis* suspension was used to inoculate the soyabean hull to obtain SBH starter inoculum for the study

3.4 Preparation of Soyabean hull starter inoculums

The starter inoculum was prepared in the traditional setting under laboratory condition as in Anigbogu *et al*. (2009) using a fermentation vat (volume 3.5 litres). The following materials were weighed and homogeneously mixed, 500g soyabean hull as substrate with 100ml of *Zymomonas mobilis* suspended in defined cultured media in the fermentation vat. Two litres of water was poured into the vat and stirred to obtain a homogeneous mixture. The mixture was under room temperature of between 23.1ºC to 24.6 ºC for 20 days and was properly turned using a plastic rod on 24 hourly basis. After which the fermented product was used as starter inoculums (fermented dough) for the study.

3.5 Preparation of life-enzyme (Soyabean hull degraded *Z. mobilis* Microbes)

The life enzyme was prepared as in Anigbogu *et al*. (2009) using 25 kg soyabean hull placed in the fermentation vat (volume = 100 litres) with 50 litres of water added to 2.5 kg previously fermented dough (containing *Z. mobilis* microbes) which acted as starter inoculums. The sample was homogeneously mixed and kept to ferment for a period of 20 days. After which, the fermented product was sun-dried, analysed and store as life-enzyme (Soyabean hull degraded *Z. mobilis* microbes) for the experimental study.

The same procedures were used to produce Cassava sifting, Sawdust and Corn cobs degraded *Zymomonas mobilis* microbes.

Figure 5: Improvized fermentation vats with fermented product

Figure 6: Untreated Soyabean hull and *Zymomonas mobilis* treated Soyabean hull

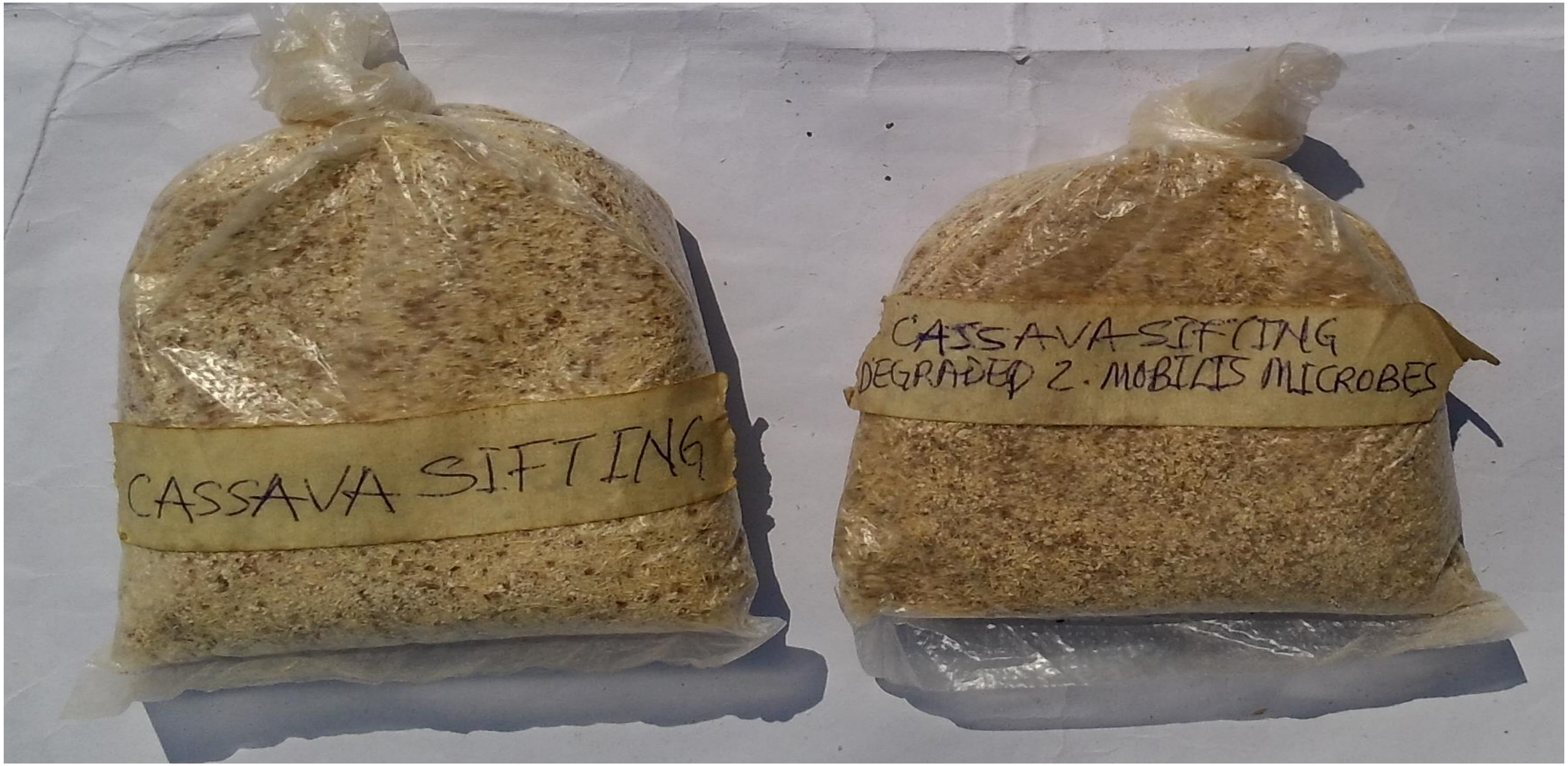

Figure 7: Untreated Cassava sifting and *Zymomonas mobilis* treated Cassava sifting

Figure 8: Untreated Sawdust and *Zymomonas mobilis* treated Sawdust

Figure 9: Untreated corn cobs and *Zymomonas mobilis* treated corn cobs

The study was divided into series of experiments which were conducted separately at different times of the year.

Experiment 1: Replacement of wheat offal with treated and untreated soyabean hull

3.6 Management of birds and experimental diets

Two hundred and forty (240) unsexed day old marshal broiler chicks were obtained from Obasanjo farms Nigeria limited, Igboora, Nigeria. They were weighed on group basis and the weight was divided by the number in the group to obtain individual weight, and randomly allotted to five dietary treatments. A total of 48 birds were used per treatment and were replicated 3 times with 16 birds each.

The chicks were brooded for 2 weeks. All routine vaccinations and necessary medication were administered to the birds. Feed and water were supplied to the birds *ad libitum*. The birds were raised for eight weeks (0-4weeks for the starter phase and 5-8 weeks for the finisher phase). The test diets were formulated such that the soyabean hull was included to replace wheat offal at 0, 50 and 100% levels. The *Zymomonas mobilis* treated soyabean hull was incorporated to replace wheat offal at 50% and 100% levels both at the starter and finisher phases and the diets were formulated to be iso-proteinous and iso – caloric.

The composition of the experimental broiler chicken diet is shown in Table 3.

Table 3: Percentage Composition of Experimental Broiler Chicken Diets (DM- Basis) for Experiment 1

Ingredients		Starter	Diets				Finishers	Diets		
		-Z.mobilis	*-Z.mobilis*	*+Z.mobilis*	*+Z.mobilis*	0%	*-Z.mobilis*	*-Z.mobilis*	*+Z.mobilis*	*+Z.mobilis*
	0%	50%	100%	50%	100%		50%	100%	50%	100%
Maize	53.60	53.60	53.60	53.60	53.60	54.60	54.60	54.60	54.60	54.60
Soyabean meal	29.50	29.50	29.50	29.50	29.50	23.50	23.50	23.50	23.50	23.50
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Groundnut cake	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Wheat offal	5.00	2.50	0.00	2.50	0.00	10.00	5.00	0.00	5.00	0.00
Soyabean hull	0.00	2.50	5.00	2.50	5.00	0.00	5.00	10.00	5.00	10.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Broiler premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Toxin Binder	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated analysis:										
Metabolizable energy (Kcal/Kg)	2857.23	2856.62	2856.01	2880.78	2904.33	2838.85	2837.63	2836.40	2885.95	2933.05
Crude Protein (%)	23.38	23.38	23.39	23.45	23.52	21.68	21.69	21.69	21.82	21.95
Crude Fibre (%)	3.62	4.30	4.98	3.91	4.19	3.67	5.03	6.39	4.25	4.82
Ether Extract (%)	3.83	3.99	4.15	3.99	4.15	3.83	4.15	4.47	4.16	4.48
Ash (%)	2.60	2.68	2.75	2.70	2.80	2.26	2.40	2.54	2.46	2.66
Nitrogen Free Extract (%)	50.57	49.66	48.74	49.95	49.33	52.56	50.73	48.91	51.32	50.09
Calcium (%)	1.48	1.50	1.53	1.51	1.54	1.47	1.51	1.56	1.53	1.60
Phosphorus (%)	0.57	0.62	0.68	0.62	0.67	0.54	0.65	0.75	0.64	0.74

Experiment 2: Replacement of wheat offal with treated and untreated cassava sifting

3.7 Management of birds and experimental diets

Two hundred and forty (240) unsexed day old marshal broiler chicks were obtained from Obasanjo farms Nigeria limited, Igboora, Nigeria. They were weighed on group basis and the weight was divided by the number in the group to obtain individual weight, and randomly allotted to five dietary treatments. A total of 48 birds were used per treatment and were replicated 3 times with 16 birds each.

The chicks were brooded for 2 weeks. All routine vaccinations and necessary medication were administered to the birds. Feed and water were supplied to the birds *ad libitum*. The birds were raised for eight weeks (0-4weeks for the starter phase and 5-8 weeks for the finisher phase). The test diets were formulated such that the cassava sifting was included to replace wheat offal at 0, 50 and 100% levels. The *Zymomonas mobilis* treated cassava sifting was incorporated to replace wheat offal at 50% and 100% levels both at the starter and finisher phases and the diets were formulated to be iso-proteinous and iso–caloric.

The composition of the experimental broiler chicken diet is shown in Table 4.

Table 4: Percentage Composition of Experimental Broiler Chicken Diets (DM- Basis) for Experiment 2

Ingredients		Starter	Diets				Finishers	Diets		
		-Z.mobilis	*-Z.mobilis*	*+Z.mobilis*	*+Z.mobilis*	0%	*-Z.mobilis*	*-Z.mobilis*	*+Z.mobilis*	*+Z.mobilis*
	0%	50%	100%	50%	100%		50%	100%	50%	100%
Maize	53.60	53.60	53.60	53.60	53.60	54.60	54.60	54.60	54.60	54.60
Soyabean meal	29.50	29.50	29.50	29.50	29.50	23.50	23.50	23.50	23.50	23.50
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Groundnut cake	2.50	2.50	s2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Wheat offal	5.00	2.50	0.00	2.50	0.00	10.00	5.00	0.00	5.00	0.00
Cassava sifting	0.00	2.50	5.00	2.50	5.00	0.00	5.00	10.00	5.00	10.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Broiler premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Toxin Binder	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated analysis:										
Metabolizable energy (Kcal/Kg)	2857.23	2875.05	2893.77	2883.34	2909.45	2838.85	2875.39	2911.92	2891.07	2943.30
Crude Protein (%)	23.38	23.09.	22.80	23.03	22.68	21.68	21.10	20.52	20.98	20.28
Crude Fibre (%)	3.62	3.73	3.84	3.81	3.99	3.67	3.90	4.12	4.05	4.42
Ether Extract (%)	3.83	3.79	3.75	3.89	3.95	3.83	3.76	3.68	3.96	4.08
Ash (%)	2.60	2.63	2.65	2.63	2.65	2.26	2.31	2.63	2.30	2.35
Nitrogen Free Extract (%)	50.57	50.73	50.96	50.64	50.73	52.56	52.93	53.05	52.71	52.87
Calcium (%)	1.48	1.48	1.49	1.51	1.53	1.47	1.47	1.48	1.52	1.57
Phosphorus (%)	0.57	0.58	0.60	0.60	0.63	0.54	0.56	0.59	0.60	0.65

Experiment 3: Replacement of wheat offal with treated and untreated sawdust

3.8 Management of birds and experimental diets

Two hundred and forty (240) unsexed day old marshal broiler chicks were obtained from Obasanjo farms Nigeria limited, Igboora, Nigeria. They were weighed on group basis and the weight was divided by the number in the group to obtain individual weight, and randomly allotted to five dietary treatments. A total of 48 birds were used per treatment and were replicated 3 times with 16 birds each.

The chicks were brooded for 2 weeks. All routine vaccinations and necessary medication were administered to the birds. Feed and water were supplied to the birds *ad libitum*. The birds were raised for eight weeks (0-4weeks for the starter phase and 5-8 weeks for the finisher phase).

The test diets were formulated such that the sawdust was included to replace wheat offal at 0, 50 and 100% levels. The *Zymomonas mobilis* treated sawdust was incorporated to replace wheat offal at 50% and 100% levels both at the starter and finisher phases and the diets were formulated to be iso-proteinous and iso – caloric.

The composition of the experimental broiler chicken diet is shown in Table 5.

Table 5: Percentage Composition of Experimental Broiler Chicken Diets (DM- Basis) for Experiment 3

Ingredients		Starter	Diets				Finisher	diets		
		-Z.mobilis	*-Z.mobilis*	*+Z.mobilis*	*+Z.mobilis*		*-Z.mobilis*	*-Z.mobilis*	*+Z.mobilis*	*+Z.mobilis*
	0%	50%	100%	50%	100%	0%	50%	100%	50%	100%
Maize	53.60	53.60	53.60	53.60	53.60	54.60	54.60	54.60	54.60	54.60
Soyabean meal	29.50	29.50	29.50	29.50	29.50	23.50	23.50	23.50	23.50	23.50
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Groundnut cake	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Wheat offal	5.00	2.50	0.00	2.50	0.00	10.00	5.00	0.00	5.00	0.00
Sawdust	0.00	2.50	5.00	2.50	5.00	0.00	5.00	10.00	5.00	10.00
Bone Meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Broiler premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Toxin binder	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated analysis:										
Metabolizable energy (MJ/Kg)	2857.23	2828.22	2799.20	2846.24	2835.24	2838.85	2780.82	2722.80	2816.86	2794.87
Crude Protein (%)	23.38	23.01	22.64	23.14	22.89	21.68	20.94	20.20	21.19	20.70
Crude Fibre (%)	3.62	4.97	6.32	4.69	5.77	3.67	6.37	9.07	5.82	7.97
Ether Extract (%)	3.83	3.75	3.68	3.86	3.90	3.83	3.69	3.54	3.91	3.98
Ash (%)	2.60	2.82	3.03	2.65	2.70	2.26	2.68	3.10	2.36	2.46
Nitrogen Free Extract(%)	50.57	49.45	48.33	49.65	48.74	52.56	50.32	48.09	50.72	48.89
Calcium (%)	1.48	1.48	1.48	1.48	1.48	1.47	1.47	1.46	1.47	1.46
Phosphorus (%)	0.57	0.59	0.61	0.59	0.61	0.54	0.57	0.61	0.57	0.61

Experiment 4: Replacement of wheat offal with treated and untreated corn cobs

3.9 Management of birds and experimental diets

Two hundred and forty (240) unsexed day old marshal broiler chicks were obtained from Obasanjo farms Nigeria limited, Igboora, Nigeria. They were weighed on group basis and the weight was divided by the number in the group to obtain individual weight, and randomly allotted to five dietary treatments. A total of 48 birds were used per treatment and were replicated 3 times with 16 birds each.

The chicks were brooded for 2 weeks. All routine vaccinations and necessary medication were administered to the birds. Feed and water were supplied to the birds *ad libitum*. The birds were raised for eight weeks (0-4weeks for the starter phase and 5-8 weeks for the finisher phase). The test diets were formulated such that the corn cobs will be included to replace wheat offal at 0, 50 and 100% levels. The *Zymomonas mobilis* treated corn cobs was incorporated to replace wheat offal at 50% and 100% levels both at the starter and finisher phases and the diets were formulated to be iso-proteinous and iso – caloric.

The composition of the experimental broiler chicken diet is shown in Table 6

Table 6: Percentage Composition of Experimental Broiler Chicken Diets (DM- Basis) for Experiment 4

Ingredients		Starter	diets				Finisher	diets		
		-Z.mobilis	*-Z.mobilis*	*+Z.mobilis*	*+Z.mobilis*		*-Z.mobilis*	*-Z.mobilis*	*+Z.mobilis*	*+Z.mobilis*
	0%	50%	100%	50%	100%	0%	50%	100%	50%	100%
Maize	53.60	53.60	53.60	53.60	53.60	54.60	54.60	54.60	54.60	54.60
Soyabean meal	29.50	29.50	29.50	29.50	29.50	23.50	23.50	23.50	23.50	23.50
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Groundnut cake	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Wheat offal	5.00	2.50	0.00	2.50	0.00	10.00	5.00	0.00	5.00	0.00
Corn cobs	0.00	2.50	5.00	2.50	5.00	0.00	5.00	10.00	5.00	10.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Broiler premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Toxin binder	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated analysis:										
Metabolizable energy (Kcal/Kg)	2857.23	2843.17	2829.10	2880.49	2903.75	2838.85	2810.72	2782.59	2885.37	2931.88
Crude Protein (%)	23.38	23.04	22.70	23.19	23.01	21.68	21.00	20.32	21.31	20.93
Crude Fibre (%)	3.62	4.54	5.45	3.88	4.14	3.67	5.51	7.34	4.20	4.72
Ether Extract (%)	3.83	3.76	3.69	3.95	4.08	3.83	3.69	3.55	4.08	4.33
Ash (%)	2.60	2.80	3.00	2.65	2.70	2.26	2.65	3.05	2.36	2.46
Nitrogen Free Extract(%)	50.57	49.86	49.16	50.32	50.07	52.56	51.14	49.73	52.06	51.56
Calcium (%)	1.48	1.55	1.63	1.54	1.59	1.47	1.62	1.76	1.58	1.69
Phosphorus (%)	0.57	0.59	0.61	0.59	0.61	0.54	0.57	0.61	0.57	0.61

3.10 **Chemical analysis**

The proximate composition (CP, CF, EE and ash) of the ground samples of untreated and treated soyabean hull, cassava sifting, sawdust and corn cobs was determined according to the standard procedures of AOAC (2015). The fibre fraction such as neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined by the method of Van Soest *et al*. (1991). Calcium and phosphorus of the test ingredients were determined by the methods of Grueling (1966). Gross energy of the ground samples was determined using a Gallenkamp Ballistic bomb calorimeter (Cam Metric Ltd., Cambridge, UK).

3.10.1 **Moisture content determination**

The moisture content was obtained using the oven-drying method AOAC (2015). The empty can was weighed (W1) and 2g of samples measured into it, and then weighed together(W2). The sample was dried in the oven at a temperature of 105^{o}C for 3 hours. Then cooled in the dessicator and weighed. Drying, cooling and weighing were continuously repeated until a constant dry weight is achieved (W3).

The percentage moisture was calculated as follows:

$$\% \text{ moisture content} = \frac{W2 - W3}{W2 - W1} \times \frac{100}{1}$$

W1 = weight of empty can

W2= weight of can + sample before drying

W3= weight of can + sample after drying

3.10.2 **Crude protein determination**

The protein content was determined by the Kjedahl method (AOAC, 2015), the total nitrogen was determined and multiplied by the factor 6.25 to obtain the crude protein value. The 0.5g of each sample was weighed into the Kjedahl flask, and mixed with

10mls of concentrated sulphuric acid. A tablet of selenium catalyst was added to it. The mixture was digested (heated) under a fume cupboard until a clear solution was obtained in a separate flask. The acid and other reagent were digested, but without sample to form the blank control. All the digests were carefully transferred to 100ml volumetric flask using distilled water and made up to a mark in the flask. A 100ml portion of each digest was mixed with equal volume of 45% NaOH solution in Kjedahl distilling unit. The mixture was distilled and the distillate collected into 10ml of 4% boric acid solution containing 3 drops of mixed indicators (bromocresol green methyl red). A total of 50ml distillate was obtained and titrated against 0.02M H_2SO_4 solution. Titration was done from the initial green colour to a deep red end point. The Nitrogen(N) content were calculated as shown:

$$\% N_2 = \frac{100}{W} \times \frac{N \times 14}{100} \times \frac{Vf}{Va} T$$

Where:

W = weight of sample analyzed

N = concentration of H_2SO_4 tiltrant

Vf = Total volume of digest

Va = Volume of digest distilled

T = Titre value – Blank

3.10.3 **Total Ash Determination**

Ash content was determined by Muffled Furnace Ignition Method (AOAC., 2015). A 5g portion of the sample was weighed into a clean, dried and weighed crucible, and then placed on the muffle furnace set at 550^0C. The sample was allowed to ash to a white grey colour, and then cooled in a dessicator, and finally weighed to get the weight of the ash, which was calculated as follows:

$$\% \text{ Ash} = \frac{\text{Weight of ash}}{\text{Weight of original food}} \times \frac{100}{1}$$

$$= \frac{W_3 - W_1}{W_2 - W_1} \times \frac{100}{1}$$

Where: W1 = weight of the empty crucible

W2 = weight of sample after washing and drying to a constant + crucible

W3=weight of sample ash +crucible

3.10.4 **Nitrogen Free Extract determination**

The nitrogen free extract (NFE) content was determined by difference (AOAC., 2015). The nitrogen free extract was determined by relationship as follows:

% NFE =100 - % (a + b + c + d + e)

a = Crude protein (CP)

b = Ash content of sample(ash)

c = Ether extract content of sample (EE)

d = Crude fibre (CF)

e = moisture (H_2O)

3.10.5 The **Metabolizable Energy** (MJ/Kg) will be estimated from Panzenga, 1985 using

ME = (37 x %CP + 81.1 x %EE + 35.5 x NFE).

3.11 **DATA COLLECTION**

3.11.1 **Performance Characteristics**

The weekly feed intake and the body weight were measured with a weighing scale in the morning before feeding and the average weight gain and feed conversion ratio were calculated. A record of mortality was kept as it occurred throughout the feeding trial. Measurement was taken weekly throughout the period of the experiment.

(i) Average Weight Gain/bird = $\dfrac{\text{Final weight – Initial weight}}{\text{Total number of birds}}$

(ii) Daily Weight Gain/bird = $\dfrac{\text{Average weight gain}}{\text{Number of Days}}$

(iii) Average Feed Intake/bird = $\dfrac{\text{Feed supplied – left over feed}}{\text{Total number of birds}}$

(iv) Daily Feed Intake = $\dfrac{\text{Total feed consumed}}{\text{Number of Days}}$

(v) Feed Conversion Ratio(FCR) = $\dfrac{\text{Feed consumed}}{\text{Weight gain}}$

(vi) Protein Efficiency Ratio (PER) = $\dfrac{\text{Weight gain}}{\text{Protein intake}}$

(vii) Total Cost of Feed Consumed (TCFC) = Total feed consumed (Kg) × Cost per Kg of feed

(viii) Cost of feed per Kg weight gain = FCR × Cost of feed/Kg

3.11.2 **Metabolic Trial**

The metabolic trial was carried out at the 4th and 8th week of the experiments, 6 experimental birds per treatment (2 broiler birds per replicate) were randomly selected and kept separately in appropriate metabolic cages equipped with individual feeders, water troughs and facility for separate excreta collection for each experiment. A 3-day acclimatization period was allowed prior to the commencement of 3-day metabolic trial. The weight of feed given to each bird was recorded. The total droppings voided from the birds was collected in a labelled aluminium foil daily, weighed wet and dry in the oven at 65ºC to constant weight. The dried droppings from the same replicate was pooled and ground. The dried, pooled and ground samples were analyzed for crude protein, crude fibre, ether extract and ash according to standard procedures of AOAC (2015).

The Apparent Digestibility was calculated using the formula:

$$\text{Dry Matter Digestibility} = \frac{\text{Weight of Feed Intake(DM)} - \text{Wt. of dropping(DM)}}{\text{Weight of Feed Intake (DM)}} \times \frac{100}{1}$$

Also, the Digestible Crude Protein (DCP) will be calculated from the result of proximate composition of both the feed and faecal samples as follows:

Digestible Crude Protein (DCP) =

$$\frac{\text{Feed Intake (DM)} \times \%\text{CP in diet} - \text{Droppings (DM)} \times \%\text{CP in droppings}}{\text{Feed Intake (DM)} \times \%\text{CP in diet}} \times \frac{100}{1}$$

The same method will be used for the digestibility of fat. crude fibre and ash.

3.11.3 **Blood collection and analysis**

Blood samples were collected individually from 15 broiler chickens (3 birds per treatment) via the wing vein using sterilized syringe at the end of the starting and finishing phases of the feeding trials. About 2.5ml of blood sample was collected from each bird into vials containing ethylene diamine tetra-acetic acid (EDTA) as anticoagulant for the determination of haematological parameters (Red Blood Cell, White Blood Cell, Packed Cell Volume and Haemoglobin). However, another set was collected into heparinised tubes for serum biochemistry measurement (Glucose, Cholesterol, Total Protein, Albumin, Globulin, Uric acid, Creatinine, Aspartate aminotransferase and Alanine aminotransferase). The blood samples were allowed to clot, and put in a refrigerator for 6 hours and later spun in a centrifuge at 900 rpm for 20 minutes. The separated blood sera was labelled for each bird and stored in the freezer at 2ºC prior to analysis. The sera were allowed to thaw under room temperature before subsequent analyses. Haemoglobin concentration was estimated using the cyanmethaemoglobin method (Cannan, 1958), packed cell volume (PCV), red blood cell (RBC) and white blood cell (WBC) count of the blood samples were determined in Wintrobe haematocrit tube according the method of Schalm *et al*. (1975).

3.11.4 **Carcass and organ weight determination**

At the end of 8 weeks, fifteen broiler chickens (3 birds per treatment) were selected at random and starved for about 18 hours to empty their crops for each experiment. They were slaughtered by cervical dislocation, allowed to bleed, scalded in warm water and defeathered. They were thereafter taken to the laboratory where other measurement like the dressed weight, weight of the cut parts and organs were taken with a sensitive electronic scale. The weight of the cut-up parts and organs was expressed as percentage of live weight according to "Modified Kosher" method as described by Abe *et al*., (1996), while the dressing percentage was calculated as follows:

$$\text{Dressing \%} = \frac{\text{Eviscerated weight}}{\text{Liveweight.}} \times \frac{100}{1}$$

3.11.5 **Measurement of Ileal digesta viscosity**

Viscosity was destermined by Stowarld method as described by Habibi (1999). At the end of the experiment (8 weeks), a total of 15 broiler chickens (3 birds per treatment) were slaughtered for each experiment to examine the ileal digesta viscosity using viscometer. The abdomen of each of the bird was opened immediately after death and the intestinal content was exposed. The ileal digesta content was collected from the Merekel's diverticulum to the ileo-caecal junction. The ileal digesta for each replicate was emptied into a sample bottle and properly labelled. A uniform weight of sample was taken from each sample bottle using a sensitive scale and was diluted to a volune of 50ml. The ileal digesta contents for each replicate was placed in a centrifuge tube and centrifuged at 6000rpm for 20minutes. The supernatant was withdrawn and viscosity was determined in a Torsion VHA-205-F viscosity using a torsion wire of 36swg and a 11/16 in cylinder.

3.11.6 **Sensory Evaluation**

The sensory evaluation of cooked samples of broiler chicken breast minced meat from three birds per treatment was carried out by ten panellists. Parameters that was evaluated by the panellists include, colour, juiciness, flavour, tenderness and overall acceptability. Each meat sample was coded and presented one after the other to each member of the panel. Each member rinsed his or her mouth with water after assessing each meat sample to avoid carry over effect. The panelists awarded scores using a nine (9) point hedonic scale of (i) Dislike extremely (ii) Dislike very much (iii) Dislike moderately (iv) Dislike slightly (v) Intermediate (vi) Like slightly (vii) Like moderately (viii) Like very much (ix) Like extremely (Ogunwole *et al*., 2013).

3.11.7 **Economy of feed conversion**

The prevailing market prices of the ingredients per kg at the time of the study was used to calculate the cost of feed per kilogram diet (#), total cost of feed consumed per bird (#) and cost of feed per kilogram weight gain (#) both for the starter and finisher phases).

The cost benefits analysis was based on the methods as applied by Anigbogu and Anosike (2010). The cost of dietary ingredients (₦/ kg) was used to calculate the cost/kg of each diet. Where the,

$$\text{Cost of the feed/kg (₦)} = \frac{\text{Total cost feed in Naira (₦)}}{\text{Quantity of feed in kg}}$$

Cost of feed consumed /Kg weight gain = feed conversion ratio x cost of feed per kg

Cost of production/broiler = cost of feed/bird + cost of broiler + cost of medication/bird + fare/bird

Gross Revenue /broiler = price/kg live weight of broiler x final weight obtained/broiler

Gross Profit /broiler =Gross revenue – cost of production

$$\text{Rate of return on investment (\%)} = \frac{\text{Profit (net income)}}{\text{Cost of production}} \times \frac{100}{1}$$

$$\text{Economic efficiency (EE)} = \frac{\text{Net revenue (profit)}}{\text{Feed cost}}$$

Cost differential =cost/kg weight gain of control diet - cost/kg weight gain of treated diet

$$\text{Relative cost benefit (\%)} = \frac{\text{Cost difference}}{\text{Cost/kg weight gain of control diet}} \times \frac{100}{1}$$

3.12 **Experimental design and Statistical analysis**

The experimental design used for this study was completely randomized design (CRD). All data collected were subjected to one-way analysis of variance (ANOVA) as outlined by Daniel (1995) with the aid of SAS (2001) and the significant means separated by Duncan's multiple range test at 5% level of significance (Steel and Torrie, 1980).

3.13 **Statistical Model**

$Y_{ij} = \mu + t_i + E_{ij}$

Where: Y_{ij} = observed value of dependent variable

μ = population mean

t_i = Effect of treatment

E_{ij} = Random residual error

CHAPTER FOUR

4.0 RESULTS

4.1 Proximate composition of untreated soyabean hull and treated soyabean hull

The result of proximate composition of the untreated soyabean hull and treated soyabean hull is shown in Table 7. The fermentation of soyabean hull with *Zymomonas mobilis* improved ($p<0.05$) the value of crude protein from 17.06% to 19.68% (13.31%), nitrogen free extract of 31.38% increased to 35.32% (11.16%). The ash also increased ($p<0.05$) from 2.87% to 4.00% which was 28.25% increment. The crude fibre and the fibre fraction were reduced ($p<0.05$) after the *Z. mobilis* treatment. The crude fibre, neutral detergent fibre, acid detergent fibre and acid detergent lignin had 78.2, 62.18, 105.11 and 88.10% reduction respectively. The calcium content of the soyabean hull increased ($p<0.05$) from 1.00 to 1.39g/Kg after biodegradation. The gross energy reduced from 3833.50 to 3644.70kcal/kg (5.18%) while the metabolizable energy of 1825.50kcal/kg increased to 2792.02kcal/kg (34.62%).

4.2 Proximate composition of untreated cassava sifting and treated cassava sifting

The result of proximate composition of untreated cassava sifting and treated cassava sifting is shown in Table 8. The crude protein content of cassava sifting of 2.97% increased ($p<0.05$) to 5.36% (44.59%) after biodegradation. The ether extract value of 2.00% increased ($p<0.05$) to 6.00% (66.67%) but, nitrogen free extract value of 65.03% reduced to 62.24% (4.48%). The crude fibre and neutral detergent fibre decreased ($p<0.05$) after treatment with *Z. mobilis*. They had 23.08% and 6.38% reduction in values. The acid detergent fibre decreased ($p<0.05$) from 18.00% to 11.00% (63.64%). The Calcium content of the Cassava sifting of 0.20 g/kg increased

Table 7: Proximate analysis of untreated and treated soyabean hull[*] (SBH) (DM-basis)

Components (%)	Untreated SBH	Treated SBH	t-test (P-value)
Dry matter	87.94^{b}	89.00^{a}	-7.64 (0.002)
Moisture	12.06^{a}	11.00^{b}	7.64 (0.002)
Crude protein	17.06^{b}	19.68^{a}	-18.88 (0.0001)
Crude fibre	35.64^{a}	20.00^{b}	112.68 (0.0001)
Ether extract	9.90	10.00	-0.72 (0.51)
Nitrogen free extract	31.38^{b}	35.32^{a}	-28.39 (0.0001)
Ash	2.87^{b}	4.00^{a}	-8.14 (0.0012)
Neutral detergent fibre	81.09^{a}	50.00^{b}	223.98 (0.0001)
Acid detergent fibre	57.43^{a}	28.00^{b}	212.03 (0.0001)
Acid detergent lignin	18.81^{a}	10.00^{b}	63.47 (0.0001)
Calcium (g/Kg DM)	1.00^{b}	1.39^{a}	-2.81 (0.0483)
Phosphorus (g/Kg DM)	2.27	2.16	0.79 (0.4724)
Gross energy (Kcal/Kg)	3833.50^{a}	3644.70^{b}	1360.19 (0.0001)
**Metabolizable energy (Kcal/Kg)	1825.50^{b}	2792.02^{a}	-6963.18 (0.0001)

Means on the same row having different superscripts are significantly different (P<0.05)

* = Average of three determinations

**Metabolizable energy values were calculated using the method

37x %CP + 81x % EE + 35.5 x % NFE for poultry birds (Fisher and Boorman, 1986)

Table 8: Proximate analysis of untreated and treated cassava sifting* (CS) (DM-basis)

Components (%)	Untreated CS	Treated CS	t-test (P-value)
Dry matter	87.00^{b}	87.50^{a}	-3.60 (0.0227)
Moisture	13.00^{a}	12.50^{b}	3.60 (0.0227)
Crude protein	2.97^{b}	5.36^{a}	-17.22 (0.0001)
Crude fibre	16.00^{a}	13.00^{b}	21.61 (0.0001)
Ether extract	2.00^{b}	6.00^{a}	-28.82 (0.0001)
Nitrogen free extract	65.03^{a}	62.24^{b}	20.10 (0.0001)
Ash	1.00	0.90	0.72 (0.5111)
Neutral detergent fibre	50.00^{a}	47.00^{b}	21.61 (0.0001)
Acid detergent fibre	18.00^{a}	11.00^{b}	-50.43 (0.0001)
Acid detergent lignin	2.00	2.00	0.000 (1.0000)
Calcium (g/Kg DM)	0.20^{b}	1.12^{a}	-6.63 (0.0027)
Phosphorus (g/Kg DM)	0.63^{b}	1.27^{a}	-4.61 (0.0099)
Gross energy (Kcal/Kg)	3600.60^{b}	3677.50^{a}	-554.02 (0.0001)
**Metabolizable energy (Kcal/Kg)	2580.66^{b}	2894.44^{a}	-2260.59 (0.0001)

Means on the same row having different superscripts are significantly different (P<0.05)

* = Average of three determinations

**Metabolizable energy values were calculated using the method

37x %CP + 81x % EE + 35.5 x % NFE for poultry birds (Fisher and Boorman, 1986)

($p<0.05$) to 1.12 g/kg and the value of Phosphorus increased ($p<0.05$) from 0.63g/kg to 1.27 g/kg after treatment with *Z. mobilis*. The gross energy had a slight increase ($p<0.05$) in value, 3600.60 to 3677.50kcal/kg (2.09%) while the metabolizable energy of 2580.66kcal/kg increased ($p<0.05$) to 2894.44kcal/kg (10.84%).

4.3 Proximate composition of untreated sawdust and treated sawdust

The result of proximate composition of the untreated sawdust and treated sawdust is shown in Table 9. The biodegradation of the sawdust with *Zymomonas mobilis* led to the improvement ($p<0.05$) in crude protein value from 2.14% to 7.13% (69.99%). The ether extract value 0.60% increased ($p<0.05$) to 5.00% (88.0%), nitrogen free extract value of 15.82% to 20.87% (24.20%). There was significant reduction ($p<0.05$) of crude fibre and fibre fraction of the sawdust. The crude fibre, neutral detergent fibre, acid detergent fibre and acid detergent lignin had 21.37, 35.32, 58.92 and 189.36% reduction, respectively after degradation. The ash content 8.47% decreased ($p<0.05$) to 2.00% (323.50%). The gross energy of 3944.70kcal/kg increased ($p<0.05$) to 4000.90kcal/kg (1.40%) while the metabolizable energy of 689.45kcal/kg increased ($p<0.05$) to 1410.20kcal/kg (51.11%).

4.4 Proximate composition of untreated corn cobs and treated corn cobs

The result of proximate composition of untreated corn cobs and treated corn cobs is shown in Table 10. The biodegradation of corn cobs resulted in improved ($p<0.05$) nutrient composition, crude protein value of 3.41% increased ($p<0.05$) to 9.45% (63.90%) while the ether extract of 0.70% increased ($p<0.05$) to 8.50% but the ash content of 7.92% decreased ($p<0.05$) to 2.00% after biodegradation. The nitrogen free extract value of 31.11% increased ($p<0.05$) to 49.05% (57.67%). The crude fibre, neutral detergent fibre, acid detergent fibre and acid detergent lignin decreased by 137.89, 38.50, 64.64 and 197.50% respectively after fermentation with *Z. mobilis.*

Table 9: Proximate analysis of untreated and treated sawdust* (SD) (DM-basis)

Components (%)	Untreated SD	Treated SD	t-test (P-value)
Dry matter	89.51[a]	86.50[b]	21.69 (0.0001)
Moisture	10.49[b]	13.50[a]	-21.69 (0.0001)
Crude protein	2.14[b]	7.13[a]	-35.95 (0.0001)
Crude fibre	62.48[a]	51.50[b]	79.10 (0.0001)
Ether extract	0.60[b]	5.00[a]	-31.70 (0.0001)
Nitrogen free extract	15.82[b]	20.87[a]	-36.38 (0.0001)
Ash	8.47[a]	2.00[b]	46.61 (0.0001)
Neutral detergent fibre	89.31[a]	66.00[b]	167.93 (0.0001)
Acid detergent fibre	76.76[a]	48.00[b]	207.20 (0.0001)
Acid detergent lignin	40.51[a]	14.00[b]	191.00 (0.0001)
Calcium (g/Kg DM)	0.05	0.04	1.23 (0.2879)
Phosphorus (g/Kg DM)	0.85	0.83	0.144 (0.8924)
Gross energy (Kcal/Kg)	3944.70[b]	4000.90[a]	-404.89 (0.0001)
**Metabolizable energy (Kcal/Kg)	689.45[b]	1410.20[a]	-5192.56 (0.0001)

Means on the same row having different superscripts are significantly different ($P<0.05$)

* = Average of three determinations

**Metabolizable energy values were calculated using the method

37x %CP + 81x % EE + 35.5 x % NFE for poultry birds (Fisher and Boorman, 1986)

Table 10: Proximate analysis of untreated and treated corn cobs[*] (CC) (DM-basis)

Components (%)	Untreated CC	Treated CC	t-test (P-value)
Dry matter	88.30	88.00	2.16 (0.0967)
Moisture	11.66	12.00	-2.45 (0.0705)
Crude protein	3.41[b]	9.45[a]	-43.51 (0.0001)
Crude fibre	45.20[a]	19.00[b]	188.76 (0.0001)
Ether extract	0.70[b]	8.50[a]	-56.19 (0.0001)
Nitrogen free extract	31.11[b]	49.05[a]	-129.25 (0.0001)
Ash	7.92[a]	2.00[b]	42.65 (0.0001)
Neutral detergent fibre	90.03[a]	65.00[b]	180.33 (0.0001)
Acid detergent fibre	69.15[a]	42.00[b]	195.60 (0.0001)
Acid detergent lignin	29.75[a]	10.00[b]	142.29 (0.0001)
Calcium (g/Kg DM)	3.05[a]	2.32[b]	5.26 (0.0063)
Phosphorus (g/Kg DM)	0.84	0.84	0.000 (1.0000)
Gross energy (Kcal/Kg)	9311.30[b]	9855.10[a]	-3917.74 (0.0001)
**Metabolizable energy (Kcal/Kg)	1287.35[b]	2780.28[a]	-10755.60 (0.0001)

Means on the same row having different superscripts are significantly different (P<0.05)

* = Average of three determinations

**Metabolizable energy values were calculated using the method

37x %CP + 81x % EE + 35.5 x % NFE for poultry birds (Fisher and Boorman, 1986)

The value of Calcium content decreased from 3.05 to 2.32g/kgDM after treatment. The gross energy increased ($p<0.05$) from 9311.30kcal/kg to 9855.10kcal/kg (5.52%) while the metabolizable energy of 1287.35kcal/kg increased ($p<0.05$) to 2780.28kcal/kg (53.70%).

4.5 **Growth response of starting broiler chickens fed diets containing soyabean hull**

The performance characteristics of starting broiler chickens fed soyabean hull based diets is shown in Table 11. The dietary treatments significantly ($p<0.05$) influenced the final body weight, average weight gain and daily weight gain. The starting broiler chickens fed 100% *Z. mobilis* treated soyabean hull (100% ZTSBH) had the highest values for average weight gain and daily weight gain while the birds fed the control diet had the least values. The average feed intake and daily feed intake are significantly ($p<0.05$) affected by the dietary treatments. The daily feed intake ranged between 42.30g and 54.40g, the birds fed 50% *Z. mobilis* treated soyabean hull (50% ZTSBH) had significantly ($p<0.05$) higher value while birds fed the control diet had the least value which was statistically similar ($p>0.05$) to the value obtained from birds fed 100% untreated soyabean hull (UTSBH). The dietary treatments significantly ($p<0.05$) affected the cost of feed consumed and cost of feed/kg weight gain. Broiler chickens fed 50% ZTSBH had the highest values for cost of feed consumed/bird and cost of feed/kg weight gain while birds on 50% UTSBH had the least value for cost of feed consumed/bird and birds on 100% ZTSBH had the least value for cost of feed/kg weight gain. The mortality was significantly influenced ($p<0.05$) across the dietary treatments, highest value was recorded in 50% ZTSBH while the least value was observed in 50% UTSBH and 100% UTSBH.

Table 11: Performance characteristics of starting broiler chickens (0 – 4weeks) fed diets containing untreated and treated Soyabean hull

Parameters	Dietary treatments 1 Control diet	2 50% UTSBH	3 100% UTSBH	4 50% ZTSBH	5 100% ZTSBH	SEM
Initial body weight (g/bird)	35.00	33.00	35.00	35.00	33.00	0.60
Final body weight (g/bird)	525.00^{e}	565.00^{d}	621.00^{b}	605.00^{c}	675.00^{a}	13.61
Average weight gain (g/bird)	490.00^{e}	532.00^{d}	586.00^{b}	570.00^{c}	642.00^{a}	13.75
Daily weight gain (g/bird)	17.50^{d}	19.00^{c}	20.93^{b}	20.36^{b}	22.93^{a}	0.51
Average feed intake (g/bird)	1181.00^{c}	1142.00^{c}	1195.00^{c}	1470.00^{a}	1282.00^{b}	32.87
Daily feed intake (g/bird)	43.74^{c}	42.30^{d}	44.26^{c}	54.40^{a}	47.48^{b}	1.16
Feed conversion ratio	2.41^{b}	2.15^{c}	2.04^{cd}	2.58^{a}	2.00^{d}	0.06
Protein efficiency ratio	2.24^{d}	2.53^{c}	2.85^{a}	1.94^{e}	2.65^{b}	0.09
Cost of the feed/Kg (₦/Kg)	151.38^{a}	150.00^{bc}	148.63^{d}	150.13^{b}	148.88^{cd}	0.30
Total cost of feed consumed/bird (₦)	178.78^{c}	171.30^{e}	177.61^{d}	220.69^{a}	190.86^{b}	4.70
Cost of feed/Kg weight gain (₦ /Kg)	364.86^{b}	321.99^{c}	303.09^{d}	387.18^{a}	297.30^{e}	9.43
Mortality (%)	4.00^{b}	0.67^{c}	0.67^{c}	6.00^{a}	3.33^{b}	0.57

Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

4.6 **Growth response of finishing broiler chickens fed diets containing soyabean hull**

The performance characteristics of finishing broiler chickens fed soyabean hull treated with *Zymomonas mobilis* based diets is shown in Table 12. The dietary treatments significantly ($p<0.05$) influenced the final body weight, average and daily weight gain. The daily weight gain values ranged between 51.89g and 60.54g, the birds fed 50% ZTSBH had the highest value while birds fed 100% ZTSBH had the least value. The average feed intake was significantly ($p<0.05$) influenced by the dietary treatments. The birds fed the control diet had the highest value which was statistically ($p>0.05$) similar to the value obtained in birds fed 50% ZTSBH. The dietary treatments did not statistically affect ($p>0.05$) the daily feed intake and the feed conversion ratio. The highest numerical value of 2.76 of FCR was observed in broiler chickens fed control diet while the least value of 2.50 was recorded for broiler chickens fed 50% ZTSBH. The protein efficiency ratio was significantly ($p<0.05$) influenced by the dietary treatments. The value ranged between 1.86 and 2.16, the birds fed 50% UTSBH and 100% UTSBH had statistically similar ($p>0.05$) and highest value while birds with the lowest value was observed in 50% ZTSBH. The dietary treatments significantly ($p<0.05$) influenced the total cost of feed consumed/bird and cost of feed/kg weight gain. The birds fed the control diet had statistically highest values for the total cost of feed consumed/bird and cost of feed/kg weight gain. However, the birds fed 50% UTSBH and 100% ZTSBH had least values which are statistically similar for total cost of feed consumed/bird while the birds fed 50% UTSBH, 100% UTSBH and 50% ZTSBH had similar ($p>0.05$) lowest values for cost of feed/kg weight gain. There was significant ($p<0.05$) influence observed in mortality across the dietary treatments.

The values ranged between 0.67 and 6.67%.

Table 12: Performance characteristics of finishing broiler chickens (5 – 8weeks) fed diets containing untreated and treated Soyabean hull

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTSBH	100% UTSBH	50% ZTSBH	100% ZTSBH	SEM
Initial body weight (g/bird)	525.00[e]	565.00[d]	621.00[b]	605.00[c]	675.00[a]	13.63
Final body weight (g/bird)	2100.00[b]	2072.00[b]	2248.00[a]	2300.00[a]	2128.00[b]	26.08
Average weight gain (g/bird)	1575.00[bc]	1507.00[c]	1627.00[ab]	1695.00[a]	1453.00[d]	25.05
Daily weight gain (g/bird)	56.25[c]	53.82[d]	58.11[b]	60.54[a]	51.89[e]	0.83
Average feed intake (g/bird)	4346.00[a]	3836.00[c]	4144.00[b]	4241.00[ab]	3920.00[c]	54.97
Daily feed intake (g/bird)	155.21	137.00	148.00	151.46	140.00	3.27
Feed conversion ratio	2.76	2.55	2.55	2.50	2.71	0.04
Protein efficiency ratio	1.86[c]	2.16[a]	2.14[a]	1.99[b]	2.01[b]	0.03
Cost of the feed/Kg (₦/Kg)	162.63[a]	159.88[b]	157.13[c]	160.13[b]	157.63[c]	0.55
Total cost of feed consumed/bird (₦)	706.79[a]	613.30[d]	651.15[c]	679.11[b]	617.91[d]	9.58
Cost of feed/Kg weight gain (₦ /Kg)	448.76[a]	406.97[c]	400.21[c]	400.66[c]	425.26[b]	5.21
Mortality (%)	6.00[a]	2.67[b]	0.67[c]	6.67[a]	4.00[b]	0.62

Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

4.7 Apparent nutrient digestibility of starting broiler chickens fed diets containing SBH

The apparent nutrient digestibility of starting broiler chickens fed diets containing Soyabean hull is shown in Table 13. The dietary treatments did not influence (p>0.05) the crude fibre digestibility. The values of dry matter digestibility ranged between 62.64 and 74.30%, the highest value observed in was statistically (p>0.05) similar to the values obtained in 50% UTSBH and 100% UTSBH. The crude protein digestibility values ranged between 65.94 and 73.67%, the highest value was recorded in 100% ZTSBH which was similar (p>0.05) to the values observed in 50% UTSBH, 100% UTSBH and 50% ZTSBH, however, significantly (p<0.05) lowest value was recorded in the control diet. The values of the neutral detergent fibre digestibility ranged between 55.31 and 66.28%, the highest value was observed in 100% ZTSBH with similar value in 50% UTSBH while the lowest value was recorded in the control diet. The acid detergent fibre digestibility values ranged between 41.92 and 70.24%, the highest value was recorded in the control group while the lowest value was obtained in 50% ZTSBH. The acid detergent lignin digestibility values ranged between 43.45 and 69.61%, the highest value was obtained in the control diet but the lowest value was recorded in 50% ZTSBH. The values of ether extract digestibility ranged between 65.06 and 72.65%, the highest value was observed in 100% ZTSBH with similar (p>0.05) value recorded in 100% UTSBH but the lowest value was recorded in the control diet. The ash digestibility values ranged between 66.42 and 73.28%, the highest value obtained in 50% UTSBH was similar (p>0.05) to the values recorded in 100% UTSBH and 100% ZTSBH. The lowest value in the control diet was similar to

Table 13: Apparent nutrient digestibility of starting broiler chickens (0 – 4weeks) fed diets containing untreated and treated Soyabean hull

	Dietary treatments					
Parameters	1	2	3	4	5	
	Control diet	50% UTSBH	100% UTSBH	50% ZTSBH	100% ZTSBH	SEM
Dry matter digestibility	62.64[c]	73.88[a]	74.18[a]	67.07[b]	74.30[a]	1.29
Crude protein digestibility	65.94[b]	72.26[a]	72.93[a]	71.51[a]	73.67[a]	0.78
Crude fibre digestibility	63.52	64.88	63.95	65.38	65.30	0.32
Acid detergent fibre digestibility	70.24[a]	46.51[c]	49.54[b]	41.92[d]	46.28[c]	2.68
Neutral detergent fibre digestibility	55.31[d]	64.35[ab]	63.73[b]	58.80[c]	66.28[a]	1.11
Acid detergent lignin digestibility	69.61[a]	62.04[c]	50.36[d]	43.45[e]	62.04[b]	2.43
Ether extract digestibility	65.06[c]	68.86[b]	71.82[a]	68.19[b]	72.65[a]	0.77
Ash digestibility	66.42[b]	73.28[a]	73.19[a]	68.39[b]	71.79[a]	0.78
Nitrogen free extract digestibility	63.58[d]	70.69[bc]	72.49[ab]	69.51[c]	73.12[a]	0.94
Calcium digestibility	70.40[bc]	70.06[c]	78.90[a]	71.83[b]	80.18[a]	1.18
Phosphorus digestibility	78.24[b]	81.49[a]	78.69[b]	79.62[b]	82.15[a]	0.45
Apparent metabolizable energy digestibility	64.33[b]	72.62[a]	73.23[a]	66.24[b]	73.63[a]	1.08

Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean

the value obtained in 50% ZTSBH. The values of nitrogen free extract digestibility ranged between 63.58 and 73.12%, the highest value was recorded in 100% ZTSBH similar to the valuein 100% UTSBH but the lowest value was obtained in the control diet. The values of Calcium digestibility ranged between 70.06 and 80.18%, the highest value ($p<0.05$) was recorded in 100% ZTSBH which was similar to the value obtained in 100% UTSBH but the lowest value was recorded in 50% UTSBH. The Phosphorus digestibility value ranged between 78.24 and 82.15%. The highest value was recorded in 100% ZTSBH which was similar ($p>0.05$) to the value in 50% UTSBH. However, least values were obtained in control diet, 100% UTSBH and 50% ZTSBH. The apparent metabolizable energy digestibility values ranged between 64.33 and 73.63%, the highest value was recorded in the birds fed 100% ZTSBH which had similar value with birds fed 50% UTSBH and 100% UTSBH. The broiler chickens fed the control diet had lowest value which was similar ($p>0.05$) to the value obtained in 50% ZTSBH.

4.8 Apparent nutrient digestibility of finishing broiler chickens fed diets containing SBH

The apparent nutrient digestibility of finishing broiler chickens fed soyabean hull treated with *Zymomonas mobilis* based diets are shown in Table 14. The dietary treatments significantly ($p<0.05$) influenced the nutrient digestibility of the finishing broiler chickens. The values of dry matter digestibility ranged between 53.17 and 71.00%, the highest value obtained in 100% UTSBH while the significantly ($p<0.05$) lowest value was recorded in 50% ZTSBH. The crude protein digestibility values ranged between 65.98 and 72.33%, the highest value recorded in 100% ZTSBH was similar ($p>0.05$) to the value obtained in 100% UTSBH but the lowest value was recorded in birds fed 50% ZTSBH. The crude fibre digestibility values ranged

Table 14: Apparent nutrient digestibility of finishing broiler chickens (5 – 8weeks) fed diets containing untreated and treated Soyabean hull

	Dietary treatments					
Parameters	1	2	3	4	5	
	Control diet	50% UTSBH	100% UTSBH	50% ZTSBH	100% ZTSBH	SEM
Dry matter digestibility	59.00^{d}	60.83^{c}	71.00^{a}	53.17^{e}	66.27^{b}	1.65
Crude protein digestibility	69.16^{b}	69.17^{b}	71.50^{a}	65.98^{c}	72.33^{a}	0.63
Crude fibre digestibility	56.67^{c}	58.33^{c}	66.50^{a}	57.60^{c}	61.81^{b}	0.99
Acid detergent fibre digestibility	59.00^{c}	57.79^{c}	62.82^{b}	55.73^{d}	66.23^{a}	1.02
Neutral detergent fibre digestibility	50.24^{d}	53.91^{c}	64.49^{a}	47.78^{e}	59.90^{b}	1.66
Acid detergent lignin digestibility	63.64^{c}	66.48^{b}	72.50^{a}	61.30^{d}	64.85^{bc}	1.03
Ether extract digestibility	65.00^{c}	60.28^{d}	70.18^{a}	56.71^{e}	66.74^{b}	1.29
Ash digestibility	61.61^{d}	64.15^{c}	71.00^{a}	63.08^{cd}	66.63^{b}	0.90
Nitrogen free extract digestibility	55.86^{c}	51.11^{d}	65.23^{a}	54.90^{c}	62.00^{b}	1.38
Calcium digestibility	69.39^{c}	69.51^{c}	67.49^{d}	71.84^{b}	85.07^{a}	1.71
Phosphorus digestibility	70.28^{d}	72.66^{c}	82.40^{a}	72.41^{c}	78.15^{b}	1.20
Apparent metabolizable energy digestibility	66.12^{c}	67.71^{c}	74.37^{a}	56.53^{d}	70.30^{b}	1.60

Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean

between 56.67 and 66.50%, the significantly highest value was observed in 100% UTSBH while the lowest value recorded in the control diet was similar (p>0.05) to the values obtained in 50% UTSBH and 50% ZTSBH. The acid detergent fibre digestibility values ranged between 55.73 and 66.23%, the birds fed 100% ZTSBH had significantly (p<0.05) highest value while birds fed 50% ZTSBH had the lowest value. The values of neutral detergent fibre digestibility values ranged between 47.78 and 64.49%, the birds fed 100% UTSBH had the highest value while the lowest value was recorded in 50% UTSBH. The acid detergent lignin digestibility values ranged between 61.30 and 72.50%, the highest value was observed in 100% UTSBH while the lowest value was obtained in 50% ZTSBH. The birds fed 100% UTSBH had significantly (p<0.05) highest value of 70.18% for ether extract digestibility and the lowest value of 56.71% was recorded in 50% ZTSBH. The ash digestibility value ranged between 61.61 and 71.00%, the highest value was recorded in 100% UTSBH with the lowest value was observed in the control diet. The nitrogen free extract digestibility value ranged between 51.11 and 65.23%, birds fed 100% UTSBH had statistically (p<0.05) highest value and lowest value was recorded in 50% UTSBH. The value of Calcium digestibility ranged between 67.49 and 85.07%, the highest value was recorded in 100% ZTSBH and the lowest value was in 100% UTSBH. The Phosphorus digestibility values ranged between 70.28 and 82.40%, the birds fed 100% UTSBH had highest (p<0.05) value while the lowest value was obtained in the control group. The highest value (74.37%) for apparent metabolizable energy digestibility was observed in 100% UTSBH and lowest value (56.53%) was recorded in 50% ZTSBH.

4.9 Haematological parameters and serum metabolites of starting broiler chickens fed diets containing SBH

The haematological and serum metabolites of starting broiler chickens fed soyabean hull treated with *Zymomonas mobilis* based diets are shown in Table 15. The dietary treatments significantly ($p<0.05$) affected the packed cell volume, haemoglobin, red blood cell and white blood cell. The starting broiler chickens fed the control diet had statistically ($p>0.05$) similar values with birds fed diets 100% UTSBH, 50% ZTSBH and 100% ZTSBH for packed cell volume and haemoglobin. The red blood cell values ranged between 2.10 and 2.75 ($x10^{12L}$) with birds on 100% ZTSBH had the highest value which was statistically similar to the values obtained in birds fed the control diet and 100% UTSBH and 50% ZTSBH. The least value was observed in birds fed 50% UTSBH. There was no significant ($p>0.05$) differences observed in MCH, MCHC and MCV. However, the dietary treatments significantly ($p<0.05$) influenced the heterophil, lymphocytes, eosinophil, monocytes and basophils. The serum metabolites were statistically ($p<0.05$) affected by the dietary treatments. The total protein values ranged between 2.45 and 3.75g/dl with the birds fed 50% UTSBH had the highest value and the least value was recorded in birds fed the control diet. The highest value of glucose was recorded in birds fed 100% ZTSBH while the lowest value was recorded in birds fed the control diet. The values of the cholesterol ranged between 77.00 and 100.00mg/dl, the highest value was recorded in birds fed 50% ZTSBH while the least value was observed in the birds fed the control diet. The birds fed the control diet, 50% UTSBH and 50% ZTSBHhad similar ($p>0.05$) values for uric acid while the least value obtained in 100% UTSBH was similar to the value recorded in 100% ZTSBH. The broiler birds fed 100% ZTSBH had highest value of AST which was similar to the values in the control group, 50% UTSBH and 100% UTSBH.

Table 15: Haematological parameters and serum metabolites of starting broiler chickens (0 – 4 weeks) fed diets containing untreated and treated Soyabean hull

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTSBH	100% UTSBH	50% ZTSBH	100% ZTSBH	SEM
Haematological parameters:						
Packed cell volume (%)	30.50^{ab}	25.00^{c}	31.00^{ab}	29.00^{b}	32.50^{a}	0.73
Haemoglobin (g/dl)	10.10^{ab}	8.30^{c}	9.65^{b}	9.30^{b}	10.60^{a}	0.62
Red blood cell ($x10^{12/L}$)	2.37^{ab}	2.10^{b}	2.50^{ab}	2.40^{ab}	2.75^{a}	0.08
Mean Corpuscular Haemoglobin (pg)	40.43	39.54	39.64	38.77	38.49	0.83
Mean Corpuscular Haemoglobin in Concentration (g/dl)	33.12	33.28	31.15	32.11	32.57	0.39
Mean Corpuscular Volume (fl)	122.18	118.92	128.00	121.09	118.19	3.31
White blood cell ($x10^{9/L}$)	11.85^{c}	22.90^{a}	23.00^{a}	19.25^{b}	21.30^{a}	1.13
Heterophil (%)	34.50^{a}	30.50^{b}	29.00^{b}	34.00^{a}	30.50^{b}	0.63
Lymphocytes (%)	64.50^{b}	68.00^{a}	68.00^{a}	64.50^{b}	68.00^{a}	0.49
Eosinophil (%)	0.00^{b}	0.00^{b}	0.50^{a}	0.50^{a}	0.00^{b}	0.08
Monocytes (%)	0.50^{b}	1.00^{ab}	1.00^{ab}	1.00^{ab}	1.50^{a}	0.14
Basophils (%)	0.50^{b}	0.50^{b}	1.50^{a}	0.00^{b}	0.00^{b}	0.16
Serum metabolites:						
Total protein (g/dl)	2.45^{d}	3.75^{a}	3.15^{b}	2.95^{bc}	2.75^{c}	0.12
Albumin (g/dl)	1.40^{c}	1.80^{b}	2.10^{a}	1.45^{c}	1.75^{b}	0.07
Globulin (g/dl)	2.05^{a}	1.95^{a}	1.05^{c}	1.50^{b}	1.00^{c}	0.13
Glucose (mg/dl)	97.00^{d}	106.00^{c}	129.50^{b}	77.00^{e}	134.00^{a}	5.65
Cholesterol (mg/dl)	77.00^{d}	82.00^{c}	91.00^{b}	100.00^{a}	89.50^{b}	2.13
Uric Acid (mg/dl)	5.20^{a}	5.20^{a}	3.15^{c}	4.60^{ab}	4.00^{bc}	0.23
Creatinine (mg/dl)	0.70^{b}	0.45^{c}	0.35^{c}	0.20^{d}	0.90^{a}	0.07
Aspartate Amino-Transferase (U/L)	58.50^{a}	55.50^{a}	57.50^{a}	48.50^{b}	60.00^{a}	1.18
Alanine Amino-Transferase (U/L)	28.50^{b}	21.50^{d}	30.50^{a}	24.00^{c}	22.00^{d}	0.99

Means on the same row having different superscripts are significantly different (P<0.05); SEM: Standard Error of Mean

However, the least value was obtained in birds fed 50% ZTSBH. The highest value of ALT was obtained in 100% UTSBH while the least value in 50% UTSBH was similar to the value in 100% ZTSBH.

4.10 Haematological parameters and serum metabolites of finishing broiler chickens fed diets containing SBH

The haematological and serum metabolites of finishing broiler chickens (5 – 8weeks) fed treated and untreated soyabean hull are shown in Table 16. The dietary treatments did not influence (p>0.05) MCHC of the broiler chickens. The birds fed 50% UTSBH had significantly highest values for packed cell volume, haemoglobin and red blood cell while the least value for red blood cell was recorded in birds fed the control diet. The values of white blood cells ranged between 14.70 and 24.60($x10^{9/L}$), the highest value was observed in birds fed 50% ZTSBH while the least value was recorded in birds fed the control diet. The birds fed the control diet had highest values for MCH and MCV which are statistically similar to the values obtained in birds fed 50% UTSBH. The values obtained in birds fed 50% UTSBH had statistically similar values with birds fed 100% UTSBH, 50% ZTSBH and100% ZTSBH. The dietary treatments significantly (p<0.05) influenced the serum metabolites. The highest values for total protein was observed in birds fed the 100% UTSBH which was statistically similar to values obtained in birds fed control diet and 100% ZTSBH. The least value was recorded in birds fed 50% UTSBH. The values of glucose ranged between 100.00 and 131.00(mg/dl), the highest value was recorded in birds fed 100% UTSBH and lowest value recorded in birds fed the control diet. The cholesterol values ranged between 72.00 and 100.00(mg/dl), the highest value was observed in birds fed the control diet and the least value was recorded in birds fed 50% UTSBH. The birds fed 100% UTSBH had highest (p<0.05) value of uric acid which was similar

Table 16: Haematological parameters and serum metabolites of finishing broiler chickens (5– 8weeks) fed diets containing untreated and treated Soyabean hull

Parameters	Dietary treatments 1	2	3	4	5	
	Control diet	50% UTSBH	100% UTSBH	50% ZTSBH	100% ZTSBH	SEM
Haematological parameters:						
Packed cell volume (%)	38.00^{b}	47.00^{a}	37.00^{b}	36.00^{b}	39.00^{b}	1.15
Haemoglobin (g/dl)	12.20^{b}	14.80^{a}	12.00^{b}	11.70^{b}	12.80^{b}	0.34
Red blood cell ($x10^{12/L}$)	2.90^{d}	3.80^{a}	3.20^{c}	3.20^{c}	3.40^{b}	0.08
Mean Corpuscular Haemoglobin (pg)	42.07^{a}	38.95^{ab}	37.51^{b}	36.55^{b}	37.67^{ab}	0.72
Mean Corpuscular Haemoglobin in Concentration (g/dl)	32.12	31.57	32.50	32.48	32.93	0.54
Mean Corpuscular Volume (fl)	131.10^{a}	123.66^{ab}	115.62^{b}	112.46^{b}	114.67^{b}	2.28
White blood cell ($x10^{9/L}$)	14.70^{d}	20.80^{b}	16.90^{c}	24.60^{a}	18.00^{c}	0.93
Heterophil (%)	33.00^{a}	36.00^{a}	27.00^{b}	34.00^{a}	37.00^{a}	1.06
Lymphocytes (%)	65.00^{b}	62.00^{bc}	69.00^{a}	65.00^{b}	61.00^{c}	0.86
Eosinophil (%)	1.00^{a}	0.00^{b}	1.00^{a}	0.00^{b}	1.00^{a}	0.16
Monocytes (%)	1.00^{ab}	2.00^{a}	2.00^{a}	0.00^{b}	1.00^{ab}	0.24
Basophils (%)	0.00^{b}	0.00^{b}	1.00^{a}	1.00^{a}	0.00^{b}	0.15
Serum metabolites:						
Total protein (g/dl)	3.30^{ab}	2.60^{c}	3.60^{a}	3.00^{bc}	3.50^{ab}	0.11
Albumin (g/dl)	2.10^{b}	1.50^{d}	1.90^{c}	2.40^{a}	1.80^{c}	0.08
Globulin (g/dl)	1.20^{b}	1.10^{b}	1.70^{a}	0.60^{c}	1.70^{a}	0.11
Glucose (mg/dl)	100.00^{b}	126.00^{a}	131.00^{a}	127.00^{a}	124.00^{a}	3.12
Cholesterol (mg/dl)	100.00^{a}	72.00^{c}	98.00^{b}	97.00^{a}	91.00^{b}	2.79
Uric Acid (mg/dl)	3.50^{ab}	3.00^{b}	4.20^{a}	3.30^{ab}	3.40^{ab}	0.17
Creatinine (mg/dl)	0.50^{b}	0.20^{c}	0.60^{ab}	0.60^{ab}	0.80^{a}	0.06
Aspartate Amino-Transferase (U/L)	47.00^{c}	46.00^{c}	52.00^{b}	56.00^{a}	50.00^{b}	1.00
Alanine Amino-Transferase (U/L)	20.00^{bc}	26.00^{a}	21.00^{abc}	25.00^{ab}	17.00^{c}	1.08

Means on the same row having different superscripts are significantly different ($P<0.05$); SEM: Standard Error of Mean

to the values obtained in control diet, 50% ZTSBH and 100% ZTSBH while the least value recorded in 50% UTSBH was similar to the values in the control group, 50% ZTSBH and 100% ZTSBH. The birds fed 50% ZTSBH had highest value for AST but the lowest value in 50% UTSBH was similar to the value in the control group. The ALT value ranged between 17.00 and 26.00 (U/L), the highest value was obtained in 50% UTSBH while the lowest value recorded in 100% ZTSBH was similar to the value obtained for birds fed control diet and 100% UTSBH.

4.11 Carcass characteristics of broiler chickens fed diets containing treated and untreated SBH

The carcass characteristics of broiler chickens fed diets containing treated and untreated soyabean hull is shown in Table 17. The dietary treatments significantly ($p<0.05$) influenced the eviscerated weight. The highest value was recorded in birds fed 50% ZTSBH while the least value was observed in birds fed 50% UTSBH.

The cut parts were significantly ($p<0.05$) affected by the dietary treatments. The breast values ranged between 20.00 and 25.22%, the highest value was observed in birds fed 50% ZTSBH while the least value was recorded in birds fed the control diet which was similar ($p>0.05$) to the values obtained in birds fed other diets. The thigh values ranged from 7.83 and 9.78%, the highest value was recorded in birds fed 100% UTSBH while the least value was recorded in birds fed 100% ZTSBH. The highest values for drumstick and back of the broiler chickens were recorded in the control group while the least values were obtained in 50% ZTSBH. The organ weight was affected ($p<0.05$) by the dietary treatments. The birds fed 50% UTSBH had higher ($p<0.05$) values for spleen, liver, kidneys and gizzard while birds fed 100% UTSBH had least values for spleen and liver. However, the birds fed 50% ZTSBH had least values for kidneys and gizzard. The whole gastro-intestinal tract values ranged

Table 17: Carcass characteristics of broiler chickens fed diets containing untreated and treated Soyabean hull

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTSBH	100% UTSBH	50% ZTSBH	100% ZTSBH	SEM
Live weight (g)	2100.00	2100.00	2250.00	2300.00	2100.00	34.23
Dressed weight (g)	2020.00	2040.00	2040.00	2040.00	1920.00	19.89
Eviscerated weight (g)	1480.00^{ab}	1420.00^{b}	1540.00^{ab}	1580.00^{a}	1500.00^{ab}	19.83
Dressing percentage (%)	70.60	67.63	68.89	68.85	71.43	1.20
Cut parts (% of LW)						
Head (%)	3.81^{a}	2.86^{c}	2.67^{d}	3.48^{b}	2.86^{c}	0.12
Breast (%)	20.00^{b}	21.90^{b}	22.22^{b}	25.22^{a}	21.90^{b}	0.55
Thigh (%)	8.57^{c}	9.52^{b}	9.78^{a}	7.83^{d}	9.52^{b}	0.20
Drumstick (%)	11.43^{a}	9.52^{c}	10.67^{b}	8.70^{d}	10.48^{b}	0.27
Wing (%)	8.57^{b}	8.57^{b}	8.89^{a}	7.83^{c}	8.57^{b}	0.10
Back (%)	17.14^{a}	16.19^{c}	16.89^{b}	15.65^{d}	14.29^{e}	0.27
Neck (%)	4.76^{a}	2.86^{e}	3.56^{d}	4.35^{b}	3.81^{c}	0.17
Shank (%)	4.76^{a}	4.76^{a}	3.56^{b}	3.81^{b}	3.81^{b}	0.15
Organ weight (% of LW)						
Heart (%)	0.77^{a}	0.49^{c}	0.54^{b}	0.56^{b}	0.50^{c}	0.03
Spleen (%)	0.11^{ab}	0.14^{a}	0.07^{b}	0.11^{ab}	0.13^{a}	0.01
Liver (%)	1.67^{bc}	1.90^{a}	1.56^{c}	1.74^{ab}	1.10^{d}	0.07
Kidneys (%)	0.29^{a}	0.29^{a}	0.18^{b}	0.17^{b}	0.29^{a}	0.02
Gizzard (%)	2.86^{a}	2.86^{a}	2.67^{b}	2.61^{b}	2.86^{a}	0.03
Whole GIT (%)	18.10^{a}	10.48^{d}	11.56^{c}	13.04^{b}	12.38^{bc}	0.71

Means on the same row having different superscripts are significantly different ($P<0.05$)

LW: Live weight

GIT: Gastro-intestinal tract

SEM: Standard Error of Mean

between 10.48 and 18.10%, the highest value was observed in birds fed the control diet and the least value was observed in birds fed 50% UTSBH.

4.12 Viscosity of ileal digesta of broiler chickens fed diets containing SBH

The viscosity of ileal digesta of broiler chickens fed soyabean hull treated with *Zymomonas mobilis* based diets is shown in Table 18. The dietary treatments significantly ($p<0.05$) influenced the ileal digesta of broiler chickens fed the experimental diets. At 100rpm, the highest ($p<0.05$) value (1.56cps) was obtained in 50% ZTSBH and the lowest value (1.10cps) was recorded in 100% UTSBH.

4.13 Sensory evaluation of meats of broiler chickens fed diets containing SBH

The sensory evaluation of meats from broiler chickens fed diets containing treated and untreated soyabean hull is shown in Table 19. The dietary treatments significantly ($p<0.05$) influenced the colour, flavour and overall acceptability but did not influence ($p>0.05$) juiciness and tenderness. The birds fed 100% ZTSBH had highest value for meat colour while the least value was recorded in 50% UTSBH. The highest value for flavour of the meat was recorded in 50% ZTSBH while the lowest value obtained in 100% ZTSBH was similar to the values recorded in 50% UTSBH and 100% UTSBH. The overall acceptability values ranged between 6.00 and 6.65, the highest value was obtained in birds fed the control diet while the least value was recorded in birds fed 100% ZTSBH.

4.14 The economy of feed conversion of broiler chickens fed diets containing SBH

The economy of feed conversion of broiler chickens fed soyabean hull with *Zymomonas mobilis* based diets is shown in Table 20. The dietary treatments significantly ($p<0.05$) affected the cost of the feed, gross revenue/broiler and gross profit. The highest value for the cost of the feed /kg was recorded in the control diet

Table 18: Viscosity of Ileal digesta of broiler chickens fed diets containing untreated and treated Soyabean hull

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTSBH	100% UTSBH	50% ZTSBH	100% ZTSBH	SEM
50rpm	1.42^{e}	1.61^{c}	1.53^{d}	2.84^{a}	2.42^{b}	0.15
60rpm	1.40^{d}	1.48^{c}	1.15^{e}	2.09^{a}	1.81^{b}	0.09
100rpm	1.33^{c}	1.31^{c}	1.10^{d}	1.56^{a}	1.50^{b}	0.04

^{abcde} Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

Table 19: Sensory evaluation of meat from broiler chickens fed diets containing untreated and treated Soyabean hull

Parameters	Dietary Treatments					
	1	2	3	4	5	
	Control diet	50% UTSBH	100% UTSBH	50% ZTSBH	100% ZTSBH	SEM
Colour	6.10^{b}	5.95^{c}	6.20^{b}	6.35^{a}	6.45^{a}	0.05
Juiciness	5.65	5.65	5.90	5.75	5.75	0.04
Flavour	5.90^{b}	5.85^{bc}	5.75^{bc}	6.20^{a}	5.70^{c}	0.05
Tenderness	6.00	5.90	5.95	5.85	5.75	0.06
Overall acceptability	6.65^{a}	6.10^{bc}	6.25^{b}	6.15^{bc}	6.00^{c}	0.07

^{abc}Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean

Table 20: Economy of feed conversion of broiler chickens fed diets containing untreated and treated Soyabean hull

Parameters	1 Control diet	2 50% UTSBH	3 100% UTSBH	4 50% ZTSBH	5 100% ZTSBH	SEM
Cost of the feed/Kg (₦/Kg)	162.63^{a}	159.88^{b}	157.13^{c}	160.13^{b}	157.63^{c}	0.55
Price/Kg live weight (₦)	750.00	750.00	750.00	750.00	750.00	0.00
Cost of production/broiler (₦/broiler)	1270.78	1169.81	1213.97	1285.01	1193.98	20.71
Gross revenue/broiler (₦/broiler)	1575.00^{b}	1551.75^{b}	1686.00^{a}	1725.00^{a}	1592.54^{b}	18.61
Gross profit (₦)	304.22^{e}	381.94^{d}	472.03^{a}	439.99^{b}	399.77^{c}	15.30
Rate of return on Investment (%)	23.94^{c}	32.65^{b}	38.88^{a}	34.24^{b}	33.48^{b}	1.32
Economic efficiency	0.34^{b}	0.49^{a}	0.57^{a}	0.49^{a}	0.49^{a}	0.02
Relative cost benefit (%)	0.00^{d}	9.31^{b}	10.82^{a}	2.39^{c}	1.17^{cd}	1.20

Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean

while the least value was recorded in 100% UTSBH. The birds fed 100% UTSBH had significantly ($p<0.05$) highest values for gross revenue, gross profit, rate of return on investment, economic efficiency and relative cost benefit while the least values were observed in birds fed the control diet. However, the least value for gross revenue was recorded in 50% UTSBH which was similar to the value recorded in the control diet and value obtained in birds fed 100% ZTSBH. The dietary treatments did not affect ($p>0.05$) the daily feed intake and feed conversion ratio. The relative cost benefit values ranged between 0.00 and 10.82%, the highest value was observed in 100% UTSBH while the least value was recorded in the control diet.

4.15 **Growth response of starting broiler chickens fed cassava sifting based diets**

The performance characteristics of starting broiler chickens fed Cassava sifting based diets are shown in Table 21. The birds fed the control diet significantly (p<0.05) had the highest values for the final body weight, average weight gain and daily weight gain while the lowest values were observed in birds fed 100% Zymomonas mobilis cassava sifting (100% ZTCS). The dietary treatments did not significantly (p>0.05) affect the average feed intake but the birds fed 100% untreated cassava sifting (100% UTCS) had numerical highest value of 1449.00g and birds fed 100% ZTCS had the lowest value of 1066.00g. The dietary treatments influenced (p<0.05) the daily feed intake, feed conversion ratio and protein efficiency ratio. The daily feed intake values ranged between 39.48 and 50.26g, the birds fed 50% UTCS had the highest value while the birds fed 100% ZTCS had the least value. The birds fed 100% UTCS had highest value of 2.34 and the least value of 1.73 was observed in birds fed 50% ZTCS for feed conversion ratio. The protein efficiency ratio obtained in birds fed the control diet, 50% UTCS and 50% ZTCS were similar (p>0.05) to the highest value recorded in the control diet. The least value was observed in birds fed 100% UTCS which was similar (p>0.05) to the value in 100% ZTCS. The dietary treatments influenced (p<0.05) the total cost of feed consumed/bird and cost of feed/kg weight gain. The cost of feed ranged between ₦175.02 and ₦237.53, the highest value was obtained in 100% UTCS while the lowest value was observed in 100% ZTCS. Moreover, the cost of feed/kg weight gain highest value of ₦383.12 was recorded in 100% UTCS but the lowest value of ₦284.89 was obtained in diet 50% ZTCS. The mortality highest value obtained in 100% UTCS was similar (p>0.05) to the value obtained in 100% ZTCS, however, similar (p>0.05) lower values were obtained in birds fed the control diet,

Table 21: Performance characteristics of starting broiler chickens (0 – 4weeks) fed diets containing untreated and treated cassava sifting

	Dietary treatments					
Parameters	1	2	3	4	5	
	Control diet	50% UTCS	100% UTCS	50% ZTCS	100% ZTCS	SEM
Initial body weight (g/bird)	38.00	40.00	40.00	40.00	40.00	0.54
Final body weight (g/bird)	757.00^{a}	700.00^{c}	660.00^{d}	726.00^{b}	548.00^{e}	19.39
Average weight gain (g/bird)	719.00^{a}	660.00^{c}	620.00^{d}	686.00^{b}	508.00^{e}	19.54
Daily weight gain (g/bird)	25.68^{a}	23.57^{c}	22.14^{d}	24.50^{b}	18.14^{e}	0.70
Average feed intake (g/bird)	1348.00^{c}	1357.00^{b}	1449.00^{a}	1190.00^{d}	1066.00^{e}	36.45
Daily feed intake (g/bird)	49.93^{c}	50.26^{b}	53.67^{a}	44.07^{d}	39.48^{e}	1.35
Feed conversion ratio	1.87^{c}	2.06^{b}	2.34^{a}	1.73^{d}	2.10^{b}	0.06
Protein efficiency ratio	2.52^{a}	2.47^{a}	2.09^{b}	2.56^{a}	2.14^{b}	0.06
Cost of the feed/Kg (₦/Kg)	164.38	164.15	163.93	164.23	164.18	0.14
Total cost of feed consumed/bird (₦)	221.58^{b}	222.75^{b}	237.53^{a}	195.43^{c}	175.02^{d}	6.17
Cost of feed/Kg weight gain (₦ /Kg)	308.18^{c}	337.50^{b}	383.12^{a}	284.89^{d}	344.52^{b}	9.23
Mortality (%)	1.60^{b}	1.60^{b}	4.00^{a}	1.60^{b}	3.20^{a}	0.30

Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

50% UTCS and 50% ZTCS.

4.16 Growth response of finishing broiler chickens fed cassava sifting based diets

The performance characteristics of finishing broiler chickens fed cassava sifting based diets are shown in Table 22. The dietary treatments affected ($p<0.05$) the final body weight, average weight gain and daily weight gain. The birds fed 50% ZTCS had highest values for final body weight, average weight gain and daily weight gain while birds fed 100% UTCS which was similar ($p>0.05$) to the values recorded in the control group and 100% UTCS. However, the birds fed control diet had least values of average weight gain and daily weight gain. The birds fed 50% UTCS had highest ($p<0.05$) values for average feed intake and daily feed intake but the least values were recorded in 100% UTCS. The dietary treatments did not influence ($p>0.05$) the feed conversion ratio and protein efficiency ratio. The feed conversion ratio values ranged between 3.03 and 3.78, the birds fed control diet had numerical ($p>0.05$) highest value while the least value was recorded in the 50% ZTCS. The birds fed the 100% ZTCS had numerical ($p>0.05$) highest value of 1.61 while the birds fed control diet had the least value for protein efficiency ratio. The birds fed 50% UTCS had highest ($p<0.05$) value for total cost of feed consumed/bird which was similar to the value recorded in 50% ZTCS, but the least value was observed in 100% UTCS. The highest value for cost of feed/kg weight gain was observed in the control group while the lowest value recorded in 50% ZTCS was similar to the value in 50% UTCS. The highest value of mortality recorded in 100% UTCS was similar to the value obtained in 100% ZTCS while the least value obtained in the control group had similar value in 50% ZTCS.

Table 22: Performance characteristics of finishing broiler chickens (5 – 8weeks) fed diets containing untreated and treated cassava sifting

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTCS	100% UTCS	50% ZTCS	100% ZTCS	SEM
Initial body weight (g/bird)	757.00^{a}	700.00^{ab}	660.00^{b}	726.00^{ab}	548.00^{c}	21.72
Final body weight (g/bird)	1570.00^{c}	1770.00^{b}	1550.00^{c}	1820.00^{a}	1560.00^{c}	31.36
Average weight gain (g/bird)	813.00^{d}	1070.00^{a}	890.00^{c}	1094.00^{a}	1012.00^{b}	29.10
Daily weight gain (g/bird)	29.04^{c}	38.21^{b}	31.79^{bc}	39.07^{a}	36.14^{ab}	1.25
Average feed intake (g/bird)	3077.00^{d}	3333.00^{a}	2893.00^{e}	3316.00^{b}	3200.00^{c}	43.76
Daily feed intake (g/bird)	109.89^{b}	119.04^{a}	103.32^{c}	118.43^{b}	114.29^{ab}	1.73
Feed conversion ratio	3.78	3.11	3.25	3.03	3.29	0.21
Protein efficiency ratio	1.18	1.46	1.33	1.41	1.61	0.12
Cost of the feed/Kg (₦/Kg)	178.89	177.89	176.89	178.14	177.39	0.64
Total cost of feed consumed/bird (₦)	550.44^{c}	592.91^{a}	511.74^{d}	590.71^{a}	567.65^{b}	8.24
Cost of feed/Kg weight gain (₦ /Kg)	677.05^{a}	554.12^{cd}	574.99^{bc}	539.96^{d}	584.00^{b}	13.13
Mortality (%)	1.60^{d}	3.20^{bc}	4.80^{a}	2.40^{cd}	4.00^{ab}	0.35

Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean

4.17 **Apparent nutrient digestibility of starting broiler chickens fed cassava sifting based diets**

The apparent nutrient digestibility of starting broiler chickens fed cassava sifting based diets is shown in Table 23. The dietary treatments did not influence (p>0.05) crude protein digestibility of the starting broiler chickens. The dry matter digestibility values ranged between 63.33 and 74.12%, the highest value observed in 100% ZTCS was similar (p>0.05) to the value in the control diet, but the lowest value in 100% UTCS was similar to the value in 50% ZTCS. The values of crude fibre digestibility ranged between 55.76 and 73.38%, the highest value was in 100% ZTCS had similar value in 100% UTCS while the lowest value was recorded in 50% UTCS. The acid detergent fibre digestibility values ranged between 70.81 and 78.30%, the highest value in 100% ZTCS had similar value with the values in 100% UTCS and 50% ZTCS. The lowest value in 50% UTCS was similar (p>0.05) to the values recorded in the control diet, 100% UTCS and 50% ZTCS. The values of neutral detergent fibre digestibility ranged between 65.35 and 74.54%, the birds fed 100% ZTCS had highest value which was similar to the value in the control diet. The lowest value in 50% UTCS was similar to the values in 100% UTCS and 50% ZTCS. The acid detergent lignin digestibility values ranged between 41.38 and 67.06%, the highest value was in 100% ZTCS but

Table 23: Apparent nutrient digestibility of starting broiler chickens (0 – 4weeks) fed diets containing untreated and treated cassava sifting

	Dietary treatments					
Parameters	1	2	3	4	5	
	Control diet	50% UTCS	100% UTCS	50% ZTCS	100% ZTCS	SEM
Dry matter digestibility	70.91^{ab}	63.33^{d}	68.24^{bc}	65.71^{cd}	74.12^{a}	1.14
Crude protein digestibility	75.92	73.19	75.25	74.46	77.61	0.65
Crude fibre digestibility	67.88^{b}	55.76^{d}	70.44^{ab}	61.63^{c}	73.38^{a}	1.77
Acid detergent fibre digestibility	73.27^{b}	70.81^{b}	74.90^{ab}	74.74^{ab}	78.30^{a}	0.83
Neutral detergent fibre digestibility	72.55^{ab}	65.35^{c}	69.45^{bc}	66.48^{c}	74.54^{a}	1.07
Acid detergent lignin digestibility	60.00^{b}	42.50^{c}	41.94^{c}	41.38^{c}	67.06^{a}	2.94
Ether extract digestibility	75.26^{ab}	70.74^{b}	73.81^{ab}	71.43^{ab}	75.88^{a}	0.75
Ash digestibility	74.76^{ab}	71.67^{b}	72.157^{ab}	73.37^{ab}	76.75^{a}	0.72
Nitrogen free extract digestibility	72.50^{ab}	61.19^{d}	70.95^{bc}	67.48^{c}	76.09^{a}	1.45
Calcium digestibility	78.76^{b}	64.27^{d}	75.70^{c}	64.20^{d}	80.38^{a}	1.89
Phosphorus digestibility	82.64^{bc}	76.36^{d}	81.35^{c}	84.90^{a}	83.62^{ab}	0.81
Apparent metabolizable energy digestibility	72.83^{ab}	68.74^{b}	70.22^{ab}	69.07^{b}	74.60^{a}	0.80

Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

the lowest value recorded in 50% ZTCS had similar (p>0.05) value with those in 50% UTCS and 100% UTCS. The values of ether extract digestibility ranged between 70.74 and 75.88%, the highest value in 50% ZTCS was similar (p>0.05) to the values recorded in the control diet, 100% UTCS and 50% ZTCS while the lowest value in 50% UTCS was also similar to the values in the control diet, 100% UTCS and 50% ZTCS. The ash digestibility values ranged between 71.67 and 76.75%, the highest value recorded in diet 5 was similar to the values in the control diet, 50% UTCS and 50% ZTCS. However, the lowest value in 50% UTCS was similar to the values in the control diet, 50% UTCS and 50% ZTCS. The nitrogen free extract digestibility ranged between 61.19 and 76.09%, the highest value in 100% ZTCS was similar to the value obtained in the control diet while the birds fed 50% UTCS had lowest value. The values of Calcium digestibility ranged between 64.20 and 80.38%, the highest value was observed in 100% ZTCS while the least value recorded in 50% ZTCS had similar value in 50% UTCS. The Phosphorus digestibility values ranged between 76.36 and 84.90%, similar highest values were observed in 50% ZTCS and 100% ZTCS, however, the least value was recorded in 50% UTCS. The apparent metabolizable energy digestibility values ranged between 68.74 and 74.60%, the highest value recorded in 100% ZTCS was similar (p>0.05) to the values in the control diet and 100% UTCS but the lowest value in 50% UTCS was similar to the values in the control diet, 100% UTCS and 50% ZTCS.

4.18 Apparent nutrient digestibility of finishing broiler chickens fed cassava sifting based diets

The apparent nutrient digestibility of finishing broiler chickens fed cassava sifting based diet is shown in Table 24. The dietary treatments did not influence (p<0.05) crude protein digestibility, acid detergent fibre digestibility, ether extract digestibility

Table 24: Apparent nutrient digestibility of finishing broiler chickens (5 – 8weeks) fed diets containing untreated and treated cassava sifting

	Dietary treatments					
Parameters	1	2	3	4	5	
	Control diet	50% UTCS	100% UTCS	50% ZTCS	100% ZTCS	SEM
Dry matter digestibility	59.00^{ab}	55.67^{ab}	52.64^{b}	55.67^{ab}	61.73^{a}	1.27
Crude protein digestibility	70.28	67.79	66.99	68.69	71.30	1.04
Crude fibre digestibility	53.75^{b}	49.05^{b}	50.46^{b}	50.83^{b}	62.96^{a}	1.64
Acid detergent fibre digestibility	68.46	60.77	65.23	62.80	64.01	1.17
Neutral detergent fibre digestibility	51.67^{a}	48.45^{ab}	42.98^{b}	47.25^{ab}	51.79^{a}	1.29
Acid detergent lignin digestibility	74.00^{a}	67.30^{ab}	70.08^{a}	60.95^{b}	68.64^{ab}	1.48
Ether extract digestibility	66.15	65.33	69.61	64.62	69.09	1.09
Ash digestibility	68.33^{ab}	70.20^{a}	60.68^{b}	64.31^{ab}	66.36^{ab}	1.30
Nitrogen free extract digestibility	61.06	60.63	61.04	64.13	62.41	1.01
Calcium digestibility	81.18^{ab}	79.88^{b}	69.45^{c}	81.58^{a}	81.06^{ab}	1.25
Phosphorus digestibility	67.54^{c}	73.99^{b}	64.51^{d}	78.20^{a}	78.41^{a}	1.51
Apparent metabolizable energy digestibility	65.42^{ab}	59.81^{ab}	60.09^{ab}	57.81^{b}	66.77^{a}	1.32

Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

and nitrogen free extract digestibility. The highest value (61.73%) recorded in 100% ZTCS for dry matter digestibility was similar to the values obtained in the control diet, 50% UTCS and 50% ZTCS, but the lowest value (52.64%) in 100% UTCS was similar to the values in the control diet, 50% UTCS and 50% ZTCS. The values of crude fibre digestibility ranged between 49.05 and 62.96%, the highest value was recorded in 100% ZTCS while the lowest value in 50% UTCS was similar ($p>0.05$) to the values in the control diet, 50% UTCS, 100% UTCS and 50% ZTCS. The neutral detergent fibre digestibility values ranged between 42.98 and 51.79%, the highest value observed in 100% ZTCS was similar ($p>0.05$) to the values recorded in the control diet, 50% UTCS and 50% ZTCS. But, the lowest value in 100% UTCS was similar to the values obtained in 50% UTCS and 50% ZTCS. The values of acid detergent lignin digestibility ranged between 60.75 and 74.00%, the highest value recorded in the control diet had similar ($p>0.05$) values in diets 50% UTCS, 100% UTCS and 100% ZTCS, however, the lowest value in 50% ZTCS was similar to the values in 50% UTCS and 100% ZTCS. The ash digestibility values ranged between 60.68 and 70.20%, the highest value in 50% UTCS was similar to the values in the control diet, 50% ZTCS and 100% ZTCS. The lowest value in 100% UTCS was similar to the values in the control diet, 50% ZTCS and 100% ZTCS. The highest value (81.58%) for Calcium digestibility recorded in 50% ZTCS was similar to the values in control group and 100% ZTCS, while the least value (69.45%) was observed in birds fed 100% UTCS. The Phoshorus digestibility values ranged between 64.51 and 78.41%, the highest value in 100% ZTCS had similar value in 50% ZTCS with the least value recorded in 100% UTCS. The values of apparent metabolizable energy digestibility values ranged between 57.81 and 66.77%, the highest value in 100% ZTCS was statistically similar to the values in the control diet, 50% UTCS and 100%

UTCS. However, the lowest value in 50% ZTCS was similar (p>0.05) to the values in the control diet, 50% UTCS and 100% UTCS.

4.19 Haematological parameters and serum metabolites of starting broiler chickens fed cassava sifting based diets

The haematological and serum metabolites of starting broiler chickens fed cassava sifting based diets are shown in Table 25. The dietary treatments did not influence (p>0.05) the red blood cell, MCHC and MCV. The birds fed 100% ZTCS had highest (p<0.05) values for packed cell volume and haemoglobin while the least values were obtained in birds fed 50% ZTCS. The values observed in white blood cell were similar (p>0.05) in birds fed the control diet, 100% UTCS and 100% ZTCS. The highest value of MCH recorded in 50% UTCS had similar values in 100% UTCS and 50% ZTCS but the least value was observed in 100% ZTCS. The values of white blood cell ranged between 10.50 and 13.60 ($x10^{9/L}$), the highest value recorded in 100% UTCS was similar (p>0.05) to the values in control diet and 100% ZTCS. The least value in 50% ZTCS had similar (p>0.05) value recorded in 50% UTCS. The heterophil values were similar (p>0.05) in birds fed the control diet, 50% UTCS, 100% UTCS and 50% ZTCS while the least value obtained in 100% ZTCS had similar (p>0.05) values in diets 50% UTCS, 100% UTCS, and 50% ZTCS. The same highest value observed for lymphocytes in 50% ZTCS and 100% ZTCS was similar (p>0.05) to the values recorded in 50% UTCS and100% UTCS but the least value obtained in the control diet was similar (p>0.05) to the value recorded in 100% UTCS. The dietary treatments did not affect (p>0.05) serum total protein and uric acid. The glucose values ranged between 100.00 and 136.00 mg/dl with the highest value observed in 50% ZTCS and the lowest value obtained in 50% UTCS. The cholesterol lowest value recorded in 50% ZTCS was similar (p>0.05) to the value recorded in 100% UTCS.

Table 25: Haematological parameters and serum metabolites of starting broiler chickens (0 – 4 weeks) fed diets containing untreated and treated cassava sifting

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTCS	100% UTCS	50% ZTCS	100% ZTCS	SEM
Haematological parameters:						
Packed cell volume (%)	24.00^{ab}	24.00^{ab}	23.00^{ab}	22.00^{b}	26.00^{a}	0.51
Haemoglobin (g/dl)	8.10^{ab}	8.00^{ab}	7.70^{ab}	7.30^{b}	8.70^{a}	0.18
Red blood cell ($x10^{12/L}$)	2.40	2.00	2.00	2.00	3.00	0.17
Mean Corpuscular Haemoglobin (pg)	34.00^{bc}	40.00^{a}	39.00^{ab}	37.00^{ab}	29.00^{c}	1.23
Mean Corpuscular Haemoglobin in Concentration (g/dl)	33.80	33.30	33.50	33.20	33.50	0.42
Mean Corpuscular Volume (fl)	100.00	120.00	115.00	110.00	87.00	6.47
White blood cell ($x10^{9/L}$)	12.50^{a}	10.70^{b}	13.60^{a}	10.50^{b}	13.30^{a}	0.40
Heterophil (%)	37.00^{a}	29.00^{ab}	31.00^{ab}	28.00^{ab}	25.00^{b}	1.56
Lymphocytes (%)	61.00^{b}	68.00^{a}	66.00^{ab}	70.00^{a}	70.00^{a}	1.08
Eosinophil (%)	0.00^{b}	0.00^{b}	0.00^{b}	1.00^{a}	1.00^{a}	0.14
Monocytes (%)	1.00^{c}	2.00^{b}	2.00^{b}	1.00^{c}	3.00^{a}	0.21
Basophils (%)	1.00^{a}	1.00^{a}	1.00^{a}	0.00^{b}	1.00^{a}	0.14
Serum metabolites:						
Total protein (g/dl)	4.00	3.00	4.20	3.70	3.90	0.20
Albumin (g/dl)	2.10^{ab}	2.20^{ab}	2.40^{ab}	2.00^{b}	2.50^{a}	0.07
Globulin (g/dl)	1.90^{a}	0.80^{b}	1.80^{a}	1.70^{a}	1.40^{a}	0.12
Glucose (mg/dl)	122.00^{b}	100.00^{d}	124.00^{b}	136.00^{a}	108.00^{c}	3.46
Cholesterol (mg/dl)	85.00^{a}	87.00^{a}	79.00^{ab}	75.00^{b}	87.00^{a}	1.64
Uric Acid (mg/dl)	5.20	5.70	3.60	5.00	3.80	0.32
Creatinine (mg/dl)	0.80^{ab}	0.40^{bc}	0.20^{c}	1.00a	0.30^{c}	0.10
Aspartate Amino-Transferase (U/L)	49.00^{b}	52.00^{ab}	40.00^{c}	51.00^{b}	56.00^{a}	1.50
Alanine Amino-Transferase (U/L)	31.00^{a}	18.00^{c}	23.00^{b}	12.00^{d}	21.00^{bc}	1.74

Means on the same row having different superscripts are significantly different ($P<0.05$); SEM: Standard Error of Mean

The AST values ranged between 40.00 and 56.00 (U/L), the highest value was observed in 100% ZTCS with similar (p>0.05) value in 50% UTCS and the least value obtained in 100% ZTCS. The birds fed the control diet had highest (p<0.05) value of 31.00 (U/L) of ALT while the lowest value of 12.00 (U/L) was recorded in 50% ZTCS.

4.20 **Haematological parameters and serum metabolites of finishing broiler chickens fed cassava sifting based diets**

The haematological parameters and serum metabolites of finishing broiler chickens fed cassava sifting based diets are shown in Table 26. The dietary treatments did not influence (p>0.05) the packed cell volume, haemoglobin, and MCHC. The red blood cell values ranged between 1.20 and 2.00 ($x10^{12/L}$), the birds fed 100% UTCS had the highest value which was similar (p>0.05) to the values in control diet and 50% UTCS while the least value obtained in 100% ZTCS was similar (p>0.05) to the values in control diet, 50% UTCS, and 50% ZTCS. The birds fed 100% ZTCS had highest (p<0.05) values of white blood cell, MCH, MCV and heterophyl but the lowest values for white blood cell was recorded in birds fed 50% ZTCS. Moreover, the birds fed 100% UTCS had the lowest value of MCH and MCV while the least value of heterophyl was obtained in the control diet. The lymphocytes values ranged between 58.00 and 80.00%, the highest value was recorded in the birds fed the control diet with similar (p>0.05) value in 50% ZTCS and the least value obtained in birds fed 100% ZTCS was similar to the values in 50% UTCS and 100% UTCS.

The dietary treatments influence (p<0.05) the serum metabolites of the finishing broiler chickens. The values of total protein ranged between 3.00 and 4.70 (g/dl), the same highest value was obtained in birds fed the control diet and 100% UTCS while the least value was observed in birds fed 50% UTCS and 100% ZTCS which was

Table 26: Haematological parameters and serum metabolites of finishing broiler chickens (5– 8weeks) fed diets containing untreated and treated cassava sifting

Parameters	Dietary treatments 1 Control diet	2 50% UTCS	3 100% UTCS	4 50% ZTCS	5 100% ZTCS	SEM
Haematological parameters:						
Packed cell volume (%)	28.00	28.00	27.00	25.00	26.00	0.74
Haemoglobin (g/dl)	9.20	9.30	8.50	8.30	8.70	0.34
Red blood cell ($x10^{12/L}$)	1.50^{ab}	1.80^{ab}	2.00^{a}	1.30^{b}	1.20^{b}	0.11
Mean Corpuscular Haemoglobin (pg)	61.00^{ab}	52.00^{bc}	43.00^{c}	64.00^{ab}	73.00^{a}	3.28
Mean Corpuscular Haemoglobin in Concentration (g/dl)	32.90	33.20	31.50	33.20	33.50	0.46
Mean Corpuscular Volume (fl)	187.00^{b}	156.00^{c}	135.00^{d}	192.00^{b}	217.00^{a}	7.83
White blood cell ($x10^{9/L}$)	12.40^{b}	12.60^{b}	12.40^{b}	10.90^{b}	14.50^{a}	0.38
Heterophil (%)	19.00^{d}	34.00^{b}	37.00^{ab}	27.00^{c}	40.00^{a}	2.12
Lymphocytes (%)	80.00^{a}	65.00^{bc}	59.00^{c}	72.00^{ab}	58.00^{c}	2.55
Eosinophil (%)	0.00^{b}	0.00^{b}	1.00^{a}	1.00^{a}	1.00^{a}	0.17
Monocytes (%)	1.00^{b}	1.00^{b}	2.00^{a}	0.00^{c}	1.00^{b}	0.19
Basophils (%)	1.00^{a}	0.00^{b}	1.00^{a}	0.00^{b}	0.00^{b}	0.14
Serum metabolites:						
Total protein (g/dl)	4.70^{a}	3.00^{b}	4.70^{a}	3.50^{b}	3.00^{b}	0.22
Albumin (g/dl)	2.80^{a}	1.80^{c}	2.50^{b}	2.40^{b}	1.50^{d}	0.13
Globulin (g/dl)	2.10^{a}	1.20^{b}	2.20^{a}	1.10^{b}	1.50^{ab}	0.15
Glucose (mg/dl)	120.00^{abc}	125.00^{ab}	115.00^{bc}	132.00^{a}	110.00^{c}	2.61
Cholesterol (mg/dl)	63.00^{b}	83.00^{a}	85.00^{a}	79.00^{a}	90.00^{a}	2.76
Uric Acid (mg/dl)	2.10^{c}	3.50^{b}	3.20^{bc}	5.20^{a}	2.50^{bc}	0.32
Creatinine (mg/dl)	0.60^{ab}	0.20^{b}	0.20^{b}	0.50^{ab}	0.80^{a}	0.08
Aspartate Amino-Transferase (U/L)	46.00^{ab}	50.00^{ab}	44.00^{b}	35.00^{c}	54.00^{a}	1.97
Alanine Amino-Transferase (U/L)	23.00^{ab}	15.00^{b}	27.00^{a}	24.00^{a}	22.00^{ab}	1.46

Means on the same row having different superscripts are significantly different ($P<0.05$); SEM: Standard Error of Mean

similar to the value in 50% ZTCS. The glucose values ranged between 110.00 and 130.00 (mg/dl), the highest value was recorded in 50% ZTCS with similar (p>0.05) values in control diet and 50% UTCS while the lowest value was obtained in 100% ZTCS had similar (p>0.05) values in control diet and 100% UTCS. The values of cholesterol were similar (p>0.05) in birds fed the experimental diets except in the birds fed the control diet which have the least value. The birds fed 50% ZTCS had highest (p<0.05) value of uric acid while least value was obtained in the control diet which was similar (p>0.05) to the values recorded in 100% UTCS and 100% ZTCS. The AST values ranged between 35.00 and 54.00 (U/L), the highest value obtained in 100% ZTCS was similar (p>0.05) to the values observed in the control diet and 50% UTCS but the lowest value was recorded in 50% ZTCS. The ALT highest value obtained in 100% UTCS was similar (p>0.05) to the values recorded in the control group, 50% ZTCS and 100% ZTCS while the least value observed in 100% ZTCS was similar (p>0.05) to the value recorded in the control diet.

4.21 Carcass characteristics of broiler chickens fed cassava sifting based diets

The carcass characteristics of broiler chickens fed cassava sifting based diet is shown in Table 27. The birds fed 50% ZTCS had highest (p<0.05) values for live weight, dressed weight and eviscerated weight while similar (p>0.05) values were obtained in control diet, 100% UTCS and 100% ZTCS for live weight and dressed weight and eviscerated weight while similar (p>0.05) values were obtained in the control group, 100% UTCS and 100% ZTCS for live weight and dressed weight. Moreover, the broiler chickens on the control diet and 100% UTCS had similar (p>0.0%) lowest value for eviscerated weight. The highest value of dressing percentage observed in 50% UTCS was similar (p>0.05to the values recorded in the 50% ZTCS but the same least value was observed in birds fed the control diet and 100% UTCS.

Table 27: Carcass characteristics of broiler chickens fed diets containing untreated and treated cassava sifting

Parameters	1	2	3	4	5	SEM
		Dietary	treatments			
	Control diet	50% UTCS	100% UTCS	50% ZTCS	100% ZTCS	
Live weight (g)	1600.00^{b}	1700.00^{ab}	1600.00^{b}	1800.00^{a}	1600.00^{b}	25.77
Dressed weight (g)	1500.00^{bc}	1620.00^{ab}	1440.00^{c}	1660.00^{a}	1520.00^{bc}	25.98
Eviscerated weight (g)	1180.00^{d}	1380.00^{b}	1180.00^{d}	1460.00^{a}	1240.00^{c}	30.16
Dressing percentage (%)	73.75^{c}	81.18^{a}	73.75^{c}	81.11^{a}	77.50^{b}	0.90
Cut parts (% of LW)						
Head (%)	1.90^{b}	3.53^{a}	3.75^{a}	3.33^{a}	3.28^{a}	0.23
Breast (%)	17.14^{c}	15.29^{d}	17.50^{bc}	18.89^{a}	18.59^{ab}	0.37
Thigh (%)	8.57^{c}	12.94^{a}	10.00^{b}	12.22^{a}	10.94^{b}	0.44
Drumstick (%)	9.52^{b}	11.76^{a}	11.25^{a}	11.11^{a}	12.03^{a}	0.28
Wing (%)	7.62^{b}	9.41^{a}	7.50^{b}	10.00^{a}	7.66^{b}	0.32
Back (%)	18.10^{a}	17.65^{ab}	13.75^{c}	16.67^{b}	16.41^{b}	0.43
Neck (%)	2.86^{c}	4.71^{a}	2.50^{c}	3.33^{c}	4.38^{ab}	0.27
Shank (%)	2.86^{c}	5.88^{a}	6.25^{a}	4.44^{b}	4.38^{b}	0.36
Organ weight (% of LW)						
Heart (%)	0.95^{ab}	1.18^{a}	1.25^{a}	0.56^{b}	0.55^{b}	0.10
Spleen (%)	0.07	0.18	0.21	0.11	0.08	0.02
Lungs (%)	0.76^{a}	0.76^{a}	0.81^{a}	0.67^{ab}	0.55^{b}	0.03
Liver (%)	1.90^{b}	3.53^{a}	3.13^{ab}	2.22^{b}	2.19^{b}	0.22
Kidneys (%)	0.45^{b}	0.59^{b}	0.94^{a}	0.56^{b}	0.60^{b}	0.05
Proventriculus (%)	0.95^{b}	1.18^{a}	1.25^{a}	1.11^{ab}	1.09^{ab}	0.03
Gizzard (%)	2.86^{d}	3.53^{b}	3.75^{a}	3.33^{c}	2.19^{e}	0.15
Empty gizzard (%)	0.95^{c}	2.35^{ab}	2.50^{a}	2.22^{b}	1.09^{c}	0.18
Abdominal fat (%)	0.95^{b}	0.59^{c}	1.25^{a}	1.11^{ab}	1.09^{ab}	0.06
Whole GIT (%)	14.29^{d}	17.65^{c}	25.00^{a}	12.22^{e}	20.23^{b}	1.20

Means on the same row having different superscripts are significantly different ($P<0.05$); LW: Live weight; SEM: Standard Error of Mean

The cut parts were influenced ($p<0.05$) by the replacement of wheat offal by cassava sifting. The birds fed 50% ZTCS and 100% ZTCS had highest ($p<0.05$) value for breast while the least value was recorded in 50% UTCS. The thigh values ranged between 8.57 and 12.22 (% LW), the highest value was observed in 50% UTCS while the lowest value was in the control group. There were similar ($p>0.05$) values for drumstick in all the dietary treatments except in the control diet where the lowest value was recorded. The highest value for the back was recorded in the control diet which was similar ($p>0.05$) to the value in 50% UTCS while the lowest value was obtained in 100% UTCS. The cassava sifting based diets did not affect ($p>0.05$) the spleen, which have similar ($p>0.05$) values across the treatments. The broiler chickens fed 100% UTCS had highest ($p<0.05$) values for heart, lungs, kidneys, proventriculus, gizzard, empty gizzard, abdominal fat and whole gastro-intestinal tract Te birds on the control diet had the least values for spleen, liver and kidneys. However, the birds on 100% ZTCS had lowest values for heart, lungs, gizzard while the birds on 50% UTCS had least value for abdominal fat. The lowest value of 12.22% for whole gastro-intestinal tract was obtained in birds fed 50% ZTCS.

4.22 Viscosity of ileal digesta of broiler chickens fed cassava sifting based diets

The viscosity of ileal digesta of broiler chickens fed cassava sifting based diets are shown in Table 28. The dietary treatments influenced ($p<0.05$) the ileal digesta viscosity of the broiler chickens. At 100rpm, the highest value (4.70cps) observed in 50% UTCS was similar to the value recorded in 50% ZTCS but, the lowest value (2.78cps) was recorded in 100% ZTCS.

Table 28: Viscosity of Ileal digesta of broiler chickens fed diets containing untreated and treated cassava sifting

Parameters	1 Control diet	2 50% UTCS	3 100% UTCS	4 50% ZTCS	5 100% ZTCS	SEM
		Dietary treatments				
50rpm	6.76^{b}	6.60^{b}	5.44^{c}	11.40^{a}	4.84^{d}	0.62
60rpm	5.50^{c}	6.47^{b}	4.00^{d}	7.03^{a}	3.57^{e}	0.36
100rpm	4.04^{b}	4.70^{a}	3.26^{c}	4.55^{a}	2.78^{d}	0.20

[abcde] Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

4.23 Sensory evaluation of meats of broiler chickens fed cassava sifting based diets

The sensory evaluation of meats from broiler chickens fed cassava sifting based diets is shown in Table 29. The dietary treatments influenced ($p<0.05$) the sensory evaluation parameters. The highest value of colour obtained in the control diet was similar ($p>0.05$) to the values recorded in diet 50% ZTCS and 100% ZTCS but the least value was observed in 50% UTCS. The meats from birds fed 50% ZTCS had significantly ($p<0.05$) highest values for juiciness, flavour, tenderness and overall acceptability, while the lowest values for colour, tenderness and overall acceptability were recorded in 50% UTCS. The least value for juiciness was observed in 100% UTCS while the least value for flavour recorded in 100% UTCS was similar ($p>0.05$) to the values recorded in control diet, 50% UTCS and 100% ZTCS.

4.24 Economy of feed conversion of broiler chickens fed cassava sifting based diets

The economy of feed conversion of broiler chickens fed cassava sifting based diet is shown in Table 30. The dietary treatments did not influence ($p>0.05$) the cost of the feed/kg and cost of production/broiler. However, there were differences ($p<0.05$) in gross revenue, gross profit, rate of return on investment, economic efficiency and relative cost benefit. The birds fed 50% ZTCS had highest ($p<0.05$) values of gross revenue and gross profit, rate of return on investment and economic efficiency while the least values for gross profit, rate of return on investment and economic efficiency were obtained in 100% ZTCS. However, the least value of gross revenue recorded in 100% UTCS was similar ($p>0.05$) to the observed values in the control group and 100% ZTCS. The relative cost benefit values ranged between 0.00 and 29.84%.

Table 29: Sensory evaluation of meat from broiler chickens fed diets containing untreated and treated cassava sifting

		Dietary	treatments			
Parameters	1	2	3	4	5	
	Control diet	50% UTCS	100% UTCS	50% ZTCS	100% ZTCS	SEM
Colour	5.95^{a}	4.85^{c}	5.25^{b}	5.85^{a}	5.75^{a}	0.12
Juiciness	5.40^{b}	4.95^{c}	4.40^{d}	6.35^{a}	4.95^{c}	0.18
Flavour	5.05^{b}	4.95^{b}	4.50^{b}	6.00^{a}	5.05^{b}	0.16
Tenderness	5.80^{b}	5.05^{d}	5.55^{c}	6.20^{a}	5.70^{bc}	0.10
Overall acceptability	5.90^{b}	5.45^{c}	5.10^{d}	6.55^{a}	5.75^{b}	0.13

^{abc}Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean

Table 30: Economy of feed conversion of broiler chickens fed diets containing untreated and treated cassava sifting

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTCS	100% UTCS	50% ZTCS	100% ZTCS	SEM
Cost of the feed/Kg (₦/Kg)	178.89	177.89	176.89	178.14	177.39	0.64
Price/Kg live weight (₦)	900.00	900.00	900.00	900.00	900.00	0.00
Cost of production/broiler (₦/broiler)	1254.51	1296.98	1215.81	1294.78	1271.72	14.88
Gross revenue/broiler (₦/broiler)	1413.00^{b}	1593.00^{a}	1395.00^{b}	1638.00^{a}	1404.00^{b}	28.83
Gross profit (₦)	158.49^{d}	296.02^{b}	179.19^{c}	343.22^{a}	137.28^{e}	22.12
Rate of return on Investment (%)	12.63^{cd}	22.82^{b}	14.74^{c}	26.51^{a}	10.40^{d}	1.69
Economic efficiency	0.29^{b}	0.50^{a}	0.35^{b}	0.58^{a}	0.23^{b}	0.04
Relative cost benefit (%)	0.00^{d}	25.13^{b}	29.84^{a}	21.93^{c}	25.86^{b}	2.82

Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

4.25 Growth response of starting broiler chickens fed sawdust based diets

The performance characteristics of starting broiler chickens fed sawdust based diets is shown in Table 31. The average weight gain and daily weight gain were influenced (p<0.05) by the dietary treatments. The average weight gain ranged from 475.00 to 633.00(g), broiler chickens fed 50% untreated sawdust (50% UTSD) had the highest value and the least value was recorded in the birds fed 100% treated sawdust (100% ZTSD). The daily weight gain ranged between 16.96 and 22.61(g), the highest value was observed in 50% UTSD while the least value observed in the birds fed 100% ZTSD had similar value with the recorded values in the control diet, 100% UTSD and 50% ZTSD.

The average feed intake and daily feed intake were significantly (p<0.05) influenced by the inclusion of treated and untreated sawdust in the diets of the starting broiler chickens. The average feed intake ranged between 1138.00 and 1223.00(g). The highest value was observed in birds fed 50% ZTSD while the least value of 1138.00g recorded in 100% ZTSD was similar to the value obtained in the control group. The daily feed intake highest value of 45.30g was recorded in 50% ZTSD while the least value of 42.15g was observed in birds fed 100% ZTSD but similar to the value recorded in the control diet. The feed conversion ratio and protein efficiency ratio were influenced (p<0.05) by the dietary treatments. The feed conversion ratio ranged from 1.84 to 2.40. The starting broiler chickens fed 50% ZTSD had the highest value which was similar (p>0.05) to the values recorded in other dietary treatments except birds fed 50% UTSD which had the least value. The highest value of protein efficiency ratio was observed in birds fed 50% UTSD while the least value was recorded for birds fed 100% ZTSD. The dietary treatment significantly (p<0.05) influenced the total cost of feed consumed/bird and cost of feed/kg weight gain.

Table 31: Performance characteristics of starting broiler chickens (0 – 4weeks) fed diets containing untreated and treated sawdust

	Dietary treatments					
Parameters	1	2	3	4	5	
	Control diet	50% UTSD	100% UTSD	50% ZTSD	100% ZTSD	SEM
Initial body weight (g/bird)	35.00	33.00	33.00	35.00	35.00	0.59
Final body weight (g/bird)	527.00^{c}	666.00^{a}	534.00^{c}	553.00^{b}	510.00^{d}	14.96
Average weight gain (g/bird)	492.00^{d}	633.00^{a}	501.00^{c}	518.00^{b}	475.00^{e}	15.07
Daily weight gain (g/bird)	17.57^{b}	22.61^{a}	17.89^{b}	17.50^{b}	16.96^{b}	0.58
Average feed intake (g/bird)	1141.00^{d}	1165.00^{b}	1153.00^{c}	1223.00^{a}	1138.00^{d}	8.30
Daily feed intake (g/bird)	42.26^{d}	43.15^{b}	42.70^{c}	45.30^{a}	42.15^{d}	8.30
Feed conversion ratio	2.32^{a}	1.84^{b}	2.30^{a}	2.36^{a}	2.40^{a}	0.06
Protein efficiency ratio	2.21^{c}	2.81^{a}	2.30^{b}	2.13^{d}	1.99^{e}	0.08
Cost of the feed/Kg (₦/Kg)	151.38^{a}	149.83^{b}	148.28^{c}	149.95^{b}	148.53^{c}	0.33
Total cost of feed consumed/bird (₦)	172.72^{c}	174.55^{b}	170.97^{c}	183.39^{a}	169.03^{d}	1.35
Cost of feed/Kg weight gain (₦ /Kg)	351.07^{ab}	275.75^{c}	341.25^{b}	354.03^{ab}	355.85^{a}	8.26
Mortality (%)	0.00^{c}	2.00^{a}	0.67^{b}	0.00^{c}	0.67^{b}	0.20

Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

The value of total cost of feed consumed/bird ranged between ₦169.03 to ₦183.39. The value of cost of feed/kg weight gain ranged from ₦275.75 to ₦355.85. The highest value in 100% ZTSD was similar to the values recorded in control diet while the least value was obtained in 50% UTSD. There was significant ($p<0.05$) difference in mortality during the starting phase. It ranged between 0.00 and 2.00%. The highest value was recorded for birds fed 50% UTSD while the lowest value was observed in 50% ZTSD had similar ($p>0.05$) value with the control diet.

4.26 Growth response of finishing broiler chickens fed sawdust based diets

The performance characteristics of finishing broiler chickens (5-8 weeks) fed sawdust based diets is shown in Table 32. The dietary treatments significantly ($p<0.05$) affected average weight gain and daily weight gain. The daily weight gain ranged between 44.61g and 50.04g. The highest value was observed in birds fed 50% ZTSD while the least value was recorded in birds fed 50% UTSD. The average feed intake and daily feed intake were affected ($p<0.05$) by the dietary treatments. The average feed intake ranged from 3561.00 and 3880.00(g). The highest value was recorded for birds fed 50% ZTSD with similar values obtained in 50% UTSD and 100% ZTSD while birds that consumed control diet had the least value. The values of daily feed intake ranged between 127.18g and 138.57g, the highest value was observed in birds fed 50% ZTSD which was similar to values obtained in 50% UTSD and 100% ZTSD while the birds fed control diet had the least value. The feed conversion ratio was not significantly ($p>0.05$) influenced by the dietary treatments. However, the protein efficiency ratio was influenced ($p<0.05$) by the inclusion of treated and untreated sawdust. The values of the protein efficiency ratio ranged between 1.46 and 1.91. The highest value was recorded for birds that were fed the control diet which was similar

Table 32: Performance characteristics of finishing broiler chickens (5 – 8weeks) fed diets containing untreated and treated sawdust

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTSD	100% UTSD	50% ZTSD	100% ZTSD	SEM
Initial body weight (g/bird)	527.00^{c}	666.00^{a}	534.00^{c}	553.00^{b}	510.00^{d}	14.96
Final body weight (g/bird)	1869.00^{c}	1915.00^{b}	1858.00^{d}	1954.00^{a}	1822.00^{e}	12.32
Average weight gain (g/bird)	1342.00^{b}	1249.00^{e}	1324.00^{c}	1401.00^{a}	1312.00^{d}	13.11
Daily weight gain (g/bird)	47.93^{b}	44.61^{e}	47.29^{c}	50.04^{a}	46.86^{d}	0.47
Average feed intake (g/bird)	3561.00^{c}	3760.00^{ab}	3729.00^{b}	3880.00^{a}	3833.00^{ab}	32.45
Daily feed intake (g/bird)	127.18^{d}	134.29^{ab}	133.18^{c}	138.57^{a}	138.57^{ab}	1.11
Feed conversion ratio	2.65	3.01	2.82	2.77	2.92	0.09
Protein efficiency ratio	1.91^{a}	1.46^{c}	1.69^{b}	1.85^{a}	1.81^{a}	0.04
Cost of the feed/Kg (₦/Kg)	175.89	176.39	173.89	175.64	174.39	0.40
Total cost of feed consumed/bird (₦)	579.13^{c}	599.83^{b}	583.33^{c}	619.95^{a}	601.51^{b}	3.96
Cost of feed/Kg weight gain (₦ /Kg)	431.54^{d}	480.25^{a}	440.58^{c}	442.50^{c}	458.47^{b}	4.63
Mortality (%)	0.67^{c}	3.33^{a}	0.67^{c}	2.67^{ab}	2.00^{b}	0.30

Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean

to values obtained in 50% ZTSD and 100% ZTSD while the least value was observed in birds on 50% UTSD.

The total cost of feed consumed and cost of feed/kg weight gain were affected ($p<0.05$) by the inclusion of treated and untreated sawdust. The total cost of feed consumed/bird had values between ₦579.15 and ₦619.95. The highest value for total cost of feed consumed/bird was recorded in 50% UTSD while the least value obtained in the control group had similar value in 100% UTSD. The cost of feed/kg weight gain had values ₦431.54 to ₦480.25. The highest value was observed in finishing broiler chickens fed 50% UTSD and the least value was recorded for birds fed the control diet. There was significant ($p<0.05$) difference in mortality across the dietary treatments, the highest value of 3.33% was recorded in 50% UTSD with similar value in 50% ZTSD and the same least value in birds fed control diet and 100% UTSD.

4.27 Apparent nutrient digestibility of starting broiler chickens fed sawdust based diet

The apparent nutrient digestibility of starting broiler chickens fed sawdust based diet is shown in Table 33. The dietary treatments significantly ($p<0.05$) influenced the nutrient digestibility. The dry matter digestibility values ranged between 66.27 and 77.64%, the highest value observed in the control diet was similar ($p>0.05$) to the value in 100% UTSD while the lowest value was recorded in birds fed 100% ZTSD. The birds fed the control diet had highest ($p<0.05$) value for crude protein digestibility which was similar ($p>0.05$) to the values in diets 100% UTSD and 50% ZTSD. The lowest value was observed in 100% ZTSD. Crude fibre digestibility values ranged between 59.17 and 77.50%, the highest value was recorded in 100% UTSD, similar values were observed in diets 50% UTSD, 50% ZTSD and 100% ZTSD while the lowest value was recorded in the control diet. The acid detergent fibre digestibility

Table 33: Apparent nutrient digestibility of starting broiler chickens (0 – 4weeks) fed diets containing untreated and treated sawdust

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTSD	100% UTSD	50% ZTSD	100% ZTSD	SEM
Dry matter digestibility	77.64^{a}	72.59^{c}	77.50^{a}	75.71^{b}	66.27^{d}	1.14
Crude protein digestibility	74.78^{a}	72.76^{b}	75.29^{a}	74.63^{a}	70.45^{c}	0.48
Crude fibre digestibility	59.17^{c}	66.28^{b}	77.50^{a}	66.86^{b}	66.27^{b}	1.57
Acid detergent fibre digestibility	72.11^{a}	68.42^{b}	72.53^{a}	71.90^{a}	62.47^{c}	1.02
Neutral detergent fibre digestibility	68.82^{a}	64.01^{c}	68.97^{a}	67.57^{b}	57.27^{d}	1.18
Acid detergent lignin digestibility	71.48^{d}	72.43^{c}	76.17^{a}	74.46^{b}	69.18^{e}	0.65
Ether extract digestibility	73.91^{a}	70.43^{d}	71.24^{c}	72.85^{b}	66.57^{e}	0.68
Ash digestibility	73.72^{a}	71.09^{c}	73.61^{a}	72.62^{b}	67.30^{d}	0.64
Nitrogen free extract digestibility	73.36^{a}	70.25^{c}	73.68^{a}	72.34^{b}	63.69^{d}	0.99
Calcium digestibility	81.21^{b}	77.63^{c}	70.68^{d}	86.06^{a}	64.46^{e}	2.05
Phosphorus digestibility	83.97^{a}	80.91^{b}	81.75^{b}	83.71^{a}	77.48c	0.65
Apparent metabolizable energy digestibility	78.10^{a}	72.66^{c}	76.20^{b}	76.04^{b}	69.57^{d}	0.81

Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean

had highest ($p<0.05$) value in 100% UTSD with similar values in the control diet and 50% ZTSD but the lowest value was recorded in 100% ZTSD. The neutral detergent fibre digestibility values ranged between 57.27 and 68.97%, the highest value recorded in 100% UTSD had similar value in the control diet but the lowest value was in 100% ZTSD. The values for acid detergent lignin digestibility ranged between 69.18 and 76.17%, the highest value was recorded for birds fed 100% UTSD and the lowest value was observed in 100% ZTSD. The ether extract digestibility values ranged between 66.57 and 73.91%, highest ($p<0.05$) value was recorded in the control diet while the lowest value was observed in 100% ZTSD. The ash digestibility values ranged between 67.30 and 73.72%, with the highest value recorded in the control diet while the lowest value was observed in 100% ZTSD. The values of nitrogen free extract digestibility ranged between 63.69 and 73.68%, the highest value was recorded in 100% UTSD while while the lowest value was observed in 100% ZTSD. The values of Calcium digestibility ranged between 64.46 and 86.06%, the highest value was recorded in 50% ZTSD with the least value observed in 100% ZTSD. The Phosphorus digestibility values were within 77.48 and 83.95%, the highest value observed in the control diet had similar value in 50% ZTSD but the lowest value was recorded in 100% ZTSD. The apparent metabolizable energy digestibility values ranged between 69.57 and 78.10%, the highest value was observed in the control diet while the lowest value was recorded in 100% ZTSD.

4.28 Apparent nutrient digestibility of finishing broiler chickens fed sawdust based diet

The apparent nutrient digestibility of finishing broiler chickens fed sawdust based diets is shown in Table 34. The dietary treatments did not influence ($p<0.05$) crude protein, ether extract, ash and nitrogen free extract digestibility. The dry matter

Table 34: Apparent nutrient digestibility of starting broiler chickens (5 – 8weeks) fed diets containing untreated and treated sawdust

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTSD	100% UTSD	50% ZTSD	100% ZTSD	SEM
Dry matter digestibility	74.41[a]	76.00[a]	72.59[ab]	68.89[b]	75.46[a]	0.88
Crude protein digestibility	77.93	78.29	77.55	76.28	78.49	0.59
Crude fibre digestibility	75.94[a]	76.00[a]	74.24[ab]	70.12[b]	75.00[a]	0.80
Acid detergent fibre digestibility	75.98[ab]	76.86[a]	74.50[ab]	71.67[b]	77.02[a]	0.76
Neutral detergent fibre digestibility	75.13[ab]	76.68[a]	73.62[ab]	70.85[b]	75.49[ab]	0.77
Acid detergent lignin digestibility	67.15[b]	74.50[a]	70.37[ab]	59.63[c]	69.54[b]	1.42
Ether extract digestibility	77.41	78.00	76.44	73.72	77.92	0.69
Ash digestibility	76.40	77.94	76.83	75.80	77.42	0.58
Nitrogen free extract digestibility	75.95	77.27	75.16	73.13	76.56	0.67
Calcium digestibility	85.71[b]	85.28[b]	84.83[b]	78.53[c]	88.29[a]	0.88
Phosphorus digestibility	87.11[a]	86.53[ab]	85.45[b]	82.85[c]	87.09[a]	0.46
Apparent metabolizable energy digestibility	75.50[a]	76.64[a]	73.94[ab]	69.78[b]	76.42[a]	0.86

Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean

digestibility values ranged between 68.89 and 76.00%, the highest value was recorded in 50% UTSD which was similar (p>0.05) to the values observed in the control diet, 100% UTSD and 50% ZTSD while the lowest value was recorded in 50% ZTSD. The crude fibre digestibility values ranged between 70.12 and 76.00%, the highest value recorded in 50% UTSD was similar (p>0.05) to values obtained in the control diet, 100% UTSD and 50% ZTSD. The lowest value was recorded in 50% ZTSD which was similar to the value recorded in 100% UTSD. The acid detergent fibre digestibility values ranged between 71.67 and 77.02%, the highest value recorded in 100% ZTSD was similar (p>0.05) to the values observed in the control diet, 50% UTSD and 100% UTSD. The lowest value observed in 50% ZTSD was similar (p>0.05) to the values recorded in the control diet and 100% UTSD. The values of the neutral detergent fibre digestibility values ranged between 70.85 and 76.68%, the highest value observed in 50% UTSD was similar (p>0.05) to the values recorded in the control diet, 100% UTSD and 100% ZTSD. The lowest value in 50% ZTSD was similar (p>0.05) to the values obtained in the control diet, 100% UTSD and 100% ZTSD. The acid detergent lignin digestibility values ranged between 59.63 and 74.50%, the highest value was observed in 50% UTSD which was similar to the value recorded in 100% UTSD but the lowest value was recorded in 50% ZTSD.

The value of Calcium digestibility ranged between 78.53 and 88.29%, the highest value was recorded for birds fed 100% ZTSD while the lowest value was obtained in 50% ZTSD. The values of phosphorus digestibility ranged between 82.85 and 87.11%, the highest value recorded in the control group was similar to the values observed in 50% UTSD and 100% ZTSD but the lowest value was recorded in 50% ZTSD. The values of apparent metabolizable energy digestibility ranged between 69.78 and 76.64%, the highest value recorded in 50% UTSD was similar (p>0.05) to the values obtained in the control diet, 100% UTSD and 100% ZTSD. The lowest value observed in 50% ZTSD was significantly (p>0.05) similar to the value recorded in 100% UTSD.

4.29 Haematological parameters and serum metabolites of starting broiler chickens fed sawdust based diets

The haematological and serum metabolites of starting broiler chickens fed sawdust *mobilis* based diets are shown in Table 35. The dietary treatments influenced (p<0.05) the packed cell volume, red blood cell, white blood cell, heterophil, lymphocytes, eosinophil, monocytes and basophils. However, haemoglobin, MCH, MCV and MCHC were not affected (p>0.05) by the dietary treatments. The broiler chickens fed 100% UTSD had highest (p<0.05) values for packed cell volume, red blood cell and lymphocytes while the birds fed 100% ZTSD had highest value for white blood cell and birds on 50% ZTSD had highest value for heterophyl. However, the birds fed 100% ZTSD had the lowest values for PVC, RBC, WBC and lymphocytes while the least value for heterophyl was recorded in 100% UTSD. The dietary treatments significantly (p<0.05) influenced the total protein, albumin, globulin, glucose, cholesterol, uric acid, creatinine, AST and ALT. The birds fed 50% ZTSD had highest (p<0.05) values for total protein, albumin and globulin but the lowest values for these serum metabolites were obtained in the control group and 100% ZTSD. The values for glucose ranged between 112.00 and 127.50(mg/dl), the highest value was recorded in birds on 100% UTSD while the least value was observed in birds on 50% UTSD.

The values of cholesterol ranged between 88.50 and 103.00(mg/dl). Starting broiler chickens on 50% ZTSD had the highest value and birds on 50% UTSD had the least value. The uric acid values ranged between 3.95 and 5.75(mg/dl), the highest value was observed in 50% UTSD wihle the least value was recorded in 100% ZTSD.

Table 35: Haematological parameters and serum metabolites of starting broiler chickens (0 – 4 weeks) fed diets containing untreated and treated sawdust

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTSD	100% UTSD	50% ZTSD	100% ZTSD	SEM
Haematological parameters:						
Packed cell volume (%)	27.50^{c}	30.50^{b}	32.00^{a}	26.00^{d}	26.50^{cd}	0.65
Haemoglobin (g/dl)	8.90	10.00	10.50	8.50	8.70	0.31
Red blood cell ($x10^{12/L}$)	2.25^{ab}	2.70^{ab}	2.88^{a}	2.15^{b}	2.50^{ab}	0.11
Mean Corpuscular Haemoglobin (pg)	40.19	37.06	37.35	39.56	35.88	1.61
Mean Corpuscular Haemoglobin in Concentration (g/dl)	32.41	32.86	32.80	32.77	32.85	0.86
Mean Corpuscular Volume (fl)	123.07	112.96	113.66	121.54	108.67	3.66
White blood cell ($x10^{9/L}$)	19.50^{b}	13.90^{d}	12.05^{e}	16.20^{c}	21.15^{a}	0.91
Heterophil (%)	31.00^{cd}	33.50^{bc}	29.00^{d}	37.00^{a}	36.00^{ab}	0.86
Lymphocytes (%)	65.50^{b}	63.50^{b}	70.00^{a}	61.50^{b}	62.50^{b}	0.95
Eosinophil (%)	0.50^{b}	1.00^{a}	0.00^{b}	0.00^{b}	0.50^{b}	0.12
Monocytes (%)	1.50^{a}	2.00^{a}	0.50^{b}	0.50^{b}	0.50^{b}	0.18
Basophils (%)	1.50^{a}	0.00^{c}	0.50^{bc}	1.00^{ab}	0.50^{bc}	0.17
Serum metabolites:						
Total protein (g/dl)	3.50^{b}	4.20^{a}	3.40^{b}	4.50^{a}	2.55^{c}	0.19
Albumin (g/dl)	1.30^{b}	2.10^{a}	2.00^{a}	2.20^{a}	1.35^{b}	0.11
Globulin (g/dl)	2.20^{a}	2.10^{a}	1.40^{b}	2.30^{a}	1.20^{b}	0.13
Glucose (mg/dl)	118.50^{d}	112.00^{e}	127.50^{a}	125.50^{b}	123.50^{c}	1.49
Cholesterol (mg/dl)	90.00^{c}	88.50^{c}	97.00^{b}	103.00^{a}	90.50^{c}	1.48
Uric Acid (mg/dl)	4.20^{c}	5.75^{a}	$4. 20^{c}$	5.35^{b}	3.95^{d}	0.19
Creatinine (mg/dl)	0.65^{b}	0.50^{c}	0.75^{b}	0.70^{b}	0.95^{a}	0.04
Aspartate Amino-Transferase (U/L)	65.00^{a}	47.00^{d}	54.00^{b}	51.00^{c}	47.00^{d}	1.81
Alanine Amino-Transferase (U/L)	21.00^{b}	20.67^{b}	26.50^{a}	24.50^{a}	21.50^{b}	0.66

Means on the same row having different superscripts are significantly different ($P<0.05$); SEM: Standard Error of Mean

The values of AST ranged between 47.00 and 65.00(U/L), highest value was obtained in the the control diet while the same lowest value was recorded in 50% UTSD and 100% ZTSD. The ALT values ranged between 20.67 and 26.50(U/L), the highest value in 100% UTSD was similar ($p<0.05$) to the value obtained in 50% ZTSD while similar lowest values were recorded in the control diet, 50% UTSD and 100% ZTSD.

4.30 Haematological parameters and serum metabolites of finishing broiler chickens fed sawdust based diets

Haematological and serum metabolites of finishing broiler chickens fed sawdust based diets are shown in Table 36. The packed cell volume, haemoglobin, red blood cell and white blood cell were influenced ($p<0.05$) by the experimental diets. The birds fed 50% UTSD had highest value for PCV while the least value was recorded in 100% ZTSD. The highest values recorded in birds fed 50% UTSD for haemoglobin and RBC were similar ($p>0.05$) to those of the birds fed the control diet. The MCH, MCHC and MCV were affected ($p<0.05$) by the dietary treatments. The highest value for MCV recorded in birds fed 50% ZTSD was similar ($p>0.05$) to the values obtained for birds on the control diet and 100% ZTSD while the least value was recorded in broilers fed 50% UTSD. The birds fed the control diet had the highest value for WBC, however, the least value was observed in birds fed 50% ZTSD. The highest value for heterophyl was recorded in 50% UTSD with similar value in 100% UTSD while the lowest value in 50% ZTSD was similar ($p>0.05$) to the value in control diet and 100% ZTSD. The values of lymphocytes ranged between 60.00 and 70.00(%), the highest value in 50% ZTSD was similar ($p>0.05$) to the values in 100% UTSD and 100% ZTSD, however, the least value was recorded in 50% UTSD. The dietary treatments influenced ($p<0.05$) the total protein, albumin, globulin, glucose, cholesterol, uric acid and

Table 36: Haematological parameters and serum metabolites of finishing broiler chickens (5– 8weeks) fed diets containing untreated and treated sawdust

Parameters	Dietary treatments 1 Control diet	2 50% UTSD	3 100% UTSD	4 50% ZTSD	5 100% ZTSD	SEM
Haematological parameters:						
Packed cell volume (%)	39.00^{b}	53.00^{a}	37.00^{b}	34.00^{c}	28.00^{d}	2.23
Haemoglobin (g/dl)	12.50^{a}	11.90^{a}	12.40^{a}	11.00^{b}	9.50^{c}	0.31
Red blood cell (x10$^{12/L}$)	3.30^{ab}	3.50^{a}	3.00^{bc}	2.60^{cd}	2.30^{d}	0.13
Mean Corpuscular Haemoglobin (pg)	37.91^{ab}	34.01^{b}	42.14^{a}	42.30^{a}	41.29^{a}	1.12
Mean Corpuscular Haemoglobin in Concentration (g/dl)	32.09^{a}	22.47^{b}	33.57^{a}	32.40^{a}	33.96^{a}	1.22
Mean Corpuscular Volume (fl)	31.25^{b}	44.53^{a}	29.83^{b}	30.98^{b}	29.55^{b}	1.58
White blood cell (x10$^{9/L}$)	23.10^{a}	17.00^{c}	15.60^{d}	12.90^{e}	18.20^{b}	0.91
Heterophil (%)	31.00^{bc}	35.00^{a}	32.00^{ab}	28.00^{c}	31.00^{bc}	0.70
Lymphocytes (%)	65.00^{b}	60.00^{c}	67.00^{ab}	70.00^{a}	68.00^{ab}	1.05
Eosinophil (%)	0.00^{b}	1.00^{a}	0.00^{b}	0.00^{b}	0.00^{b}	0.12
Monocytes (%)	3.00^{a}	2.00^{ab}	1.00^{bc}	1.00^{bc}	0.00^{c}	0.30
Basophils (%)	1.00^{ab}	2.00^{a}	0.00^{b}	1.00^{ab}	1.00^{ab}	0.21
Serum metabolites:						
Total protein (g/dl)	3.10^{c}	6.30^{a}	4.60^{b}	2.10^{e}	2.70^{d}	0.41
Albumin (g/dl)	1.80^{b}	2.90^{a}	1.50^{bc}	1.00^{c}	1.80^{b}	0.18
Globulin (g/dl)	1.30^{c}	3.40^{a}	3.10^{b}	1.10^{d}	0.90^{e}	0.29
Glucose (mg/dl)	120.00^{c}	122.00^{b}	112.00^{e}	115.00^{d}	133.00^{a}	1.94
Cholesterol (mg/dl)	87.00^{b}	76.00^{e}	84.00^{c}	82.00^{d}	90.00^{a}	1.29
Uric Acid (mg/dl)	3.20^{b}	5.00^{a}	4.80^{a}	3.00^{b}	2.80^{b}	0.28
Creatinine (mg/dl)	0.10^{c}	0.40^{ab}	0.40^{ab}	0.30^{b}	0.50^{a}	0.04
Aspartate Amino-Transferase (U/L)	45.00^{c}	50.00^{b}	49.00^{b}	48.00^{b}	63.00^{a}	1.69
Alanine Amino-Transferase (U/L)	24.00^{b}	28.00^{a}	14.00^{d}	19.00^{c}	23.00^{b}	1.33

Means on the same row having different superscripts are significantly different ($P<0.05$); SEM: Standard Error of Mean

creatinine. The finishing broiler chickens fed 50% UTSD had the highest values for total protein, albumin, globulin and uric acid while birds on 50% ZTSD had the least values for total protein and albumin. The cholesterol values were within (122.00 - 133.00mg/dl), the broiler birds on 100 ZTSD had the highest value while birds on 100% UTSD had the least value. The AST and ALT were significantly ($p<0.05$) affected by the dietary treatments. The highest value of AST was obtained in 100% ZTSD while the lowest value was recorded in the control diet. Moreover, the birds fed 50% UTSD had highest ($p<0.05$) value for ALT while the lowest value was recorded in 100% UTSD.

4.31 Carcass characteristics of broiler chickens fed sawdust based diets

The carcass characteristics of broiler chickens fed sawdust based diets is shown in Table 37. The dietary treatments influenced ($p<0.05$) the dressed weight and eviscerated weight. The dressed weight values ranged between 1500.00 to 1850.00g. The broiler chickens fed 50% ZTSD had the highest value while the least value was observed in birds fed 100% UTSD. The birds on other diets similar ($p>0.05$) values with the control group. The eviscerated weight (1250.00 - 1360.00g) had highest value in birds fed 50% UTSD which had similar ($p>0.05$) values with birds on the control diet and 100% ZTSD. The least value was recorded in birds fed 50% ZTSD. The drumstick was not affected ($p>0.05$) by the experimental diets. The values of the breast ranged from 18.95 to 21.62%, the highest value recorded in the birds fed control diet was similar ($p>0.05$) to birds fed 100% UTSD while the lowest value was observed in birds fed 50% UTSD. The thigh values (9.73-10.81%), the highest value recorded in the birds fed control diet were similar ($p>0.05$) to the values of birds fed 50% UTSD, 100% UTSD and 50% ZTSD except in birds fed 100% ZTSD which had the least value. The back had similar ($p>0.05$) values across the dietary treatments

Table 37: Carcass characteristics of broiler chickens fed diets containing untreated and treated sawdust

Parameters	1 Control diet	2 50% UTSD	3 100% UTSD	4 50% ZTSD	5 100% ZTSD	SEM
		Dietary	treatments			
Live weight (g)	1850.00	1900.00	1900.00	1900.00	1850.00	17.75
Dressed weight (g)	1720.00^{b}	1740.00^{b}	1500.00^{c}	1850.00^{a}	1680.00^{b}	33.07
Eviscerated weight (g)	1320.00^{ab}	1360.00^{a}	1280.00^{b}	1250.00^{b}	1300.00^{ab}	12.73
Dressing percentage (%)	71.35	71.79	67.47	65.77	70.33	0.97
Cut parts (% of LW)						
Head (%)	3.24^{b}	3.16^{b}	3.16^{b}	3.16^{b}	4.32^{a}	0.13
Breast (%)	21.62^{a}	18.95^{c}	21.05^{ab}	20.00^{b}	19.46^{c}	0.30
Thigh (%)	10.81^{a}	10.53^{a}	10.53^{a}	10.53^{a}	9.73^{b}	0.10
Drumstick (%)	10.81	10.53	10.53	10.53	11.89	0.24
Wing (%)	8.65^{c}	9.47^{b}	8.42^{d}	9.47^{b}	16.22^{a}	0.78
Back (%)	16.22^{a}	16.84^{a}	16.84^{a}	15.79^{a}	9.73^{b}	0.74
Neck (%)	3.24^{b}	3.16^{b}	3.16^{b}	4.21^{a}	4.32^{a}	0.17
Shank (%)	5.41^{a}	5.26^{a}	4.21^{b}	5.26^{a}	5.41a	0.15
Organ weight (% of LW)						
Heart (%)	0.39^{c}	0.42^{b}	0.59^{a}	0.53^{ab}	0.59^{a}	0.03
Spleen (%)	0.13^{b}	0.16^{b}	0.19^{b}	0.29^{a}	0.19^{b}	0.02
Liver (%)	1.89^{d}	2.11^{c}	2.37^{b}	2.63^{a}	2.16^{c}	0.07
Kidneys (%)	0.22^{b}	0.21^{b}	0.21^{b}	0.21^{b}	0.32^{a}	0.01
Gizzard (%)	2.16^{c}	2.11^{c}	4.21^{a}	3.16^{b}	2.16^{c}	0.22
Whole GIT (%)	12.97^{c}	11.71^{e}	13.68^{b}	12.63^{d}	14.05^{a}	0.22

Means on the same row having different superscripts are significantly different ($P<0.05$)

LW: Live weight

GIT: Gastro-intestinal tract

SEM: Standard Error of Mean

except in 100% ZTSD which had the least value. The organ weight was affected (p<0.05) by the dietary treatments. The values of the heart ranged between 0.39 and 0.59(%), the highest value in 100% ZTSD was similar to the values recorded in 100% UTSD and 50% ZTSD while the least value was observed in the control diet. The birds fed 50% ZTSD had highest value for liver with the lowest value in the control diet. The highest value of the whole gastro-intestinal tract was observed in 100% ZTSD while the lowest value was recorded in 50% UTSD.

4.32 Viscosity of ileal digesta of broiler chickens fed sawdust based diets

The viscosity of ileal digesta of broiler chickens fed sawdust based diets is shown in Table 38. The dietary treatments influenced (p<0.05) the viscosity of ileal digesta of the broiler chickens. At 100rpm, the highest value of 1.49cps was recorded in the control diet and the lowest value of 1.13cps observed in 50% ZTSD was similar (p>0.05) to the values recorded in 100% UTSD and 100% ZTSD.

4.33 Sensory evaluation of meat from broiler chickens fed sawdust based diets

The sensory evaluation of meats from broiler chickens fed sawdust based diets is shown in Table 39. The dietary treatments significantly (p<0.05) influenced the colour, juiciness, flavour, tenderness and overall acceptability. The highest value of 6.65 recorded in the control diet for colour was statistically (p>0.05) similar to the values obtained in 100% UTSD and 50% ZTSD but the lowest value of 5.75 was recorded in 50% UTSD. The highest value of 6.35 obtained in 100% UTSD for juiciness was similar (p>0.05) to the value in 100% ZTSD but the least value was observed in 50% UTSD. The flavour values ranged from 5.15 to 6.10 with the highest value obtained in 100% UTSD which was similar (p>0.05) to the values recorded in the control diet, 50% ZTSD and 100% ZTSD, however, the least value was recorded in 50% UTSD. The highest value of 6.65 for tenderness was recorded in 50% ZTSD

Table 38: Viscosity of Ileal digesta of broiler chickens fed diets containing untreated and treated sawdust

		Dietary	treatments			
Parameters	1	2	3	4	5	
	Control diet	50% UTSD	100% UTSD	50% ZTSD	100% ZTSD	SEM
50rpm	1.82^{a}	1.30^{c}	0.94^{d}	1.47^{b}	0.86^{e}	0.09
60rpm	1.57^{a}	1.29^{b}	1.07^{d}	1.17^{c}	0.73^{e}	0.07
100rpm	1.49^{a}	1.24^{b}	1.15^{c}	1.13^{c}	1.14^{c}	0.04

^{abcde} Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

Table 39: Sensory evaluation of meat from broiler chickens fed diets containing untreated and treated sawdust

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTSD	100% UTSD	50% ZTSD	100% ZTSD	SEM
Colour	6.65^{a}	5.75^{c}	6.60^{a}	6.60^{a}	6.25^{b}	0.09
Juiciness	6.05^{b}	5.35^{c}	6.35^{a}	5.95^{b}	6.12^{ab}	0.10
Flavour	5.75^{a}	5.15^{b}	6.10^{a}	5.70^{a}	5.85^{a}	0.10
Tenderness	6.20^{c}	5.95^{d}	6.45^{b}	6.65^{a}	6.40^{b}	0.07
Overall acceptability	6.50^{a}	6.00^{b}	6.40^{a}	6.40^{a}	6.15^{b}	0.05

^{abc}Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean

but the least value of 6.00 in 50% UTSD. The control diet had the highest value for overall acceptability which was similar (p>0.05) to the values obtained in 100% UTSD and 50% ZTSD but the lowest value was recorded in 50% UTSD.

4.34 Economy of feed conversion of broiler chickens fed sawdust based diets

The economy of feed conversion of broiler chickens fed sawdust based diets is shown in Table 40. The dietary treatments influenced (p<0.05) the cost of production/broiler, gross revenue, gross profit, rate of return on investment, economic efficiency and relative cost benefit. The cost of production values ranged between ₦1137.06 and ₦1188.55, the highest value was recorded for birds fed 50% ZTSD while the least value was observed in birds fed the control diet which was similar (p>0.05) to the values for birds fed 100% UTSD. The gross profitt values ranged from ₦210.75 to ₦276.95, the highest value was observed in birds fed 50% ZTSD which had similar (p>0.05) with the birds fed 50% UTSD but, the least value was recorded for birds on 100% ZTSD. The birds fed the control diet and 50% UTSD, 100% UTSD and 50% ZTSD had similar (p>0.05) values for rate of return on investment and economic efficiency while birds fed 100% ZTSD had the least values.

The values of relative cost benefit ranged between 0.00 and 11.29%, the highest value was recorded in 50% UTSD while the least value was obtained in the control diet but similar (p>0.05) value was observed in birds fed 100% UTSD and 50% ZTSD.

Table 40: Economy of feed conversion of broiler chickens fed diets containing untreated and treated sawdust

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTSD	100% UTSD	50% ZTSD	100% ZTSD	SEM
Cost of the feed/Kg (₦/Kg)	175.89	176.39	173.89	175.64	174.39	0.40
Price/Kg live weight (₦)	750.00	750.00	750.00	750.00	750.00	0.00
Cost of production/broiler (₦/broiler)	1137.06^{c}	1159.59^{b}	1139.50^{c}	1188.55^{a}	1155.75^{b}	5.18
Gross revenue/broiler (₦/broiler)	1401.75^{ab}	1434.00^{ab}	1391.25^{b}	1465.50^{a}	1366.50^{b}	14.21
Gross profit (₦)	264.69^{b}	274.41^{a}	251.75^{c}	276.95^{a}	210.75^{d}	6.54
Rate of return on Investment (%)	23.28^{a}	23.66^{a}	22.09^{a}	23.30^{a}	18.23^{b}	0.61
Economic efficiency	0.35^{a}	0.35^{a}	0.33^{a}	0.34^{a}	0.27^{b}	0.01
Relative cost benefit (%)	0.00^{d}	11.29^{a}	2.09^{c}	2.54^{c}	6.24^{b}	1.08

Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

4.35 **Growth response of starting broiler chickens fed corn cobs based diets**

The performance characteristics of starting broiler chickens fed corn cobs based diets is shown in Table 41. The dietary treatments significantly (p<0.05) affected the average weight gain and daily weight gain. There was similar (p>0.05) values for daily weight gain observed in the birds fed the control diet and 100% *Zymomonas mobilis* treated corn cobs (100% ZTCC) which were significantly (p<0.05) different from values obtained in birds fed other diets. The average feed intake and daily feed intake are significantly (p<0.05) affected by the dietary treatments. The birds fed 50% ZTCC had highest values for daily feed intake while the birds fed 100% ZTCC had the least value. Feed conversion ratio values ranged between 1.92 and 2.40, the highest value was recorded in birds fed 50% UTCC while the least value was observed in birds fed 100% ZTCC.

The dietary treatments significantly (p<0.05) influenced the cost of feed consumed/bird and cost of feed/kg weight gain. The total cost of feed consumed/bird ranged between ₦217.18 and ₦245.95, the highest value was observed in 50% UTCC and the least value recorded in 100% ZTCC. The highest value for the cost of feed/weight gain was recorded in 50% UTCC and the least value observed in 100% ZTCC. The values of the mortality ranged between 0.00 and 0.80%. The value recorded in the control diet was similar (p>0.05) to the value obtained in 50% ZTCC which was higher than the values obtained in other dietary treatments.

4.36 **Growth response of finishing broiler chickens fed corn cobs based diets**

The performance characteristics of finishing broiler chickens fed corn cobs based diets is shown in Table 42. The dietary treatments significantly (p<0.05) influenced average weight gain and daily weight gain. The birds fed the control diet had higher values for average body gain and daily weight gain while the least values were recorded in birds

Table 41: Performance characteristics of starting broiler chickens (0 – 4weeks) fed diets containing untreated and treated corn cobs

	Dietary treatments					
Parameters	1	2	3	4	5	
	Control diet	50% UTCC	100% UTCC	50% ZTCC	100% ZTCC	SEM
Initial body weight (g/bird)	43.00	43.00	44.00	43.00	44.00	0.35
Final body weight (g/bird)	736.00^{a}	643.00^{d}	680.00^{c}	724.00^{b}	738.00^{a}	9.92
Average weight gain (g/bird)	693.00^{a}	600.00^{d}	636.00^{c}	681.00^{b}	694.00^{a}	9.91
Daily weight gain (g/bird)	24.75^{a}	21.43^{d}	22.71^{c}	24.32^{b}	24.79^{a}	0.35
Average feed intake (g/bird)	1454.00^{b}	1440.00^{c}	1401.00^{d}	1504.00^{a}	1335.00^{e}	15.11
Daily feed intake (g/bird)	53.85^{b}	53.33^{c}	51.89^{d}	55.70^{a}	49.44^{e}	0.56
Feed conversion ratio	2.10^{c}	2.40^{a}	2.20^{b}	2.21^{b}	1.92^{d}	0.04
Protein efficiency ratio	2.29	2.02	2.18	2.02	2.43	0.10
Cost of the feed/Kg (₦/Kg)	164.38^{a}	163.40^{ab}	162.43^{b}	163.53^{ab}	162.68^{b}	0.23
Total cost of feed consumed/bird (₦)	239.01^{b}	235.30^{b}	227.56^{c}	245.95^{a}	217.18^{d}	2.72
Cost of feed/Kg weight gain (₦ /Kg)	344.89^{c}	392.17^{a}	357.81^{b}	361.16^{b}	312.94^{d}	7.03
Mortality (%)	0.80^{a}	0.00^{b}	0.00^{b}	0.80^{a}	0.00^{b}	0.11

Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

Table 42: Performance characteristics of finishing broiler chickens (5 – 8weeks) fed diets containing untreated and treated corn cobs

	Dietary treatments					
Parameters	1	2	3	4	5	
	Control diet	50% UTCC	100% UTCC	50% ZTCC	100% ZTCC	SEM
Initial body weight (g/bird)	736.00^{a}	643.00^{b}	680.00^{c}	724.00^{b}	738.00^{a}	9.92
Final body weight (g/bird)	2133.00^{a}	1963.00^{b}	1920.00^{c}	1913.00^{d}	2130.00^{a}	26.53
Average weight gain (g/bird)	1397.00^{a}	1320.00^{c}	1240.00^{d}	1189.00^{e}	1392.00^{b}	22.01
Daily weight gain (g/bird)	49.89^{a}	47.14^{c}	44.29^{d}	42.46^{e}	49.71^{b}	0.79
Average feed intake (g/bird)	4055.00^{a}	3771.00^{c}	3806.00^{b}	3479.00^{e}	3488.00^{d}	57.83
Daily feed intake (g/bird)	144.82^{a}	134.68^{c}	135.93^{b}	124.25^{e}	124.57^{d}	2.07
Feed conversion ratio	2.90^{b}	2.86^{c}	3.07^{a}	2.93^{b}	2.51^{d}	0.05
Protein efficiency ratio	1.59	1.65	1.69	1.48	1.80	0.05
Cost of the feed/Kg (₦/Kg)	174.89^{bc}	176.39^{a}	173.89^{c}	175.64^{ab}	174.39^{c}	0.27
Total cost of feed consumed/bird (₦)	709.18^{a}	665.17^{ab}	661.83^{ab}	611.05^{b}	608.27^{b}	14.68
Cost of feed/Kg weight gain (₦ /Kg)	507.64^{a}	503.91^{a}	533.73^{a}	513.92^{a}	436.98^{b}	11.63
Mortality (%)	4.80^{a}	0.80^{c}	2.40^{b}	2.40^{b}	0.80^{c}	0.41

Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

fed 50% ZTCC. The average feed intake and daily feed intake are significantly ($p<0.05$) affected by the dietary treatments. The birds fed the control diet had highest value for average feed intake and daily feed intake while the least values were observed in birds fed 50% ZTCC. The feed conversion ratio values ranged between 2.51 and 3.07, the highest value was recorded in birds fed 100% UTCC while the least value was observed in birds fed 100% ZTCC. Protein efficiency ratio was similar ($p>0.05$) across the dietary treatments. The highest numerical value was recorded in 1005 ZTCC while the least value was observed in 50% ZTCC.

The cost of feed consumed/bird and cost of feed/kg weight gain are significantly ($p<0.05$) affected by the dietary treatments. The finishing broiler chickens fed the control diet had highest values for the cost of feed consumed/bird and cost of feed/kg weight gain which are similar ($p>0.05$) to values obtained in birds fed 50% UTCC and 100% UTCC. However, the least values were obtained in birds fed 100% ZTCC. The values of the mortality range between 0.80 and 4.80%. There was highest ($p<0.05$) value for mortality in birds fed the control diet while the lowest similar values were obtained in 50% UTCC and 100% ZTCC.

4.37 Apparent nutrient digestibility of starting broiler chickens fed corn cobs based diets

The nutrient digestibility of starting broiler chickens fed corn cobs based diets are shown in Table 43. The dietary treatments influenced ($p<0.05$) the nutrient digestibility of the starting broiler chickens. The birds fed 50% UTCC had the highest value of 79.91% for dry matter digestibility and the lowest value of 65.92% observed in 100% ZTCC had similar value ($p>0.05$) with birds fed 100% UTCC and 50% ZTCC. The values of crude protein digestibility ranged between 69.25 and 76.75%, the highest value recorded in 50% UTCC was similar ($p>0.05$) to the values recorded

Table 43: Apparent nutrient digestibility of starting broiler chickens (0 – 4weeks) fed diets containing unreated and treated corn cobs

	Dietary treatments					
Parameters	1	2	3	4	5	
	Control diet	50% UTCC	100% UTCC	50% ZTCC	100% ZTCC	SEM
Dry matter digestibility	76.50^{a}	79.91^{a}	69.00^{b}	69.00^{b}	65.92^{b}	1.48
Crude protein digestibility	75.38^{a}	76.75^{a}	73.42^{ab}	72.63^{ab}	69.25^{b}	0.84
Crude fibre digestibility	61.25^{b}	68.31^{a}	46.67^{c}	46.67^{c}	47.46^{c}	2.46
Acid detergent fibre digestibility	75.59^{a}	76.62^{a}	74.36^{a}	72.50^{a}	68.46^{b}	0.91
Neutral detergent fibre digestibility	68.18^{a}	72.07^{a}	61.72^{b}	62.50^{b}	60.34^{b}	1.28
Acid detergent lignin digestibility	42.50^{bc}	52.73^{a}	39.00^{cd}	35.67^{d}	43.46^{b}	1.78
Ether extract digestibility	74.05^{ab}	74.55^{a}	69.09^{c}	70.00^{bc}	72.31^{abc}	0.75
Ash digestibility	75.31^{ab}	76.52^{a}	68.39^{c}	69.33^{c}	71.35^{bc}	0.99
Nitrogen free extract digestibility	71.01^{a}	70.17^{b}	64.01^{b}	62.50^{b}	63.80^{b}	1.07
Calcium digestibility	78.43^{b}	74.25^{d}	75.92^{c}	73.52^{d}	83.48^{a}	0.99
Phosphorus digestibility	81.59^{a}	80.39^{a}	76.17^{b}	73.66^{c}	76.26^{b}	0.80
Apparent metabolizable energy digestibility	69.57^{b}	73.89^{a}	64.30^{c}	65.15^{c}	61.33^{c}	1.27

Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean

in the control diet, 100% UTCC and 50% ZTCC. However, the lowest value recorded in 100% ZTCC was similar to the values observed in 100% UTCC and 50% ZTCC. The crude fibre digestibility values ranged between 46.67 and 68.31%, the highest value was obtained in 50% UTCC while the lowest values recorded in 100% UTCC and 50% ZTCC were similar (p>0.05) to the value observed in 100% ZTCC. The values of acid detergent fibre digestibility ranged between 68.46 and 76.62%, the highest value observed in 50% UTCC had similar (p>0.05) value with the control diet, 100% UTCC and 50% ZTCC, however, lowest (p<0.05) value was recorded in 100% ZTCC. The neutral detergent fibre digestibility values ranged between 60.37 and 72.07%, the highest value recorded in 50% UTCC had similar value with the control diet while the lowest value in 100% ZTCC was similar to the values in 100% UTCC and 50% ZTCC. The values of the acid detergent lignin digestibility ranged between 35.67 and 52.73%, the highest value was obtained in 50% UTCC while the lowest value was recorded in 50% ZTCC with similar (p>0.05) value in 100% UTCC. The ether extract digestibility values ranged between 69.09 and 74.55%, the highest value observed in 50% UTCC was similar (p>0.05) to the values recorded in the control diet and 100% ZTCC. The values of the ash digestibility ranged between 68.39 and 76.52%, the highest value was recorded in 50% UTCC but the lowest value was observed in 100% UTCC with similar (p>0.05) values recorded in 50% ZTCC and 100% ZTCC. The nitrogen free extract digestibility values ranged between 62.50 and 70.59%, the highest value was obtained in the control diet while other treatments had similar (p>0.05) values. The values of Calcium digestibility ranged between 73.53 and 83.48%, the highest value was recorded in 100% ZTCC while the lowest value observed in 50% ZTCC was similar to the recorded value in 50% UTCC. Moreover, the Phosphorus digestibility values ranged between 73.66 and 81.59%, the the lowest value of 71.16% in the control diet was similar (p>0.05) to the value recorded highest value recorded in the control diet was similar (p>0.05) to the value obtained in 50% UTCC but the least value was recorded in 50% ZTCC. The significantly (p<0.050 highest value (73.89%) for apparent metabolizable energy digestibility was recorded in the control diet while the lowest value (62.33%) in 100% ZTCC was similar (p>0.05) to the values in 100% UTCC and 50% ZTCC.

4.38 Apparent nutrient digestibility of finishing broiler chickens fed corn cobs based diets

The apparent nutrient digestibility of finishing broiler chickens fed corn based diets is shown in Table 44. The dietary treatments influenced (p>0.05) the nutrient digestibility of finishing broiler chickens. The birds fed 50% ZTCC had highest (p>0.05) value of 74.00% for dry matter digestibility but the lowest value of 50.54% recorded in 100% UTCC and 100% ZTCC was similar to the value observed in the control diet. The crude protein digestibility values ranged between 66.67 and 75.24%, the highest value obtained in 50% ZTCC was similar (p>0.05) to the value in 50% UTCC, but the lowest value in 100% UTCC was similar (p>0.05) to the values in the control diet and 100% ZTCC. The values of crude fibre digestibility ranged between 47.11 and 65.00%, the highest value was recorded in 50% ZTCC while the lowest value was obtained in 50% UTCC. The acid detergent fibre digestibility values ranged between 53.90 and 71.29%, the birds fed 50% ZTCC had highest (p<0.05) value while the lowest value recorded in 100% UTCC was similar (p>0.05) to the value in 100% ZTCC. The values of neutral detergent fibre digestibility values ranged between 44.74 and 65.76%, the highest value was observed in 50% ZTCC but the lowest value in

Table 44: Apparent nutrient digestibility of finishing broiler chickens (5 – 8weeks) fed diets containing untreated and treated corn cobs

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTCC	100% UTCC	50% ZTCC	100% ZTCC	SEM
Dry matter digestibility	53.29^{c}	62.68^{b}	50.54^{c}	74.00^{a}	50.54^{c}	2.47
Crude protein digestibility	68.06^{bc}	71.14^{ab}	66.67^{c}	75.24^{a}	68.13^{bc}	0.96
Crude fibre digestibility	55.45^{b}	47.11^{c}	41.54^{d}	65.00^{a}	59.02^{b}	2.29
Acid detergent fibre digestibility	60.77^{c}	66.84^{b}	53.90^{d}	71.29^{a}	54.85^{d}	1.87
Neutral detergent fibre digestibility	49.30^{c}	55.12^{b}	44.74^{d}	65.76^{a}	47.95^{cd}	2.04
Acid detergent lignin digestibility	60.16^{c}	68.04^{b}	62.52^{c}	70.63^{b}	76.15^{a}	1.61
Ether extract digestibility	69.01^{bc}	70.43^{ab}	61.54^{d}	73.75^{a}	65.21^{cd}	1.23
Ash digestibility	66.61^{b}	70.31^{ab}	57.38^{c}	72.50^{a}	55.64^{c}	1.88
Nitrogen free extract digestibility	44.29^{e}	64.97^{b}	48.88^{d}	70.68^{a}	58.36^{c}	2.66
Calcium digestibility	66.80^{d}	70.88^{c}	66.52^{d}	86.99^{a}	81.25^{b}	2.20
Phosphorus digestibility	72.78^{b}	74.07^{b}	73.29^{b}	86.05^{a}	65.57^{c}	1.77
Apparent metabolizable energy digestibility	65.44^{b}	65.50^{b}	60.22^{c}	76.90^{a}	57.94^{c}	1.81

Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean

100% UTCC was similar (p>0.05) to the value in 100% ZTCC. The birds fed 100% ZTCC had highest (p<0.05) value of 76.15% for acid detergent lignin digestibility but the lowest value in the control group (60.16%) was similar to the value (62.52%) obtained in 100% UTCC. The ash digestibility highest value in 50% ZTCC was similar (p>0.05) to the values recorded in the control diet but the lowest value in 100% ZTCC was similar (p>0.05) to the value in 100% UTCC. The nitrogen free extract digestibility highest value was obtained in birds fed 50% ZTCC while the lowest value was recoeded in the control group. The values of Calcium digestibility ranged between 66.52 and 86.99%, the highest value was recorded in 50% ZTCC while the least value observed in 100% UTCC had similar (p>0.05) value in control diet. The highest value for phosphorus digestibility was obtained in 50% ZTCC, however, the lowest value was recorded in the control diet. The birds fed 50% ZTCC had highest (p<0.05) value of apparent metabolizable energy digestibility while those fed 100% ZTCC had lowest value.

4.39 Haematological parameters and serum metabolites of starting broiler chickens fed corn cobs based diets

The haematological and serum metabolites of starting broiler chickens fed corn based diets are shown in Table 45. The dietary treatments significantly (p<0.05) affected the red blood cell, white blood cell, MCH, MCV, heterophil and lymphocytes. The birds fed the control diet had highest value for red blood cell while birds fed 50% ZTCC had the least value. The birds fed 50% ZTCC had highest (p<0.05) values for white blood cell, MCH, and MCV but, the lowest values for MCH and MCV were recorded in the control diet. Also, the highest value for lymphocytes was recorded in 100% UTCC which was similar to the values observed in the control diet, 50% UTCC and 100%

Table 45: Haematological parameters and serum metabolites of starting broiler chickens (0 – 4 weeks) fed diets containing untreated and treated corn cobs

Parameters	Dietary treatments 1	2	3	4	5	
	Control diet	50% UTCC	100% UTCC	50% ZTCC	100% ZTCC	SEM
Haematological parameters:						
Packed cell volume (%)	27.00	25.00	25.00	28.00	30.00	0.79
Haemoglobin (g/dl)	9.00	8.30	8.00	9.30	10.00	0.32
Red blood cell ($x10^{12/L}$)	3.70^{a}	1.30^{d}	2.10^{c}	1.20^{d}	3.00^{b}	0.27
Mean Corpuscular Haemoglobin (pg)	24.00^{e}	64.00^{b}	38.00^{c}	78.00^{a}	33.00^{d}	5.44
Mean Corpuscular Haemoglobin in Concentration (g/dl)	33.30	33.20	32.00	33.20	33.30	0.57
Mean Corpuscular Volume (fl)	73.00^{d}	192.00^{b}	119.00^{c}	233.00^{a}	100.00^{c}	16.14
White blood cell ($x10^{9/L}$)	16.10^{ab}	14.50^{b}	11.80^{c}	18.20^{a}	15.40^{b}	0.63
Heterophil (%)	32.00^{ab}	33.00^{ab}	24.00^{c}	30.00^{b}	36.00^{a}	1.21
Lymphocytes (%)	69.00^{ab}	65.00^{ab}	72.00^{a}	70.00^{ab}	63.00^{b}	1.22
Eosinophil (%)	0.00^{b}	1.00^{a}	0.00^{b}	0.00^{b}	0.00^{b}	0.12
Monocytes (%)	0.00^{b}	1.00^{a}	1.00^{a}	0.00^{b}	0.00^{b}	0.13
Basophils (%)	1.00^{b}	0.00^{c}	2.00^{a}	0.00^{c}	1.00^{b}	0.20
Serum metabolites:						
Total protein (g/dl)	4.50^{a}	3.50^{b}	3.10^{c}	3.10^{c}	3.20^{bc}	0.15
Albumin (g/dl)	2.30^{ab}	2.50^{a}	2.00^{bc}	1.80^{cd}	1.60^{d}	0.10
Globulin (g/dl)	2.20^{a}	1.00^{c}	1.10^{bc}	1.30^{bc}	1.60^{b}	0.13
Glucose (mg/dl)	120.00	128.00	121.00	113.00	118.00	3.55
Cholesterol (mg/dl)	90.00^{ab}	88.00^{ab}	80.00^{b}	83.00^{ab}	100.00^{a}	2.31
Uric Acid (mg/dl)	3.60^{bc}	4.50^{ab}	4.50^{ab}	2.80^{c}	5.27^{a}	0.28
Creatinine (mg/dl)	0.50^{a}	0.60^{a}	0.70^{a}	0.10^{b}	0.70^{a}	0.07
Aspartate Amino-Transferase (U/L)	42.00^{ab}	45.00^{ab}	42.00^{ab}	50.00^{a}	38.00^{b}	1.63
Alanine Amino-Transferase (U/L)	24.00^{ab}	21.00^{ab}	25.00^{a}	20.00^{b}	24.00^{ab}	0.71

Means on the same row having different superscripts are significantly different ($P<0.05$); SEM: Standard Error of Mean

UTCC. Moreover, the lowest values for WBC and heterophil were recorded in birds fed 100% UTCC. Moreover, there were influence ($p<0.05$) on the eosinophil, monocytes, and basophils across the dietary treatments. The dietary treatments influenced ($p<0.05$) all the serum metabolites observed in the current study. The birds fed the control diet had highest value for total protein while the least same value was recorded for birds fed 100% UTCC and 50% ZTCC which was similar ($p>0.05$) to the value recorded in 100% ZTCC. The dietary treatments did not influence ($p>0.05$) the glucose. Although, birds on 50% UTCC had numerical higher value, with least value in 50% ZTCC. The cholesterol values (80.00-100.00mg/dl) were affected ($p<0.05$) by the dietary treatments, the highest value was observed in birds fed 100% ZTCC while the least value was recorded in birds fed 100% UTCC. The highest value for uric acid recorded in 100% ZTCC, was similar ($p>0.05$) to the values obtained in 50% UTCC and 100% UTCC while the least value was recorded in 50% ZTCC. The AST values ranged between 38.00 and 50.00 (U/L), with the highest value observed in birds fed 50% ZTCC which was similar ($p>0.05$) to values obtained in birds fed the control diet, 50% UTCC and 100% UTCC. The lowest value was obtained in birds fed 100% ZTCC. The birds fed 100% UTCC had highest value of 25.00U/L which was similar ($p>0.05$) to values obtained in control diet, 50% UTCC and 100% ZTCC while the least value was obtained in 50% ZTCC.

4.40 Haematological parameters and serum metabolites of finishing broiler chickens fed corn cobs based diets

The haematological and serum metabolites of finishing broiler chickens fed corn cobs based diets are shown in Table 46. The dietary treatments ($p<0.05$) influenced ($p<0.05$) the haematological parameters except MCHC. The birds fed 50% UTCC had highest ($p<0.05$) values for PCV, and haemoglobin which were similar ($p>0.05$) to the

Table 46: Haematological parameters and serum metabolites of finishing broiler chickens (5– 8weeks) fed diets containing untreated and treated corn cobs

Parameters	Dietary treatments 1 Control diet	2 50% UTCC	3 100% UTCC	4 50% ZTCC	5 100% ZTCC	SEM
Haematological parameters:						
Packed cell volume (%)	30.00[b]	39.00[a]	29.00[b]	27.00[b]	26.00[b]	1.63
Haemoglobin (g/dl)	10.00[b]	13.00[a]	9.70[b]	9.00[b]	8.60[b]	0.51
Red blood cell ($x10^{12/L}$)	1.00[b]	1.20[b]	1.20[b]	2.00[a]	1.40[b]	0.11
Mean Corpuscular Haemoglobin (pg)	100.00[a]	108.00[a]	81.00[b]	45.00[d]	61.00[c]	6.53
Mean Corpuscular Haemoglobin in Concentration (g/dl)	33.30	33.30	33.40	33.30	33.10	0.52
Mean Corpuscular Volume (fl)	300.00[b]	325.00[a]	242.00[c]	135.00[e]	186.00[d]	18.91
White blood cell ($x10^{9/L}$)	12.00[b]	10.60[b]	15.10[a]	16.80[a]	11.80[b]	0.65
Heterophil (%)	29.00[b]	38.00[a]	22.00[c]	21.00[c]	36.00[a]	1.98
Lymphocytes (%)	70.00[b]	60.00[c]	78.00[a]	77.00[ab]	62.00[c]	2.17
Eosinophil (%)	0.00[b]	0.00[b]	0.00[b]	0.00[b]	1.00[a]	0.11
Monocytes (%)	1.00[b]	2.00[a]	0.00[c]	1.00[b]	1.00[b]	0.17
Basophils (%)	0.00[b]	0.00[b]	0.00[b]	1.00[a]	0.00[b]	0.11
Serum metabolites:						
Total protein (g/dl)	3.10[c]	6.30[a]	4.60[b]	2.10[e]	2.70[d]	0.41
Albumin (g/dl)	1.80[b]	2.90[a]	1.50[bc]	1.00[c]	1.80[b]	0.18
Globulin (g/dl)	1.30[c]	3.40[a]	3.10[b]	1.10[d]	0.90[e]	0.29
Glucose (mg/dl)	120.00[c]	122.00[b]	112.00[e]	115.00[d]	133.00[a]	1.94
Cholesterol (mg/dl)	87.00[b]	76.00[e]	84.00[c]	82.00[d]	90.00[a]	1.29
Uric Acid (mg/dl)	3.20[b]	5.00[a]	4.80[a]	3.00[b]	2.80[b]	0.28
Creatinine (mg/dl)	0.10[c]	0.40[ab]	0.40[ab]	0.30[b]	0.50[a]	0.04
Aspartate Amino-Transferase (U/L)	45.00[c]	50.00[b]	49.00[b]	48.00[b]	63.00[a]	1.69
Alanine Amino-Transferase (U/L)	24.00[b]	28.00[a]	14.00[d]	19.00[c]	23.00[b]	1.33

Means on the same row having different superscripts are significantly different ($P<0.05$); SEM: Standard Error of Mean

values obtained across the dietary treatments. The red blood cell values ranged between 1.00 and 2.00 (x $10^{12/L)}$, the highest value was recorded in birds fed 50% ZTCC while the least value recorded in the control diet was similar ($p>0.05$) to the values obtained in other diets. The highest value of WBC was obtained in birds fed 50% ZTCC while the least values was observed in birds fed 50% UTCC was similar ($p>0.05$) to the values recorded in the control group and 100% ZTCC. The birds fed 50% UTCC had highest ($p<0.05$) values of MCH, MCV and heterophil while the least values were recorded in birds fed 50% ZTCC. The finishing broiler chickens fed 50% UTCC had highest ($p<0.05$) values for total protein, albumin, globulin, uric acid and ALT. The least values for total protein and albumin was observed in birds fed 50% ZTCC while birds fed 100% ZTCC had least values for globulin and uric acid. The birds fed diet 5 had highest ($p<0.05$) values for glucose, cholesterol, creatinine and AST, while the least values for these metabolites were recorded in control diet, 100% UTCC and 50% ZTCC.

4.41 Carcass characteristics of broiler chickens fed corn cobs based diets

The carcass characteristics of broiler chickens fed corn cobs based diets is shown in Table 47. The dietary treatments influenced ($p<0.05$) the live weight, dressed weight, eviscerated weight and the dressing percentage. The dressing percentage values ranged between 69.13 and 77.28%, the highest value was recorded in birds fed the control diet while the least value was obtained in birds fed 100% UTCC. The birds fed the control diet had highest ($p<0.05$) value for breast which was ($p>0.05$) similar to the values obtained in birds fed 50% UTCC and 100% ZTCC. The values of thigh ranged between 10.53 and 11.00(%), the highest value obtained in birds fed 100% UTCC was similar ($p>0.05$) to the value obtained in birds fed 100% ZTCC but the lowest values were observed in birds fed 50% UTCC and 50% ZTCC. The highest value of

Table 47: Carcass characteristics of broiler chickens fed diets containing untreated and treated corn cobs

Parameters		Dietary	treatments			
	1	2	3	4	5	
	Control diet	50% UTCC	100% UTCC	50% ZTCC	100% ZTCC	SEM
Live weight (g)	2200.00^{a}	1900.00^{b}	2000.00^{b}	1900.00^{b}	2000.00^{b}	32.46
Dressed weight (g)	2120.00^{a}	1820.00^{c}	1940.00^{b}	1780.00^{c}	1900.00^{b}	32.24
Eviscerated weight (g)	1700.00^{a}	1460.00^{c}	1380.00^{d}	1460.00^{c}	1540.00^{b}	29.08
Dressing percentage (%)	77.28^{a}	77.00^{a}	69.13^{b}	76.85^{a}	77.00^{a}	1.05
Cut parts (% of LW)						
Head (%)	2.73^{e}	4.21^{a}	3.00^{d}	3.16^{c}	4.00^{b}	0.16
Breast (%)	20.00^{a}	17.89^{ab}	16.00^{b}	15.79^{b}	18.00^{ab}	0.51
Thigh (%)	10.91^{b}	10.53^{c}	11.00^{a}	10.53^{c}	11.00^{a}	0.06
Drumstick (%)	10.91^{a}	10.53^{a}	8.00^{b}	10.53^{a}	11.00^{a}	0.33
Wing (%)	8.18^{ab}	8.42^{ab}	7.00^{b}	8.42^{ab}	9.00^{a}	0.27
Back (%)	17.27^{c}	15.79^{d}	16.00^{d}	18.95^{a}	18.00^{b}	0.32
Neck (%)	3.64^{b}	3.16^{c}	3.00^{c}	4.21^{a}	4.00^{ab}	0.13
Shank (%)	4.55^{c}	4.21^{d}	4.00^{e}	5.26^{a}	5.00^{b}	0.13
Organ weight (% of LW)						
Heart (%)	0.91^{c}	1.05^{a}	1.00^{b}	1.05^{a}	1.00^{b}	0.01
Spleen (%)	0.18^{a}	0.13^{b}	0.11^{bc}	0.13^{b}	0.10^{c}	0.01
Lungs (%)	0.82^{ab}	0.95^{a}	0.75^{bc}	0.63^{c}	0.80^{b}	0.03
Liver (%)	3.64^{a}	3.16^{b}	3.00^{b}	3.16^{b}	4.00^{a}	0.11
Kidneys (%)	0.73^{b}	0.68^{b}	0.43^{d}	0.58^{c}	0.90^{a}	0.04
Proventriculus (%)	0.91	1.05	1.00	1.05	1.00	0.03
Gizzard (%)	2.73^{c}	5.26^{a}	5.00^{a}	4.21^{b}	3.00^{c}	0.28
Empty gizzard (%)	1.82^{c}	3.16^{a}	3.00^{ab}	3.16^{a}	2.50^{b}	0.15
Abdominal fat (%)	0.91^{c}	1.05^{b}	1.00^{b}	2.11^{a}	1.00^{b}	0.12
Whole GIT (%)	15.45^{d}	18.95^{b}	17.00^{c}	16.84^{c}	21.00^{a}	0.53

Means on the same row having different superscripts are significantly different ($P<0.05$)

LW: Live weight

GIT: Gastro-intestinal tract

SEM: Standard Error of Mean

drumstick recorded in birds fed 100% ZTCC was similar (p>0.05) to the values obtained in the birds fed the control diet and diets 2,4 and 5. The lowest value of 8.00% was recorded in birds fed diet 3. The highest value of the back was recorded in 50% ZTCC but, the lowest value was observed in the control group. The dietary treatments did not influence (p<0.05 the proventriculus of the broiler chickens. The birds fed 50% UTCC and 100% UTCC had the same highest value for heart while the least value was obtained in the birds fed the control diet. The liver values ranged between 3.00 and 4.00%, the birds fed 100% ZTCC had the highest value while the least value was obtained in birds fed 100% UTCC. The birds fed 5 had highest (p<0.05) value for whole GIT while the least value was obtained in birds fed the control diet.

4.42 Viscosity of ileal digesta of broiler chickens fed corn cobs based diets

The viscosity of ileal digesta of broiler chickens fed corn cobs based diets are shown in Table 48. The dietary treatments significantly (p<0.05) influenced the ileal digesta viscosity of the broiler chickens. At 100rpm, the highest value (7.40cps) was observed in 100% UTCC but the lowest value (3.03) was recorded in the control diet.

4.43 Sensory evaluation of meats from broiler chickens fed corn cobs based diets

The sensory evaluation of meats from broiler chickens fed corn cobs based diets is shown in Table 49. The dietary treatments influenced (p<0.05) the colour, juiciness, flavour, tenderness and overall acceptability. The birds fed 50% ZTCC had highest (p<0.05) value of 6.00 for colour of the meat while least value was observed in birds fed 100% ZTCC which was similar (p>0.05) to the values obtained in other dietary treatments. The birds on 100% UTCC had highest (p<0.05) values for juiciness, flavour and tenderness, however, the least values for the aforementioned parameters

Table 48: Viscosity of Ileal digesta of broiler chickens fed diets containing untreated and treated corn cobs

Parameters		Dietary	treatments			
	1	2	3	4	5	
	Control diet	50% UTCC	100% UTCC	50% ZTCC	100% ZTCC	SEM
50rpm	4.04^{d}	7.22^{c}	15.14^{a}	7.50^{c}	9.20^{b}	0.98
60rpm	3.58^{c}	6.05^{b}	12.90^{a}	5.80^{b}	6.02^{b}	0.85
100rpm	3.03^{c}	4.22^{b}	7.40^{a}	3.90^{bc}	3.30^{c}	0.43

^{abcde} Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

Table 49: Sensory evaluation of meat from broiler chickens fed diets containing untreated and treated corn cobs

Parameters	Dietary treatments 1 Control diet	2 50% UTSD	3 100% UTSD	4 50% ZTSD	5 100% ZTSD	SEM
Colour	6.65^{a}	5.75^{c}	6.60^{a}	6.60^{a}	6.25^{b}	0.09
Juiciness	6.05^{b}	5.35^{c}	6.35^{a}	5.95^{b}	6.12^{ab}	0.10
Flavour	5.75^{a}	5.15^{b}	6.10^{a}	5.70^{a}	5.85^{a}	0.10
Tenderness	6.20^{c}	5.95^{d}	6.45^{b}	6.65^{a}	6.40^{b}	0.07
Overall acceptability	6.50^{a}	6.00^{b}	6.40^{a}	6.40^{a}	6.15^{b}	0.05

^{abc}Means on the same row having different superscripts are significantly different (P<0.05)

SEM: Standard Error of Mean

were recorded in 50% UTCC, 50% ZTCC and 100% ZTCC. The overall acceptability values ranged between 5.05 and 5.90, the highest value was recorded in birds fed 100% UTCC and the lowest value was obtained in birds fed 50% UTCC.

4.44 Economy of feed conversion of broiler chickens fed corn cobs based diets

The economy of feed conversion of broiler chickens fed corn cobs based diets is shown in Table 50. The dietary treatments significantly (p<0.05) influenced the cost of the feed/kg, the highest value of ₦176.39 was obtained in 50% UTCC which was similar (p>0.05) to the value obtained in 50% ZTCC with the least value of ₦173.89 observed in 100% UTCC. The cost of production/broiler ranged between ₦1312.34 and ₦1413.25, the highest value was obtained in the control diet while the lowest value was recorded in 100% ZTCC which was similar (p>0.05) to the value in 50% ZTCC. The gross profit was higher (p<0.05) for birds fed 100% ZTCC but lower value was obtained in 100% UTCC. The birds fed 100% ZTCC had highest (p<0.05) values of rate of return on investment, economic efficiency and relative cost benefit while the least values for rate of return on investment and economic efficiency were recorded in 100% UTCC. The values of relative cost benefit ranged between 0.00 and 13.92%, the highest value was recorded in 100% ZTCC while the least value observed in the control diet was similar (p>0.05) to value recorded in birds on 50% UTCC. Also, similar (p>0.05) value was obtained in birds on 50% UTCC and 50% ZTCC for relative cost benefit.

4.45 Overview of the best growth response of the finishing broiler chickens (5 - 8 weeks)

The overview of the best growth response of the finishing broiler chickens is shown in Table 51. The values showed that untreated and treated soyabean hull promoted best growth response of finishing broiler chickens, followed by untreated and treated

Table 50: Economy of feed conversion of broiler chickens fed diets containing untreated and treated corn cobs

Parameters	Dietary treatments					
	1	2	3	4	5	
	Control diet	50% UTCC	100% UTCC	50% ZTCC	100% ZTCC	SEM
Cost of the feed/Kg (₦/Kg)	174.89[bc]	176.39[a]	173.89[c]	175.64[ab]	174.39[c]	0.27
Price/Kg live weight (₦)	900.00	900.00	900.00	900.00	900.00	0.00
Cost of production/broiler (₦/broiler)	1413.25[a]	1369.24[b]	1365.90[b]	1315.12[c]	1312.34[c]	10.13
Gross revenue/broiler (₦/broiler)	1917.00[a]	1764.00[b]	1728.00[c]	1719.00[c]	1917.00[a]	24.08
Gross profit (₦)	503.75[b]	394.76[d]	362.10[e]	403.88[c]	604.66[a]	23.82
Rate of return on Investment (%)	35.64[b]	28.83[d]	26.51[e]	30.71[c]	46.07[a]	1.86
Economic efficiency	0.71[b]	0.59[b]	0.55[b]	0.66[b]	0.99[a]	0.05
Relative cost benefit (%)	0.00[d]	0.73[cd]	5.14[b]	1.24[c]	13.92[a]	1.39

Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean

Table 51: Overview of the best growth response from finishing broiler chickens (5 – 8 weeks) fed diets containing various fibrous feedstuffs treated with ***Zymomonas mobilis***

Parameters	Soyabean hull	Cassava sifting	Sawdust	Corn cobs
Average weight gain (g/bird)	1453.00 – 1695.00	813.00 – 1094.00	1249.00 – 1401.00	1189.00 – 1397.00
Daily weight gain (g/bird)	51.89 – 60.54	29.04 – 39.07	44.61 – 50.04	42.46 – 49.89
Average feed intake (g/bird)	3836.00 – 4346.00	2893.00 – 3333.00	3561.00 -3880.00	3479.00 – 4055.00
Daily feed intake (g/bird)	137.00 – 155.21	103.32 – 119.04	127.18 – 138.57	124.25 – 144.82
Feed conversion ratio	2.50 – 2.76	3.03 – 3.78	2.65 – 3.01	2.51 – 3.07
Protein efficiency ratio	1.86 - 2.16	1.18 – 1.61	1.46 – 1.91	1.48 – 1.80

sawdust, untreated and treated corn cobs with the least growth response from broiler chickens fed untreated and treated cassava sifting based diets.

CHAPTER FIVE

5.0 DISCUSSION

The proximate composition of the experimental diets met the nutrient requirements of the starting and finishing broiler chickens in the tropics as stated by Olomu, 1995. The crude protein of Z*ymomonas mobilis* fermented soyabean hull of 19.68% was greater than the value of 14.45% obtained in fermented cowpea husk as reported by Adedire *et al*. (2012). However, the crude fibre, nitrogen free extract, ash and acid detergent fibre values were lower than the values for the fermented cowpea husk by the same authors. The improved nutrient composition of treated soyabean hull may be due to the fermentation with *Zymomonas mobilis*. The biodegradation had considerably increased its crude protein content. In addition, Egounlety and Aworh (2000) observed that fermentation brings about numerous biochemical and nutritional changes in the raw materials, besides the breakdown of certain constituents, reduction of antinutritional factors and the synthesis of B vitamins. The metabolizable energy of fermented soyabean hull of 2793.02kcal/kg is comparable with the value of 2764.10kcal/kg of wheat offal (Aduku, 1993). The reduced gross energy following fermentation may be attributed to the fact that a large proportion of the fermentable carbohydrates of the soyabean hull could have been removed during fermentation as observed by Adeyemi *et al*. (2011) for fermented pineapple peels. However, the values of crude protein, ether extract, ash were lower than the values reported by Esonu *et al*. (1997), but the values of acid detergent fibre, neutral detergent fibre and nitrogen free extract were greater than the values obtained by the same authors.

The fermentation of cassava sifting with *Zymomonas mobilis* improved its crude protein, ether extract and ash content. This observation agreed with the findings of Eka (1979) who reported that there may be enrichment of products following fermentation of foodstuffs as fermented products exhibited a relative increase in protein, lipid and ash content. In the same vein, Adeyemi *et al*. (2007) reported that the increased crude protein may be linked with the proliferation of microbial bodies. The crude protein value of 5.36% of fermented cassava sifting was less than the values of 8.8% reported for maize (NRC, 1994), and 15.61% reported for wheat offal (Aduku, 1993). This implied that *Z. mobilis* treated cassava sifting can be used for partial replacement of maize protein. However, the crude protein of fermented cassava sifting is greater than the values of 2.5% reported for cassava pellets (INRA, 1989), while the metabolizable energy content of 2894.44 Kcal/Kg was comparable to the value of 2832 kcal/kg reported by CVB (1998) for cassava pellets. The low calcium content of cassava sifting following fermentation may be due to gradual leaching of the mineral in the fermenting water as observed by Oso *et al*. (2012) for fermented pigeon pea. This agreed with the findings of Dulhan *et al*. (2002) who reported reduction in calcium content of pigeon pea seeds soaked in water.

The crude protein of *Z. mobilis* fermented sawdust of 7.13% was greater than the value of 5.56% reported by Anigbogu and Anosike (2010) for *Zymomonas mobilis* degraded sawdust but lower than the value reported for wheat offal by Aduku (1993). The crude fibre of 51.50% obtained in the study was lower than the value (58.85%) reported by Anigbogu and Anosike (2010). However, the value of ether extract of 5.00% was greater than 0.16% reported by the same authors. The difference might be due to the specie of trees, length of storage of the timber, sawdust at the sawmills and the milling pattern (Oke and Oke, 2007). There was improvement in the gross energy of the fermented sawdust. This might be due to the hydrolysis of the crude fibre into disaccharides and monosaccharide which resulted in the availability and utilization of liberated energy (Faniyi, 2006; Adedire *et al*., 2012).

The proximate composition of the treated corn cobs used in the study was closer to the previous results reported in the literature. The crude protein of fermented corn cobs of 9.45% reported in the study was greater than 4.79% reported by Olagunju *et al.* (2013) and lower than 12.06% for fermented corn cobs by Adedire *et al*. (2012). The crude fibre of the fermented corn cobs of 19.00% was greater than the value of 6.83% reported by Olagunju *et al*. (2013) but lower than the value of 26.55% reported by Adeyemi *et al*. (2008) for fermented corn cobs. The difference between the reported value in the study and literature, may be due to the length of storage, drying period and the specie of maize from which the cobs was harvested. The ether extract value of 8.50% was greater than the value of 1.00% reported by Adeyemi *et al*. (2008), but the values of ash and nitrogen free extract were lower than the values reported for fermented corn cobs by Adedire *et al*. (2012) and Olagunju *et al*. (2013). The difference in the values may be due to the microorganisms used for fermentation The metabolizable energy of fermented corn cobs (2780.28 kcal/kg) was comparable to the value (2764.10 kcal/kg) for wheat offal (Aduku, 1993). The fermentation of corn cobs with *Zymomonas mobilis* improved its crude protein content. This could be attributed to the possible secretion of enzyme. This agreed with the reports of Olagunju *et al*. (2013) who reported that fermentation of corn cobs with white rot fungi improved its protein content, fibre level, ash and some mineral elements like calcium, potassium and zinc. Also, Olagunju *et al*. (2013) reported that increase in crude protein content of corn cobs by Lachnocladium spp. might be due to the secretion of laccase and manganese peroxidase, amylases and cellulases (Oboh and Akindahunsi, 2003) by the fermenting organism (Sidharth *et al*. 2013) and increase in the growth of the fungi (Omer *et al*., 2012). The variation in nutrients could be due to differences in the type of cultivars, fermentation period/duration, processing methods, conditions and storage methods (Udedibie and Carlini, 2000; Onu *et al*. (2001). However, reduced Ca and P content of the fermented corn cobs when compared with the non-fermented product suggested utilization of the constituent minerals by *Zymomonas mobilis* during fermentation as observed by Oso *et al*. (2015).

The soyabean based diets influenced the weight, feed intake, feed conversion ratio, protein efficiency ratio, total cost of feed consumed/bird and cost of feed/kg weight gain of the starting broiler chickens. This observation agreed with the findings of Opoola *et al*. (2016) who reported that the final weight, body weight gain, feed intake and feed conversion ratio were significantly affected by dietary treatments. The improvement in the growth performance of the starting broiler chickens fed the *Z. mobilis* treated soyabean hull (ZTSBH) may be due to the reduction of anti-nutritional factors as observed by Reddy and Pierson (1994) and Khattab and Arntfield (2009). They reported appreciable reductions in the tannin and phytic acid contents of cereals and legumes respectively. The birds fed 50% ZTSBH and 100% ZTSBH had higher values of daily feed intake than birds fed the control and other diets. This agreed with the findings of Steenfeldt *et al*. (1998) who reported an increase in feed intake of broiler chickens when their diets were supplemented with enzyme. Moreover, birds fed 100% ZTSBH had the lowest value of feed conversion ratio which was similar to the value obtained in 100% untreated soyabean hull (UTSBH). This may be due to better utilization of the incorporated treated soyabean hull in the diet. The total cost of feed consumed/bird was higher for birds fed 50% ZTSBH and 100% ZTSBH. This might be due to high feed consumption by the broiler chickens. However, the birds fed 100% ZTSBH had the lowest value of cost of feed/kg weight gain compared with the control and other diets. This attested to the fact that replacement of wheat offal with treated soyabean hull based diet was more cost effective than other treatments.

Also, the inclusion of soyabean based diets influenced the body weight, average feed intake, protein efficiency ratio, total cost of feed consumed/bird and cost of feed/kg weight gain of the finishing broiler chickens. The broiler chickens fed 50% ZTSBH had the highest values of final body weight, average weight gain and daily weight gain. However, the values recorded for final body weight and average weight gain were similar to the values obtained from the birds fed 100% UTSBH. This observation did not agree with the findings of Odeh *et al*. (2016) who reported no differences in final weight gain and daily weight gain for broiler chickens fed rice milling waste based diets. The values of daily weight gain (51.89 - 60.54g/bird) obtained in this study were higher than the 34.18g/bird as reported by Olomu (1995) for broiler chickens at 9 weeks of age in the tropics and 42.95 - 46.39g/birds reported by Odeh *et al*. (2016). This may be attributed to the quality of the soyabean based diets used in the study. Moreover, a higher body weight observed in chicks fed 100% ZTSBH at day 28 which was not reflected at the finisher phase might be due to the fact that older poultry birds' nutrient requirements decrease with age (NRC., 1994) and because they possessed a well-developed digestive tracts and organs (Lilja, 1983). However, the daily feed intake was similar across the dietary treatments but the control group had numerically higher value for daily feed intake. The reduced feed intake recorded in the study could be said to indicate an adequacy of the energy content of the diets because the broiler chickens were fed isocaloric dietsThe values of the feed conversion ratio were not affected by dietary treatments. Feed conversion ratio measures how efficient the broiler chickens convert feed consumed into meat. The numerical lowest value obtained in 50% ZTSBH (2.50) is similar to the value (2.50) reported by Olomu (1995). Adeyemo and Longe (2007) defined protein efficiency ratio as a clear indicator of the quality of dietary protein. They further stated that dietary protein quality can be assessed by its availability for tissue deposition. The birds fed 50% UTSBH and 100% UTSBH had similar higher value for protein efficiency ratio than the values in other diets. The value of mortality recorded in diet 4 was comparable to the value of 6.78% obtained for Anak 2000 broiler chickens by Awobajo *et al*. (2007). The Poultry International (1994) reported that genetic factors (breeds) may be responsible for high death rate of some breeds of domestic fowls. The economic value of replacement of wheat offal with treated and untreated soyabean hull in diets of broiler chickens was depicted by the reduced total cost of feed consumed/bird and cost of feed/kg weight gain. This may be due to the low cost of soyabean hull, low processing cost and the nutrient composition of the soyabean hull which supported growth response of broiler chickens. This observation agreed with the findings of Odeh *et al*. (2016) who fed graded levels of rice milling waste to broiler chickens and Ngiki *et al*. (2014) who replaced maize with cassava root-leaf meal mixture in broiler chicken diets. Mortality was recorded in all the dietary treatments which may not be linked with the diets. This agreed with the report of the Poultry International (1994) that total flock mortality may be due to the birds' age and health, ventilation and season of the year.

The broiler chickens fed the experimental 100% ZTSBH had highest values for dry matter (DM), crude protein digestibility (CPD), neutral detergent fibre digestibility (NDFD), ether extract digestibility (EED), nitrogen free extract (NFED), Calcium, Phosphorus and apparent metabolizable energy digestibility (AMED) compared to the values from other diets. This observation agreed with the reports of Agboola *et al*. (2014) who reported that apparent nutrient digestibility in broiler chickens was significantly improved with enzyme supplementation. Although, Adeniji and Omonijo (2004) reported that fibres are arranged in such a way that proteins are trapped within them which make it difficult for enzyme to digest them in the gastro-intestinal tracts of non-ruminant animals. The treatment of soyabean hull with *Zymomonas mobilis* to produce life-enzyme based diets assisted the broiler chickens at the starter phase to digest and promote optimum nutrients absorption from the GIT. Replacement of wheat offal with *Zymomonas mobilis* based diet improved ether extract digestibility as evidenced by the highest value recorded in broiler chickens fed 100% ZTSBH. It was noted that the presence of non-starch polysaccharides in the diet reduced bile acid secretions which affected lipid emulsification. This can lead to decreased absorption of lipids and fat-soluble vitamins (Knarreborg *et al*., 2002) which can be related to a slower digesta passage rate. However, soluble NSP increased the retention time of the digesta in the intestine (Van Der Klis *et al.*, 1993) which decreased oxygen tension and promoted the development of anaerobic microflora. The multiplication of the anaerobic microflora leads to the production of toxins and deconjugation of bile salts which are essential for fat digestion (Carre *et al*., 1995). The dietary treatments influenced the nutrient digestibility of finishing broiler chickens fed soyabean hull treated with *Zymomonas mobilis* based diets. This result did not agree with the reports of Milad *et al*. (2011) who reported that there were no significant differences in the apparent nutrient digestibility in broiler chickens fed corn bran-based diets with or without polyzyme. The superior value of crude protein digestibility obtained in 100% ZTSBH may be due to the life-enzyme derived from the treatment of soyabean hull with *Zymomonas mobilis*. Moreover, Almirall *et al*., (1995) reported that enzyme supplementation enhanced carbohydrate digestibility, reduced gut viscosity and led to improvement of fat utilization in broiler chickens. The nutrient digestibility values observed in 50% ZTSBH and 100% ZTSBH for finishing broiler chickens were not superior to the values obtained in other diets. This was in agreement with the findings of other researchers (McCracken and Bedford, 2001 and Rebole *et al*., 2010) who reported no response or negative response to the effects of enzymes on broiler performance. Moreover, McCracken and Bedford (2001) observed that the diet composition and diet form could affect the performance response of broilers to enzyme supplementation. Biggs *et al*. (2007) stated that differences in responses might be due to the intrinsic properties of enzyme product. Myashauskene *et al*. (1984) reported that the utilization of an enzyme in broiler chicken feed caused greater proteolytic activity in the stomach and duodenum that ultimately improved the digestibility of crude protein. The birds fed 100% UTSBH had highest values for most of the nutrient digestibility parameters except in crude protein and acid detergent fibre digestibility. The observation was not in agreement with the reports of Adebiyi *et al*. (2009) who reported that poultry birds on the control diet had the highest apparent nutrient digestibility values when broiler chickens were fed different physically treated cowpea seed hull. The report agreed with the findings of Fafiolu *et al*. (2015) who observed that palm kernel extraction residue (PKER) had a significantly higher apparent digestibility, digestive dry matter, crude protein, ether extract, ash, nitrogen free extract and metabolizable energy in Marshall broiler chickens.

The values of PCV (25.00 - 32.50%) and haemaglobin (8.30 - 10.60g/dl) were within the normal range (22.00 – 35.00%) and (7.00 – 13g/dl) reported by Bounous *et al*. (2000) for healthy broiler chickens. The packed cell volume and haemoglobin concentration are generally influenced by inadequate intake of energy and protein with lower values indicating anaemia (Maxwel, 1982; Rastogi, 2007; Muhammad and Oloyede, 2009). The results obtained for PCV and Haemoglobin of the birds suggested the nutritional adequacy of the soyabean hull based diets. The red blood cell values (2.10 - 2.75x$10^{12/L}$) were within the normal range (1.58 - 3.28x$10^{12/L}$) reported by Jain

(1986). The values followed the same trend as the MCH and Hb. Furthermore, MCH followed the same pattern as MCV across the dietary treatments. Although, MCH is an indicator of the blood carrying ability of the red blood cell, this could suggest that the broiler chickens fed the diets are more efficient in performing respiratory function as observed by Abdulazeez *et al*. (2016) and Soetan *et al*. (2013). The values of white blood cell (11.85 - 23.00x$10^{9/L}$) obtained in the study were lower than the value of 25.00(x$10^{9/L)}$ reported by Diarra and Usman (2008). The control group had the least value of WBC, since white blood cells are known to fight against diseases, the result of this study indicated that birds on soyabean hull based diets had similar immunity status which is superior to those of the control group. Furthermore, livestock with low white blood cell count are exposed to high risk of disease infection, while those with high counts are capable of producing antibodies in the process of phagocytocis and have higher degree of resistance to diseases (Soetan *et al*., 2013). The values of lymphocytes were within the normal range (45.0 - 70.0%) reported by Jain (1993) but the values of eosinophil, monocyte and basophil from the study were lower than the normal ranges: eosinophil (1.5 – 6.0%), monocyte (5.0 – 10.0%) and basophil (rare) reported by Jain (1993). Moreover, the dietary treatments affected the serum metabolites of the broiler chickens. At 28 days of age, the broiler chickens had higher total protein values in the dietary treatments except in the control group. This observation indicates that the birds had low protein demand to tissues (Café *et al*., 2012). The mean values of total protein are within the range cited by Thrall (2007) that is 2.5 to 4.5 (g/dl). The values of albumin obtained in the control group, and diets 2, 4 and 5 were lower than the values (2.0 to 3.5g/dl) cited by Anon (1980) and Jain (1986). The globulin values (1.00-2.05g/dl) in the study are comparable with the normal range for *Gallus gallus* specie that is 0.5 to 1.8g/dl as cited by Thrall (2007).

The values of glucose (77.00 - 134.00mg/dl) were within the normal range for broiler chickens (65.00-140mg/dl) cited by Am. Med. Laboratory (2001). The values of cholesterol obtained in the control group, diets 50% UTSBH, 100% UTSBH and 100% ZTSBH (77.00, 82.00, 91.00 and 89.50mg/dl) were lower than the values (100.30-108.21mg/dl) reported by Aderemi (2004). This may be due to demand of energy caused by higher body development at the starter phase as reported by Almeida *et al*. (2006) and Café *et al*. (2012). The uric acid values (3.15-5.20mg/dl) in this study were lower than the normal range (7.00 - 21.00mg/dl) reported by Am. Med. Laboratory (2001) for broiler chickens. Szabo *et al*. (2005) reported a direct relationship between protein intake and blood level of uric acid of growing turkey (*Meleagris gallopavo*). The birds fed 100% ZTSBH had higher creatinine which might be due to the life-ezyme incorporated to their diet. This might be directly related to increased muscle activity and volume (Café *et al*., 2012). The values of ALT (21.50 - 30.50 IU/L) were within the values (19 to 50 IU/L) reported by Lumeij (1997) for most species of birds. The dietary treatments influenced the haematological parameters with the exception of MCHC. This observation is in agreement with the findings of Abdulazeez *et al*. (2016) who fed broiler chickens with graded levels of Baobab (*Adansonia digitata* L.) seed meal. The PCV values (36.00 - 47.00%) in the study were greater than the values (31.00 - 40.00%) reported by Oyewale (1987) and Swenson (1970). This is an indication that the birds were not anaemic and were immunologically balanced. The haemoglobin values (11.70 - 14.80g/dl) were greater than the normal range (7.0 - 13.0g/dl) cited by Jain (1993) and Bounous *et al*. (2000). This further indicated that, all the broiler chickens had higher tendency to resist respiratory stress because haemoglobin is the oxygen-carrying pigment which is carried on the red blood cells (Muhammad and Oloyede, 2009). The red blood cell values (2.90 - 3.80x10$^{12/L}$) were greater than the normal range (1.58 - 3.28x10$^{12/L}$) reported by Jain (1986). Also, the treated and untreated soyabean hull based diets were nutritionally adequate in providing a sound plane of nutrition. The dietary treatments influenced the mean corpuscular volume (MCV) of the broiler chickens. The mean corpuscular haemoglobin (MCH) followed the same pattern as MCV. The significant differences observed in this study could be attributed to inclusion of *Zymomonas mobilis* treated soyabean hull in the experimental diets. This observation agreed with the reports of Muhammad *et al*. (2015) who fed diets containing differently processed mucuna seed meal to finisher broiler chickens. The MCH and MCV values in all the dietary treatments in this study fell within the normal range of 16 to 53 (pg) and 90 to 140 (fl) respectively as earlier reported by Mitruka and Rawnsley (1977) and Anon (1980). This finding is in line with what had been earlier reported by Tuleun *et al*. (2007) and Muhammad *et al*. (2015) in broiler chickens that nutrient is an important factor in haemopoesis. Also, Seivered (1977) reported that increased MCV, MCH and MCHC lead to anaemia in farm animals. The white blood cell values (14.70 - 24.60x10$^{9/L}$) from this study were lower than the average value of 25.00(x10$^{9/L}$) reported by Diarra and Usman (2008) for broiler chickens. It could be due to individual differences of the broiler chickens. White blood cell fight against diseases, the result of this study indicated that broiler chickens on treated and untreated soyabean hull -based diets have similar immunity status which is superior to those of the control group. Therefore, farm animals with low white blood cell count are exposed to high risk of disease infection, however, livestock with high WBC counts are capable of producing antibodies in the process of phagocytocis and have higher degree of resistance to diseases (Soetan *et al*., 2013). The lymphocyte values (61.00 - 69.00%) in the study are greater than the values (29.00 - 34.67%) reported by Kpanja *et al*. (2016) and lower than the values (94.03 - 98.33%) reported by Muhammad *et al*. (2015) for broiler chickens fed unprocessed and processed velvet bean (*Mucuna pruriens* L.) as dietary protein sources. The values of eosinophil (0.00 - 1.00%) observed in the study were lower than the value (1.5 - 6.00%) reported by Clinical Diagnostic Division (1990). The value of eosinophil (1.00%) observed in the control group, 100% UTSBH and 100% ZTSBH was within the values (1.00 - 1.67%) reported by Daudu (2012). The monocytes values (0.00 - 2.00%) in the study were lower than the values (5.0 - 10.0%) reported by Jain (1993) and the values (2.00 - 4.33%) reported by Daudu *et al*. (2015) for broiler chickens fed diets containing mango seed kernel based diets. The values of basophil (0.00 - 1.00%) are lower than the values (4.00 - 5.50%) reported by Madubuike and Ekenyem (2006). They fed broiler chickens with varying dietary levels of *Ipomoea asarifolia* leaf meal based diets. Also, Jain (1993) reported 'rare' for the value of basophil for healthy broiler chickens. Moreover, the values of lymphocytes, monocyte and eosinophil suggest the resistance of the broiler chickens in disease conditions. For example, high lymphocyte values would be recorded in bacterial and viral infection such as coccidiosis and high monocytes values would be recorded in case of injury to body tissues. It can be inferred from the result that the replacement of wheat offal with treated and untreated soyabean hull did not adversely influence the broiler chicken physiological status. The dietary treatments influenced the serum metabolites of the finishing broiler chickens fed soyabean hull treated with *Zymomonas mobilis* based diets. The values of total protein (2.60 - 3.50g/dl) were comparable with the values (3.00 -5.00g/dl) reported by Obikaonu *et al*. (2012), lower than the values (5.00 - 8.00g/dl) by Anon (1980). However, the values of (2.60g/dl) obtained in 50% UTSBH was lower than the values (3.31 - 5.39g/dl) reported by Mitruka and Rawnsley (1997) for broiler chickens. It implied an efficient utilization of the dietary protein by the finishing broiler chickens. Reddy and Salunkhe (1984) reported lower values of plasma total protein as a result of inhibition of protein utilization in broiler chickens. The values of the albumin (1.50 - 2.40g/dl) in the study were comparable with the values (2.0 - 3.5g/dl) reported by Anon (1980) and Jain (1986). Sasipriya and Siddhuraju (2013) observed that in the liver with acute or chronic damage, the level of albumin in the blood will typically be low. Moreover, the globulin values (0.60 - 1.70g/dl) were lower than the values (2 - 3.50g/dl) reported by Marieb and Hoehn (2007). The blood glucose values (100.00 - 131.00mg/dl) in the study were within the normal range for broiler chickens reported by Am. Med. Laboratory (2001). The values of the glucose obtained in the control group (100mg/dl) was lower than the normal range (125 - 200iu/l) by Anon (1980), and Jain (1986) but the values from other diets were lower than the normal blood glucose values for broiler chickens (200 to 500mg/dl) cited by Café *et al*. (2012) and 234.94 - 309.17(mg/dl) reported by the same authors. The decrease in total protein concentration in the control group may be an indication of reduction in protein synthesis. The values of cholesterol (72.00 - 100.00mg/dl) were lower than the values (100.30 -108.21mg/dl) by Aderemi (2004) while the values in the control group, diets 100% UTSBH and 50% ZTSBH were within the range (93.33 - 116.67mg/dL) reported by Nworgu (2004). The values of the cholesterol may be due to the level of fats in the diets as observed by Olorode *et al*. (1996) when they fed sheabutter or palm kernel cake in broilers in the humid tropics. The uric acid values (3.00 - 4.20mg/dl) were lower than the normal range (7.00 - 21mg/dl) reported by Am. Med. Laboratory (2001). Babatunde and Pond (1987) observed that blood urea concentration is inversely related to the protein quality, the replacement of wheat offal with soyabean hull based diet confirmed the adequacy of the feed stuff in the diets of broiler chickens. However, Oyebimpe (2012) observed that high urea concentration may be toxic to the liver and kidneys of broiler chickens. Iyayi and Tewe (1998) reported that total protein and serum urea depend mainly on the quality and quantity of protein in the diet. The increased level of serum uric acid could be due to the anti-nutritional factors which lower the quality of protein indicating imbalances in amino acids (Kaneko, 1989) besides kidney malfunction which results in high level of serum uric acid (Nworgu *et al*., 2007). Also, Kwiecien *et al*. (2015) reported that an increased concentration of uric acid in plasma may be due to oxidative stress and it can be a result of the body's adaptation to increased production of reactive oxygen species. The values of creatinine for control diet, 100% UTSBH, 50% ZTSBH, and 100% ZTSBH (0.50 - 0.80mg/dl) were greater than the values (0.46+/- 0.05mg/dl) reported by (Silva *et al*., 2007) for 42-day old broiler chickens, while the lowest value (0.20mg/dl) obtained in 50% UTSBH was lower than the values reported by the same authors. It had been reported in the literature that the level of creatinine is directly related to muscle volume and activity, and therefore, its lower blood levels in old and young chickens (Rajman *et al*., 2006; Agawane and Lonkar, 2004; Sandhu *et al*., 1998). The values of AST (46.00 - 56.00U/L) in the study were greater than the values (21.00 - 32.33ui/l) reported by Opoola *et al*. (2016). Moreover, the ALT values (17.00-26.00U/L) were comparable with the values (19.00 - 32.00U/L) by Opoola *et al*. (2016). It implied that the livers were not adversely affected by the replacement of wheat offal with treated and untreated soyabean hull. Broiler chickens fed 100% ZTSBH had the lowest value (17.00U/L) of ALT which is an indication that *Zymomonas mobilis* treated soyabean hull have decreased antinutritional factors thereby maintaining the integrity of the liver.

The dietary treatments did not significantly ($p>0.05$) influenced the live weight, dressed weight and dressing percentage of the broiler chickens. This observation was contrary to the findings of Zanu *et al*. (2017) who reported lower ($p<0.05$) weight of carcass, dressed weight and dressing percentage for broiler chickens fed cassava root flour. Moreover, Adeyemo and Longe (2007) reported significant differences for live weight, plucked weight and dressed weight when broiler chickens were fed graded levels of cotton seed cake based diets. The values of live weight (2.10 – 2.30kg) in the study were greater than the values (1.60 - 1.95kg) reported by Adeyemo and Longe (2007). However, the values of dressing percentage (67.63 - 71.43%) were comparable to the findings of Adeyemo and Longe (2007) who reported 65.63 - 73.33% for dressed weight when broiler chickens were fed graded levels of cotton seed cake. Also, the values were within the values (67.6 - 82.07%) of dressing percentage reported by Zanu *et al*. (2017). The cut up parts and organ weight of finishing broiler chickens were influenced by the treated and untreated soyabean hull based diets. This observation did not agree with the reports of Fafiolu *et al*. (2015). They reported no significant differences in the weight of the cut-up parts, and harvested organs, and length of the GIT when palm kernel extraction residue (PKER) and palm kernel sludge (PKS) were fed to Marshall broiler chickens. The values of the primal cut (breast, thigh, drumstick and backs) obtained in broiler chickens on 100% ZTSBH were comparable with the control group. It indicates that treated soyabean hull based diet promoted the deposition of muscle. The treated soyabean hull based diet did not elevate the values of the organs compared with the control group and other dietary treatments. This may indicate that there were no abnormalities or pathological lesions in these organs.

The dietary treatments influenced the ileal digesta viscosity of the broiler chickens. This observation did not agree with the findings of Alzawqari *et al*. (2010) who reported that the supplementation of glycine and desiccated oxbile to broiler chicken diet had no significant effect on ileal digesta viscosity. Moreover, the replacement of wheat offal with the treated soyabean hull in the diets of broiler chickens resulted in the highest values of viscosity of ileal digesta. The highest value (2.84cps) in the study obtained in 50% ZTSBH was within the values (2.50-140.00cps) reported by Jozefiak *et al*. (2007), they observed that xylanase supplementation reduced ileal viscosity significantly only in broiler chickens fed with rye.

The soyabean hull based diets influenced the colour, flavour and overall acceptability of the meat of the broiler chickens. The strong influence of ZTSBH on the colour of the meat might be due to the improved colour of the SBH by the *Z.* mobilis. The overall acceptability of the taste panelists might be due to the positive effect of ZTSBH on the colour of the meat as observed by Liang *et* al. (2004). There were no differences in juiciness and tenderness of the meat of the broiler chickens used in the study. This agreed with the findings of Ponte *et al*. (2008) who reported that subterranean clover pasture had no impact on the juiciness and tenderness of broiler meat. Although, Ponte *et al.* (2008) observed that differences in tenderness may be due to the fast growth of broiler chickens which led to larger muscle fibres and differences in proteolytic potential (Dransfield and Sosnicki, 1999). Moreover, Seabra *et al*. (2001) observed that tenderness is usually thought to be the essential organoleptic attribute of meat, the taste panelists classified meat from broiler chickens fed the control diet with the highest value for overall acceptability. The replacement of wheat offal with untreated and treated soyabean hull may possibly resulted in different flavours which led to different sensory attributes (Gordon and Charles, 2002). The values (5.65 - 6.65 points) on a nine-point hedonic scale in the study were within the values (6.00 - 8.70 points) reported by Adeyemo and Sanni (2013) for meat from broiler chickens fed hydrolyzed cassava peel meal based diets. Moreover, the values were within the values (6.50 - 7.57 points) of meat from Marshall broiler chickens reported by Olaifa *et al*. (2016) and 4.60 - 7.20 points (Amao *et al*., 2015) from meat of organically raised broiler chickens. The scores of meat were above the threshold of 5 points, which suggested that replacement of wheat offal by soyabean hull have positive impact in improving sensory characteristics of meat and do not exert any adverse effect on the quality or acceptability of meat.

The dietary treatment influenced the economy of feed conversion of broiler chickens fed *Z. mobilis* treated soyabean hull based diets with the exception of price/kg live weight and cost of production/broiler. The values of cost of the feed/kg were lower in 100% UTSBH and 100% ZTSBH than the values obtained in the control and 50% UTSBH and 50% ZTSBH. This may be due to the cost of the fibrous by-product and fermentation of soyabean hull compared to the cost of wheat offal as at the time of the study. This observation did not agree with the findings of Augustine *et al*. (2010) who reported a numerical decrease in the feed cost per kg for broiler chickens fed graded levels of *Cassia obtusifolia* seed meal based diets. The highest value of cost of the feed/kg recorded in the control group may be due to the cost of wheat offal at the time of the experiment. This observation did not agree with the findings of Yunusa *et al*. (2015) who reported a non-significantly lower value of feed cost/kg in the control diet than other diets when broiler chickens were fed different dietary energy sources. There were no differences in the cost of production/broiler (₦/broiler) in the study. This may be due to the similar daily feed intake of the broiler chickens. Ewa *et al*. (2006) observed that revenue is a factor determined by final body weight and the ruling market price at the time of the study. Therefore, the highest value of gross revenue/broiler was recorded in 100% UTSBH and 50% ZTSBH while similar values were obtained in the control group and other diets. The broiler chickens fed 100% UTSBH had highest values of gross profit, rate of return on investment, economic efficiency and relative cost benefit which may be due to the final body weight and feed intake of the broiler chickens. However, the broiler chickens on 100% ZTSBH had higher values of gross profit and rate of return on investment than the control group. This may be due to the inclusion of *Z. mobilis* treated soyabean hull in the diets which is cost effective than the wheat offal in the control diet.

At the starter phase, the birds fed the control diet (wheat offal based diet) had highest values for final body weight, average weight gain and daily weight gain than birds fed other diets. However, birds on 50% ZTCS had better performance in term of body weight compared with the other birds. This may be due to the combination of *Z. mobilis* treated cassava sifting with wheat offal in the diet. The inclusion of treated cassava sifting depressed average feed intake and daily feed intake in 50% ZTCS and 100% ZTCS. This may be due to the low palatability of the diets. This agreed with the reports of Muller *et al*. (1974) that cassava root meal is low in palatability and as the levels increased in the diet, it reduces the palatability of the diet. Although, isocaloric feeds were formulated for birds, the higher feed intake in birds fed 100% UTCS without corresponding increase in weight may be ascribed to the lower energy concentration per kg of feed with the starting broiler chickens increasing intake to meet their energy requirement (Hill and Dansky, 1954). The result agreed with the earlier work of Esonu *et al*. (2003) who reported that inclusion of fibrous feed stuff in a feeding trial had an energy dilution effect on feed thereby increased feed intake. However, the birds fed 50% ZTCS had superior values for feed conversion ratio and protein efficiency ratio. This may be due to the combination of wheat offal and treated cassava sifting with their complementary role in the supply of protein in the diet. It may show that birds in this group optimally utilized the feed protein consumed to maximize production in relation to the control and other diets. Maynard *et al*. (1979) reported that FCR and PER are parameters that suggest the extent of diet utilization. The high cost of feed consumed/bird in 50% ZTCS is in agreement with the report of Bogart and Taylor (1983) that high daily feed intake resulted in high cost of production. The low cost of feed/kg weight gain of 50% ZTCS could be due to the low feed intake compared with the control diet. The highest mortality occurred in 100% UTCS which was similar to the value in 100% ZTCS but lower values were obtained in the control and other diets. The mortality may not be linked with the cassava sifting based diets.

At the finisher phase, the birds on 50% ZTCS had superior final body weight, average weight gain and daily weight gain. This observation was contrary to the result obtained at the starting phase. Moreover, birds on 50% ZTCS had better performance in term of growth parameters compared to other birds on the other diets. This may be due to the adequacy of the diets due to complementary effect of wheat offal and treated cassava sifting fed to the birds.

The birds fed 50% UTCS had higher values for average feed intake and daily feed intake than other birds fed other diets. The increased feed intake might be due to higher body weight than other groups. There were no differences on FCR and PER of the finishing broiler chickens. Moreover, the birds on 50% ZTCS had superior numerical value for feed conversion ratio while broiler chickens fed 100% ZTCS had numerical higher value of protein efficiency ratio. This further confirmed that cassava sifting can replace wheat offal in the diet of broiler chickens. The total cost of feed consumed/bird was higher in 50% UTCS with similar values in 50% ZTCS. This may be due to increased feed intake (Bogart and Taylor, 1983). The cost of feed/kg weight gain was higher in control diet than other diets. This could be as a result of higher feed consumption which did not result in an improved performance of the broiler chickens. Mortality was recorded across the dietary treatments, the highest mortality was recorded in 100% UTCS, the least value in the control group was similar to the values in 50% UTCS and 50% ZTCS. Although, mortality may be unrelated to the cassava sifting based diets, other factors might be responsible. Manning *et al*. (2007) stated that mortality is related to slaughter age, the longer the growing cycle, the higher the mortality. The ACP (2006) pegged the benchmark standard of 5% mortality in broiler chicken production irrespective of age. All the dietary treatments had mortality rate below this standard.

There were differences in all the parameters evaluated with the exception of crude protein digestibility, acid detergent fibre digestibility, ether extract digestibility, nitrogen free extract. In all parameters measured, highest or similar values occurred in birds fed 100% ZTCS as compared to the control group. The improved nutrient digestibility of birds with *Zymomonas mobilis* treated cassava sifting based diets could be attributed to the bacteria adopted which is capable of degrading the fibre components of the diets. It released the trapped nutrients, thereby rendering more nutrients available for utilization by the birds (Akpodiete *et al*., 2006; Aguihe *et al*., 2015). Earlier works had reported that enzyme enhanced the efficiency of feed utilization by improving the nutrient digestibility (Ani and Nnamani, 2011; Annison and Choct, 1991; Bedford, 1995). It implies that *Zymomonas mobilis* could hydrolyze the non-starch polysaccharides of cassava sifting based diet so as to make nutrients and minerals more available to the birds.

The dietary treatments did not influence the red blood cell, MCHC, MCV., total protein and uric acid but affected other haematological and serum metabolites of the starting broiler chickens. The PCV values (22.00 – 26.00%) obtained in this study were within the normal range (22.00 – 35.00%) for broiler chickens (Bounous *et al*., 2000). Isaac *et al*. (2013) stated that PCV is involved in the transport of oxygen and absorbed nutrients. Therefore, increased PCV showed better circulation and thus resulted in an increased primary and secondary polycythemia. The values of haemoglobin obtained from the dietary treatments fell within the values (7.00 – 13.00g/dl) reported by Bounous *et al*. (2000). Although, the red blood cells were not significantly influenced by the dietary treatments, the values were within the normal values (1.58 - 3.28 $x10^{12}L$) by Jain (1986). The birds fed 100% UTCS had highest value for white blood cell which was similar to the values in the control diet and 100% ZTCS. The replacement of treated and untreated cassava sifting did not have deleterious effect on the blood parameters studied. The haematological constituents reflect the physiological responsiveness of the livestock to its environment (external or internal). It is a veritable tool for monitoring animal health (Udedibie and Asoluka, 2008).

At the finishing phase, the cassava sifting based diets did not affect the packed cell volume, haemoglobin, and MCHC. The values of PCV fell within the normal range (22.00 – 34.00%) by Jain (1993). It implied that dietary treatments had no effect on the relative quantity of blood cells as compared with the total volume of blood (Health and Olusanya, 1985). This report did not agree with the finding of Madubuike and Ekenyem (2006) who reported significant difference in PCV of broiler chickens fed varying levels of *Ipomoea asarifolia* leaf meal. Church *et al*. (1984) and Babatunde *et al*. (1987) showed that PCV and haemoglobin are correlated with the nutritional status of the livestock which directly relate to the nutritional balance of the diet fed to the animals. However, the birds fed 50% ZTCS and 100% ZTCS had lowest values for red blood cells which were similar to the control diet but were below the normal range of RBC (1.58 – 3.28 x 10^{12}L) by Jain (1986). Ugwuene, (2011) stated that a reduced red blood cell count implies a reduction in the level of oxygen that would be carried to the tissues as well as the level of carbon dioxide returned to the lungs. There were significant differences (P<0.05) among treatments with respect to mean corpuscular haemoglobin (MCH) and mean corpuscular volume (MCV). The values of MCH which is the average amount of haemoglobin in each red blood cell measured, followed the same trend as MCV. The statistical differences noticed in MCH and MCV could be attributed to the inclusion of treated and untreated cassava sifting in the experimental diets. Birds fed 50% UTCS and 100% UTCS had MCH values that fell within the normal range (16 - 53pg) and birds fed 100% UTCS had MCV values within 16 to 53pg as earlier reported by Mitruka and Rawnsley (1977) and Anon (1980). All the birds on the control and other diets have highest values for MCH and MCV which were higher than the normal range (33.00 – 47.00pg) and (90.00 – 140.00fl) for healthy broiler chickens. This observation was not in agreement with the reports of Muhammad *et al*. (2015) and Tuleun *et al*. (2007) for broilers chickens. White blood cells are involved in protecting the animals from infection and consist of lymphocytes, monocytes, neutrophils, eosinophils and basophils. They kill virus-infected cells, promote the production of antibodies and destroy foreign materials (antigens) that enter the body. Therefore, higher presence in the blood would connote a threat to normal health and the body builds up its defence against the threat (Olugbemi *et al*., 2010). Champe *et al*. (2008) stated that neutrophils and monocytes are components of white blood cells that are responsible in both oxygen-independent and oxygen-dependent mechanism for fighting virus, engulfing and killing bacteria. The values of lymphocytes (58.00 to 80.00%) implied that, all the broiler chickens in the treatments had adequate immune response status. Thus, inclusion of treated and untreated cassava sifting did not predispose broiler chickens to infection, as higher count than normal implies that the immune system of the birds may be combating some kind of infection, as reported by Adeyemo and Longe (2007) and Frandson (1986). Basophils contain the anticoagulant, Heparin, which is normally released in areas of inflammation to prevent lymph, clotting and stasis of blood (Frandson, 1986). Therefore, treated cassava sifting inclusion in the 50% ZTCS and 100% ZTCS did not cause inflammation in the broiler chickens. Adeyemo and Longe (2007) reported eosinophil to phagocytise particles formed when an antibodies and antigen react, which is a strategy for fighting disease infection by chickens. The dietary treatments influenced the serum metabolites of the finishing broiler chickens. The range of 3.00 - 4.70g/dl for total protein observed in this study was within the normal range of 5.00 to 8.00(g/dl/bird) and 3.31 to 5.39(g/dl) reported by Anon (1980), Mitruka and Rawnsley (1977). Hence, the values indicated nutritional adequacy of the cassava sifting in respect of protein, therefore, high serum protein and albumin values are reflection of amount of protein and better quality in the diets (Omoikhoje *et al*., 2004 and Eggum, 1970). The albumin values range of 1.50 to 2.80(g/dl) showed significant differences among the treatment groups but they are within the reference values of 2.0 - 3.5(g/dl) reported by Anon (1980) and Jain (1986). The globulin values range of 1.10 - 2.20(g/dl) observed in this experiment are low compared with the normal ranges of 2.33 - 3.33(g/dl). Globulin is responsible for immunoglobin which are the main sites of the antibodies (Peters *et al*., 1982). Melluzzi *et al*. (1991) observed that alteration in nutritional protein status are better shown in the albumin than in the globulin content of the blood. The glucose values ranged between 110.00 to 132.00(mg/dl), the lowest value of 110.00mg/dl observed in 100% ZTCS was similar to the values obtained in the control diet and 100% UTCS. The value was below the range of 125 – 200(iu/l) reported by Anon (1980) and Jain (1986). However, Balogun (1982) and Melluzzi *et al*. (1991) revealed that low blood glucose could be an indication of incipient problem with ketosis or inadequate intake. The values of uric acid (2.10 - 5.20mg/dl) obtained in the study are low compared with the normal uric acid in blood of broiler chickens of 7 - 21(mg/dl) (Am. Met. Laboratory, 2001). Oyebimpe (2012) observed that higher value of uric acid may indicate poor utilization of protein or the kidneys are not functioning properly. Also, low levels could be due to low protein intake or severe liver failure. The serum urea comes from the diet and tissue deamination of proteins. It indicates the good quality of dietary protein (Altama, 1979; Ewulola and Egbunike, 2008). The values of creatinine (0.20 - 0.80mg/dl) obtained in this study are within the reference values (0.90 – 1.85mg/dl) reported by Mitruka and Rawnsley (1977) for chickens. Higher values of creatinine than normal indicate kidney malfunction (Champe *et al*., 2008). Oke (1978) reported that high level of creatinine is sometimes observed in the kidney diseases due to kidney's role of removing creatinine, muscle degeneration and exposure to toxic substances which impair kidney functions. The lower value might indicate that the inclusion of the fibrous feedstuff did not cause muscular wastage due to anti-nutritional factors. The values of cholesterol (63.00 – 90.00mg/dl) obtained in the study are within the normal range (52 – 148mg/dl) reported by Mitruka and Rawnsley (1977) and comparable with the values of (84 – 94mg/dl) for broiler chickens fed maggot meal by Akpodiete and Okagbare (2002). It had been reported by Hale *et al*. (1986) that dietary fibre lowered blood cholesterol, total lipids and glucose. The lowered values of cholesterol might be due to high fibre content of the diets. The value of AST (35 - 54U/L) was within the normal range while the values obtained in the control group and other dietary treatments were lower than the values (52 – 270U/L) reported by Coles (2007). However, the values of ALT (15 – 27U/L) are within the normal range for most birds (6.5 – 263U/L) reported by Coles (2007). The same author also observed that the values of AST and ALT can considerably vary according to the age, animal species, sex and environment. This observation was contrary to the reports of Khempaka *et al*. (2014), they reported no significant different higher values of AST (300.72 – 358.60U/L) and lower values of ALT (12.25 – 18.80U/L) when broiler chickens were fed cassava pulp feedstuff fermented with A*spergillus oryzae* based diet. Other authors have reported high values of AST in broiler chickens with different results arising from the dietary energy density, amino acid content and age under normal state of health (Azadmanesh and Jahanian, 2012; Corduk *et al*., 2007; Emadi *et al*., 2010).

The dietary treatments influenced the live weight, dressed weight, eviscerated weight and the dressing percentage. Furthermore, Zanu *et al*. (2017) reported lower weight of carcass, dressed weight and dressing percentage for broiler chickens fed cassava root flour. The values of the dressing percentage (73.75 - 81.18%) were influenced by the dietary treatments. The highest value in the 50% UTCS had similar value with 50% ZTCS but the lowest similar values were obtained in the control diet and 100% UTCS. This showed that treated and untreated *Z. mobilis* treated cassava sifting had positive influence on the carcass yield of the broiler chickens as reflected by the dressing percentage. The values of the dressing percentage obtained are comparable with the finding of other authors such as Esonu *et al*. (2008) who reported 74.82 - 77.39% and Lamidi *et al*. (2008) who obtained 69.49 - 73.98%. However, the reduction in dressing percentage recorded in 100% UTCS was caused by an increase in the weight of gastro-intestinal tract (25.00%) which was twice the value (12.22%) obtained in 50% ZTCS. Moreover, González-Alvarado *et al*. (2007) and Jiménez-Moreno *et al*. (2009) had reported that inclusion of fibre increased the relative weight of the different segments of the gastro-intestinal tract in birds. The cassava sifting based diets influenced the cut up parts (% of live weight) of the broiler chickens. This was contrary to the reports of Muhammad *et al*. (2015) who reported no significant differences in the values for cut–up parts expressed as percentage of slaughter weight.

Moreover, there were differences between groups for organ weight except in spleen. This result was contrary to the report of Noman *et al*. (2015) who reported no differences between groups in weight of liver, gizzard, heart, spleen or pancreas. Plumber and Kiepper (2011) reported that higher body weight and lower organ weight indicate good performance. Also, Fafiolu *et al*. (2015) reported no differences in the weight of the cut up parts, dressed weight and harvested organs of Marshall broiler chickens fed palm kernel extraction residue and palm kernel sludge based diets. The significantly higher values of gizzard observed in 50% UTCS and100% UTCS might be due to the untreated fibrous feedstuff in the broiler chickens' diet. Hetland *et al*. (2005) reported that it is difficult to grind coarse insoluble fibre which result in increased gizzard size. The bulk handling due to increased fibre content of ration affect the weight of gastro-intestinal tract and gizzard positively (Adeyemo and Longe, 2007). Rose (2001) also noted that increased development of the gizzard will enhance its grinding role. Aderemi (2003) reported that anti-nutritional factors could be associated with the enlargement of organs such as liver and pancreas because of their higher detoxification activity.

The values of the viscosity of ileal digesta of the broiler chickens fed cassava sifting based diets observed in this study were within the values reported in the literature.

Veldman and Vahl (1994) reported 2.9 - 5.6(cp), Allen *et al*. (1996) stated 7.5 - 35.6(cp) and 2.2 - 21.2(cp) (Dusel *et al*., 1998) for wheat based diets. The lowest values recorded in 100% ZTCS did not lead to improve performance of broiler chickens. This is in agreement with the findings of Liang and Liu (1999). They reported that at low viscosities (<10cp), decreased viscosity did not result in further improvement in growth performance. Dusel *et al*. (1998) observed that absolute digesta viscosity is not a reliable indicator for predicting growth performance. But, in many cases, the positive effect of enzymes on growth performance could be linked with a decreased digesta viscosity.

The replacement of wheat offal with untreated and treated cassava sifting influenced the sensory attributes of meats from broiler chickens. Briedenstein and Carpenter (1983) observed that colour, juiciness, flavour and tenderness are the primary determinants of the eating quality of meat. The panellists' scores for the sensory attributes were higher for the ZTCS than UTCS. This might be due to the improvement of the meat quality by the inclusion of the *Zymomonas mobilis* treated cassava sifting in the diets. This agreed with the observation of Omojola and Adesehinwa (2007) who reported that flavour, juiciness and tenderness were among the eating qualities that were significantly improved by the exogenous enzyme inclusion in broiler chickens' diets. Tenderness is the most important organoleptic attribute of meat (Seabra *et al*., 2001) therefore, the panelists classified meat from birds fed 50% ZTCS with the highest value for overall acceptability. The values of overall acceptability from this study are low compared with the result of Ogunwole *et al*. (2013) who reported 6.72 - 7.23 when broiler chickens were fed diets supplemented with graded levels of ascorbic acid. The birds fed the control diet had the highest score for colour but similar to the values obtained in 50% ZTCS and 100% ZTCS. Liang *et* *al*. (2004) observed that the skin and meat colour constitute the initial means of visual assessment of acceptability by the consumers. Also, variation in colour and texture is a function of fibre size, myoglobin concentration and broiler great-grandparent lines (Olaifa *et al*., 2016).

Poultry meat quality is influenced by the diet, genotype, age at slaughter and motor activity of birds, and their adaptation for outdoor production (Ojedapo *et al*., 2008; 2009). Organoleptic attributes are the trait that influence the consumers to regularly purchase and consume meat. The colour of the meat from the control diet was slightly acceptable, 50% UTCS and 100% UTCS was intermediate, diet 4 was slightly acceptable and 100% ZTCS was slightly acceptable. The juiciness of the meat for the control, 50% UTCS and 100% ZTCS was intermediate, 100% UTCS was dislike slightly and 50% ZTCS slightly acceptable. The flavour of the meat for control diet, 50% UTCS, 100% UTCS and 100% ZTCS was intermediate while 50% ZTCS was slightly acceptable. The tenderness of the meat for the control diet, 100% UTCS, 50% UTCS and 100% ZTCS was slightly acceptable but 50% UTCS was intermediate. The overall acceptability of meat in control diet and 100% ZTCS was slightly acceptable, 50% UTCS and 100% UTCS was intermediate while 50% ZTCS was moderately acceptable. The less tender breast meat of broiler chickens in the dietary treatments could be attributed to increased locomotion activities due to enough space for exercises thereby making the muscles very tough (Shields *et al*., 2004). Fanatico *et al*. (2007) reported that consumers preferred meat from farm animal reared on semi-intensive system to those reared on intensive system.

It was observed that replacement of wheat offal with cassava sifting had influence on the gross revenue/broiler and gross profit/broiler across the dietary treatments. The birds fed 50% ZTCS had higher values of gross revenue/broiler, gross profit, rate of return on investment and economic efficiency. This was closely followed by the values obtained in birds fed 50% UTCS. This may be due to the combination of wheat offal with treated or untreated cassava sifting which resulted in the better performance of birds compared to the control group. However, birds fed 100% ZTCS had lowest values for gross revenue/broiler, gross profit/broiler, rate of return on investment and economic efficiency. This may be due to the poor growth performance of the birds coupled with the high average feed intake recorded in this group. This observation did not agree with the findings of Aguihe *et al*. (2015), who reported that addition of Maxigrain® to cassava peel meal (CPM) based diet resulted in the maximum profit which was connected with the ease to which broilers utilized the CPM and gained higher body weight.

At the starter phase, the birds fed 50% untreated sawdust (50% UTSD) had highest values of final body weight, average weight gain and daily weight gain but the least values were obtained in birds fed 100% ZTSD. However, broiler chickens fed other diets had similar daily weight gain. Therefore, addition of *Z. mobilis* treated sawdust improved the growth performance of the broiler chickens. Moreover, Acamovic (2001) reported that endogenous losses can be altered by supplementary enzymes, and other compounds for example tannins due to the release of contents of the cells of dietary components by enzyme action. However, Mathlouthi *et al*. (2002) reported that there was no beneficial effect of xylanase addition to diet containing 10% wheat bran compared to wheat or wheat-barley diets fed to laying hens. This observation agreed with the findings of Lawal *et al*. (2012) who reported that body weights of broiler chickens fed degraded wheat offal improved at the starter phase. The result was also in agreement with the report of Yunusa *et al*. (2015), they reported significant differences in daily weight gain and feed conversion ratio of the chicks at the end of the starter phase. Generally, broiler chickens fed the experimental diets did not show any particular trend in their pattern of feed consumption, though statistical differences in treatment means were obtained between the treatments. This may be due to the energy levels of diets which was compensated for by other ingredients to meet the energy requirement of the broiler chickens as the diets were formulated to be isocaloric and isonitrogenous. There were similar values in the control diet and other diets for feed conversion ratio while the lowest value of 1.84 was recorded in 50% UTSD. Also, higher value of protein efficiency ratio was recorded in 50% UTSD with the lowest value in 100% ZTSD. This observation may be due to combination of wheat offal and untreated sawdust in the diet. Also, the quantity of the sawdust was not high enough to cause any deleterious effect on the growth performance. The broiler chickens fed 50% ZTSD had higher value of total cost of feed consumed/bird while the lowest value was obtained in 100% ZTSD. This observation was due to the significantly highest value of daily feed intake recorded for birds fed 50% ZTSD.

The higher cost of feed/kg weight gain recorded in 100% ZTSD was similar ($p>0.05$) to the values obtained in the control diet and 50% ZTSD. However, the lowest value was recorded in 50% UTSD. This may be due to the highest weight gain of the birds therefore, it was more economical to feed starter broiler chickens with mixture of wheat offal and untreated sawdust based diet. There was no mortality observed in the control diet and 50% ZTSD but the highest values were obtained in 50% UTSD. There was no trend in the mortality rate but it was not likely that sawdust contained high level of toxic substances which may be deleterious to the animal health.

However, at the finisher phase, the trend of the performance characteristics did not follow the pattern established at the starter phase. The broiler chickens fed 50% ZTSD had higher values of final body weight, average weight gain and daily weight gain, the birds on 50% UTSD had lowest values of average weight gain and daily weight gain. The combination of wheat offal and *Z. mobilis* treated sawdust promote improved weight gain of the broiler chickens. In addition, the broiler chickens on the 50% ZTSD had higher values of average feed intake and daily feed intake which were similar to the values recorded in 50% UTSD and 100% ZTSD. The lowest values were obtained in the control group. The increased feed intake may be due to the increased passage rate of the more fibrous digesta in the small intestine. This agreed with the reports of Sundu *et al*. (2006) that hard and fibrous feedstuffs may increase the contraction of the gizzard. This may have sped up the peristaltic movement of the digesta which can lead to increased feed intake. There was no difference in feed conversion ratio, but the control diet had lowest numerical value. The reduction in FCR in 100% UTSD and 50% ZTSD may have resulted from higher protein content of diets having treated sawdust and wheat offal as compared to the control diet. This is because protein is essential in the accretion of meat by broiler chickens (Aftab *et al*., 2006). The similarities among all treatments in the feed conversion ratio (FCR) indicated that the treated and untreated sawdust based diets were favourable compared to the control diet. The comparable FCR was in agreement with the reports of Ngiki *et al*. (2014) who included cassava root-leaf meal mixture in broiler diets and Eruvbetine *et al*. (2003) who included cassava leaf meal and cassava root meal (50:50) in the diets of broiler chickens. The protein efficiency ratio (PER) was significantly influenced by the sawdust based diets. Similar values were obtained in the control diet, 50% ZTSD and 100% ZTSD while lowest value was recorded in 50% UTSD. This could be due to efficient utilization of the protein in the diets which resulted in high body weight gain. The total cost of feed consumed/bird increased across the dietary treatments. The birds on 50% ZTSD and 100% ZTSD had higher values than other diets including the control diet. This could be due to increase feed consumption by the broiler chickens. Also, cost of feed/kg weight gain was influenced by the inclusion of treated and untreated sawdust in the diets, the birds on 50% UTSD had statistically highest value, similar values were obtained in 100% UTSD and 50% ZTSD while the lowest value was recorded in the control diet. This observation revealed that the broiler chickens will consume more feed at higher cost to maintain the similar weight with the birds fed the control diet. The result did not agree with the findings of Makinde and Sonaiya (2011) who reported that the inclusion of 100 and 150g sun dried blend of maize offal and blood meal (SDMBM) in broiler diets resulted in superior feed cost per unit weight gain compared to the control diet. However, the observation agreed with the report of Afolayan *et al*. (2012), they reported increased feed cost/kg weight gain as the levels of sweet potato meal substituted for maize on a weight for weight basis.

At the starter phase, the values of dry matter, ether extract, ash and apparent metabolizable energy digestibility were significantly higher in birds fed the control diet while crude protein, crude fibre, acid detergent fibre, neutral detergent fibre, acid detergent lignin and nitrogen free extract digestibility values were statistically higher in birds fed 100% UTSD. The depressed nutrient digestibility and increased feed conversion ratio with the inclusion of treated sawdust in the diets may be attributed to the fact that the residual anti-nutrient (tannins) are probably complexing some nutrients thereby obstructing their absorption and the complete utilization of the nutrients. The observation was similar with the findings of Kayode *et al*. (2012). They reported that nutrient retention decreased with increase in fungal mixed-culture fermented mango kernel cake at the broiler starting phase.

At the finisher phase, the birds fed 100% ZTSD had statistically higher nutrient digestibility for most of the parameters measured were similar to the values obtained in the control group. An improvement in the broiler chicken's nutrient digestibility was observed during the finisher phase compared with what was obtained during the starter phase of the experiment. The performance of the chickens was better at the finisher phase than at the starter phases, this may be due to a better utilization of the nutrients with increase in the age of the broiler chickens, as reported by Kayode *et al*. (2012); Onilude and Osho (1999). Oldale (1996) reported that the inclusion of raw materials in livestock's diet is restricted by many factors including the quality and digestibility of the materials, the species concerned and the age of the livestock. Amuchie (2001) reported that anti-nutritional factors in the diet of animal have statistical negative effects on farm animal production such as reduction in palatability, digestibility and utilization of ration. There could be intoxication of different classes of farm animals, resulting in mortality or decreased production of animal and reduction in the quality of meat, egg and milk products due to the presence of toxic residues.

At the starter phase, the dietary treatment influenced the haematological parameters with the exception of haemoglobin, MCH, MCHC and MCV. The blood variables most often influenced by dietary treatments were identified as RBC, PCV, plasma protein, glucose and clotting time (Aletor, 1989; Aletor and Egberongbe, 1992). The packed cell volume, haemoglobin and red blood cell values were within the normal ranges (22.00 – 35.00%), (7.00 – 13.00g/dl) and (1.58 – 3.28 x 10^{12}L) reported by Jain (1986) and Bounous *et al*. (2000). High PCV, Hb and RBC show improved oxygen-carrying capacity of the cells, which result to better availability of nutrients (Oleforuh-Okoleh *et al*., 2015). Although, there were no differences among dietary treatments for MCH, MCHC and MCV, their values were within the normal ranges (33.00 – 47.00pg), (26.00 – 35.00g/dl) and (90.00 – 140.00fl) cited by Jain (1993) and Benerjee

(2004). This may indicate similar haemoglobin content. This observation agreed with the findings of Fasuyi and Aletor (2005). They reported a no significant difference in MCH, MCV and Hbc when cassava leaf protein concentrate replaced fish meal in broiler diets. The white blood cell values were within the normal values for broiler chickens (1.20 – 3.00 x 104µl) reported by Jain (1993). The WBC, heterophil, eosinophil, basophils, monocytes and lymphocyte indicate the immunity potentials of the chickens. The sawdust based diets influenced the serum metabolites of the broiler chickens. The values of total protein were within the normal range for *Gallus gallus* specie that is 2.5 to 4.5g/dl as cited by Thrall (2007). The values of albumin obtained in the control group and 100% ZTSD are similar but are lower than the normal range (2.00 – 3.50g/dl) reported by Anon (1980) and Jain (1986). The birds on 100% UTSD and 50% ZTSD had values of globulin which were lower than the normal range (2.00 - 3.50g/dl) reported by Marieb and Hoehn (2007). However, the values were within the normal range (0.5 to 1.8g/dl) as cited by Thrall (2007). The total protein, albumin and globulin values obtained in the study attest to the nutritional adequacy of treated and untreated sawdust in replacing wheat offal in meeting the protein needs of the broiler chickens.

Moreover, the values of glucose (112.00 – 127.50mg/dl) obtained in this study were lower than the normal range (200 - 500mg/dl) reported by Café *et al*. (2012). The values of cholesterol (88.50 - 103.00mg/dl) observed in the study were within the values (58.00 – 128.00mg/dl) reported by Zomrawi *et al*. (2012) for broiler chickens fed ginger root powder at levels 0.5, 1 and 1.5% respectively. The birds fed 100% ZTSD had lowest value of uric acid compared to other diets. Babatunde and Pond (1987) observed that blood urea concentration is inversely related to protein quality, therefore, the lowest value of total protein observed in 100% ZTSD may be due to the inferior protein quality and/or nutrition of the sawdust.

The dietary treatments influenced the haematological parameters of the finishing broiler chickens. The birds fed the control diets, 50% UTSD and 100% UTSD had higher values of PCV compared with the normal range (22.00 – 35.00%) by Bounous *et al*. (2000) while the values of PCV of birds on 50% ZTSD and 100% ZTSD were within the normal range. This is an indication that the fibrous feedstuffs ensure good health status of the birds because low PCV values indicate anaemia. The haemoglobin values (9.50 - 12.50g/dl) were within the normal range (7.00 – 13.00g/dl) reported by Jain (1993). This might indicate that the replacement of wheat offal with treated and untreated sawdust in the broiler chicken diets was nutritionally adequate in providing a sound plane of nutrition. Lindsay (1977) reported that haemoglobin concentration decreased in livestock on low protein intake, parasite infection or liver damage. However, the PCV and Hb are correlated with the nutritional status of the livestock which directly relate to the nutritional balance of the diet fed to the livestock (Church *et al*. 1984, Babatunde *et al*. 1987). This further indicated that, all the broiler chickens had higher tendency to resist respiratory stress because Hb which is carried by the RBC is the oxygen carrying pigment as earlier reported by Muhammad and Oloyede (2009). The red blood cell values (2.30 - 3.50 x $10^{12/L}$) obtained in the diets were within the normal range (2.54 – 3.30 x $10^6 mm^{-3)}$ reported by Aletor and Egberongbe (1992). It had been reported by Ugwuene (2011) that reduced RBC indicates reduction in the level of oxygen that would be carried to the tissues as well as the level of carbon dioxide returned to the lungs. The values of MCH (34.01 – 42.30pg) observed in the study were within the normal range (33.00 – 47.00pg) reported by Jain (1993). The values of MCHC (22.47g/dl) in birds fed 50% UTSD were lower than the normal range (26.00 – 35.00g/dl) for broiler chickens (Jain 1993). However, all the values obtained for MCV were lower than the normal range (90.00 – 140.00fl) reported by Jain (1993). MCV is an important trait which is responsible for the cell size of erythrocytes and it is an essential factor in determining the ability of poultry birds to withstand prolonged oxygen starvation (Mitruka and Rawnsley, 1977). The value of white blood cells (23.10 x $10^{9/L}$) obtained in the control group was significantly ($p<0.05$) higher than the values (12.90 – 18.20 x $10^{9/L)}$ recorded for broiler chickens in other dietary treatments. The values (12.90 - 23.10 x $10^{9/L}$) of WBC were within the normal range of 9.20 to 31.00 x $10^6 mm^{-3}$ reported in literature (Riddell, 2011; Mitruka and Rawnsley, 1977; Banks, 1974) for healthy Nigerian local chickens. The white blood cells play essential role in disease resistance, especially in the production of antibodies and the process of phagocytosis. The lymphocytes were the most numerous and frequent white blood cell type followed by heterophils, eosinophils and the monocytes (Afolabi *et al*., 2011). The same trend was observed by Bounous *et al*. (2000) and described the lymphocytes as the most numerous WBC in chickens and turkeys. However, the result from the study did not agree with their reports because the values obtained for eosinophil (0.00 – 0.10%) were lower than the values of monocytes (0.00 – 3.00%). The lymphocytes (60.00 - 70.00%) and monocytes (0.00 - 3.00%) which were agranulocytes of WBC, were within the normal range from 47.2 to 85.0% and 0.06 to 5.0% respectively for a healthy chicken (Riddell, 2011; Mitruka and Rawnsley, 1977). However, the birds on 100% ZTSD had zero value for monocytes which was lower than the value reported in literature. Banks (1974) reported 6% monocytes for domestic chickens and Islam *et al*. (2004) reported 3.42+/-0.50%) monocytes for local chicken of Bangladesh. Moreover, lymphocytes are involved in antibody production, as they are reactive cells in inflammation and delayed hypersensitivity (Banks, 1974). Small lymphocytes may be responsible for the development of clones of plasma cells while monocytes are phagocytic cells. The high lymphocytes and heterophil count in this study is consistent with the findings of Afolabi *et al*. (2010) who also observed high lymphocytes and heterophils in chickens. This is in contrary to the reports of Oyewale (1987) who observed higher white blood cell count and lower lymphocyte counts in Nigerian fowls. The heterophils (28.00 to 35.00%) and the eosinophils (0.00 to 1.00%) that are granulocytes of WBC were within normal range from 10 to 53.6% and 0.00 to 15% respectively for a healthy chicken (Riddell, 2011; Pampori and Iqbal, 2007; Mitruka and Rawnsley, 1977). The eosinophil functions in phagocytosis while the basophils are responsible for the elaboration of histamines and heparin in circulating blood (Afolabi, *et al.*, 2011). The chemistry of serum or detection/identification/analysis/verification of serum metabolites such as cholesterol, urea, etc., in the blood system is for the purposes of detecting organ diseases in domestic animals and the amount of available protein in the diets (Iyayi and Tewe, 1998). The serum biochemical constituents are positively correlated with the quality of the diet (Brown and Clime, 1972; Adeyemi *et al*., 2000). Kaneko (1997) reported that serum protein profile and the absolute values of individual fractions are an excellent basis for a tentative diagnosis. Moreover, the dietary treatments influenced the serum metabolites of the finishing broiler chickens. The values of total protein obtained in birds fed 50% ZTSD (2.10g/dl) and 100% ZTSD (2.70g/dl) were lower than the normal range (3.00 – 5.00g/dl) reported by Obikaonu *et al*. (2012) but the higher value (6.30g/dl) was recorded in 50% UTSD was within the normal range (5.00 – 8.00g/dl) reported by Anon (1980). Reddy and Salunkhe (1984) reported decreased total protein which was attributed to inhibition of protein utilization in broiler chickens. The value of albumin (1.00g/dl) recorded in

50% ZTSD was lower than the normal range (2.10 - 3.45g/dl) reported by Am. Met. Laboratory (2001). However, the values of globulin obtained in the control group, 50% ZTSD and 100% ZTSD (0.90 - 1.30g/dl) were lower than the normal range (2.00 - 3.50g/dl) reported by Marieb and Hoehn (2007). Globulin carries essential metals through the blood stream to the various parts of the body of farm animals. It helps to fight infections in the body of animals. Therefore, high globulin levels are often pronounced in birds with serious infections because of abnormally increased production of antibodies.

The values of globulin (0.90 – 3.40g/dl) observed in the study revealed that the inclusion of treated sawdust in the broiler diet did not precipitate any severe effects on the health status of the birds. Serum urea can be used as a test of protein break down, renal function, hydration status and liver failure (Agboola *et al*. 2013). The concentration of uric acid also depends on diet especially those with high protein content. However, the values of uric acid (2.80 - 5.00mg/dl) in this study were lower than the normal range (7.00 – 21.00mg/dl) reported by Am. Met. Laboratory, (2001). The values obtained when treated sawdust replaced wheat offal in 50% ZTSD (3.00mg/dl) and 100% ZTSD (2.80mg/dl) were similar to the value (3.20mg/dl) in the control group. This probably suggested that there was a better digestion, utilization and absorption of protein from the treated sawdust used which invariably improved protein utilization. High concentration of urea may be toxic to both the liver and kidney while low levels could be due to low protein intake or severe liver failure (Oyebimpe, 2012). It had been reported by Baron (1973) that increased concentration of creatinine is associated with renal impairment. The values of glucose (112.00 - 133.00mg/dl) in this study were within the normal range (65.00 – 140.00mg/dl) reported by Am. Met. Laboratory (2001). The cholesterol values (76.00 - 90.00mg/dl) were within the values (76.30 - 115.57mg/dl) reported by Onyimonyi *et al*. (2012) who fed dried garlic powder to broiler chickens. However, the values were lower than (100.30 - 108.21mg/dl) reported by Aderemi (2004), (93.33 - 116.67mg/dl) by Nworgu (2004) and (143.10 - 163.00mg/dl) reported by Nworgu *et al*. (2007). This will restore the confidence of consumers who earlier had reduced or stopped their consumption of chicken due to cholesterol scare. Also, this will protect the consumers from the negative effect of cholesterol which include obesity, heart attack and stroke (Onyimonyi *et al*., 2012). Ekpenyong and Biobaku (1986) reported that the levels of SAST and SALT are normally low in blood but they become high when the plane of nutrition is low or when there is an occurrence of liver damage by toxic substances. The values of AST (45.00 - 63.00U/L) were comparable to the values reported by Sobayo *et al*. (2013) when they fed graded levels of *Garcinia kola* (Bitter kola used as phytobiotic in broiler chicken diets. Moreover, the values of ALT (14.00 - 28.00U/L) were within the values of 13.55 - 47.90(U/L) reported by the same authors. The dietary treatments influenced the sensory parameters. The values of colour ranged between 5.75 to 6.65 points as assessed on a nine-point hedonic scale were similar to the values (5.71 to 6.75) reported by Omojola and Adesehinwa (2007) but they observed that the colour rating improved as the level of enzyme inclusion increased with no significant differences.

There was no difference in live weight of the broiler chickens fed the experimental diets. This was in harmony with the observation of Odeh *et al*. (2016) who reported no difference between treatments for the live weight. However, there were differences in dressed weight and eviscerated weight. This was contrary to the findings of Abdulraheem *et al*. (2006) who observed no statistical difference between treatment groups when rice bran was used to replace maize in broiler chicken diets. Birds on

50% ZTSD had superior higher value of dressed weight compared with control diet. The higher dressed carcass weight (1850.00g) of broiler chickens fed 50% ZTSD may be considered to be a direct consequence of the better body weight and FCR of the broiler chickens in this treatment. Although, birds fed the control diet with dressed weight of 1720.00g and 100% ZTSD with value of 1680.00g did not have the highest live weight per finisher broiler chicken, they manifested remarkable dressed weight as a percentage of live weight indicating that all diets supported a proportional cumulative weight gain. However, it implies that the dressed weight of broiler chickens was not directly proportional to the weight gain or performance traits. Also, high weight gain value may not imply a concomitant increase in the dressed weight value expressed as a percentage of live weight (Fasuyi and Aletor, 2005). The dressing percentage was not influenced by the dietary treatments. Birds on 50% UTSD had numerical higher value (71.79%) of dressing percentage compared to the control (71.35%) and other diets (65.77 – 70.33%). This may suggest that treated and untreated sawdust can be utilized to replace wheat offal in broiler diets. The values of dressing percentage (65.77 - 71.79%) were lower than the values (74.15 – 86.29%) reported by Odeh *et al*. (2016). The dietary treatments influenced the cut-up parts of the broiler chicken except the drumstick. The birds fed 100% ZTSD had the lowest values of thigh (9.73%) and back (9.73%) compared with birds fed other diets. It may imply that the replacement of wheat offal by treated sawdust may not fully support the growth of some body parts of the broiler chickens. This observation is in agreement with the reports of Fasuyi and Aletor (2005).

The organ weights of the broiler chickens were influenced by the sawdust based diets. This observation was contrary to the findings of Adebiyi *et al*. (2009), they reported no significant differences in the weight of heart and gizzard when differently treated cowpea seed hulls was fed to broiler chickens. The birds fed 100% UTSD had highest value (4.21%) of gizzard followed by the value (3.16%) obtained in 50% ZTSD there were similar values in the control and other diets. The increase in the size of the gizzard might be due to the muscular activity which might have also resulted in the increased weight of liver of the birds fed 100% UTSD and 50% ZTSD. The values of the whole gastrointestinal tract did not follow any trend, but birds fed 100% UTSD (13.68%) and 100% ZTSD (14.05%) had highest values while the least value (11.71%) was obtained in birds on 50% UTSD. Abdelsamie *et al*. (1983) reported that higher fibre contents at similar feed intakes enhanced relative weight and length of the gastrointestinal tracts of broiler chickens. Longe and Ogedengbe (1989) reported that the gravity of feeding dietary fibre on growth response is a function of the source and concentration of the fibre source.

The sawdust based diets influenced the viscosity of ileal digesta of broiler chickens. This result was contrary to the findings of Omidiwura and Agboola (2016). They reported that there were no significant differences observed in the digesta viscosities of different sections of the GIT except at the duodenum. The inclusion of treated sawdust to replace wheat offal in the broiler chicken diets reduced the ileal digesta viscosity at 100rpm. This observation was in agreement with the findings of Gunal *et al*. (2004) who reported that the supplementation of low or high viscous wheat-based diets with the enzyme preparations of amylase or xylanase activity led to statistical reduction in ileal digesta viscosity. Also, Yasar and Forbes (2000) reported that enzyme supplementation of wheat-based diets markedly reduced digesta viscosity in broiler chickens. However, Flourie, *et al*. (1984) proposed that increased GIT viscosity increases the thickness of the intestinal unstirred water layer thereby reduce the nutrient uptake. The birds in the control group had statistically higher values of ileal digesta viscosity compared with the values in other diets. This may be due to the possible reduction in feed passage rate throughout the GIT. Increased digesta viscosity may be involved in the slowdown of the passage rate of digesta within the gut (Yasar, 2003). However, the passage rate was not determined in the study. Van Der Klis *et al*. (1993) and Almirall *et al*. (1995) reported that increased digesta viscosity induced by viscous gel forming dietary compounds reduced the rate of digestion and passage of digesta throughout the gut and may depress feed intake similar in the case of the control diet. The values of ileal digesta viscosity obtained in the study (0.73 -1.82cps) were lower than the values (5.0 -11.6 cps) reported by Yasar (2003) for 42-day old broiler chickens fed with diets based on wheat grain of different particle sizes. Also, it has been reported by earlier authors that broiler chickens fed wheat-based diets had fore-gut viscosity ranged from 1.5 to 21.1cps and the distal viscosity from 2.7 to 39.2cps (Allen *et al*., 1996; Bedford *et al*., 1991; Bedford, 1997; and Liang and Liu, 1999).

The replacement of wheat offal with untreated and treated sawdust had influence on the sensory attributes of the broiler chicken meat. The values obtained in 100% UTSD, 50% ZTSD and 100% ZTSD were similar to the control group. This implied that the taste panellists could not differentiate the meat samples. The sawdust based diets improved the juiciness and tenderness of the meat. Therefore, *Z. mobilis* treated sawdust promoted overall acceptability of meat from broiler chickens without any deleterious influence on the meat quality. Briedenstein and Carpenter (1983) reported that colour, flavour, juiciness and tenderness are the essential parameters of the eating quality of meat. Also, Pippen *et al*. (1969) reported that the components responsible for flavour are from lean portion and dissolved in the fat during cooking. However, Awosanya *et al*. (1990) observed that the only factor which was responsible for consumers' overall acceptability of rabbit meat is the age at which the animal is slaughtered. Therefore, the younger the age of the livestock, the more acceptable is its meat. Moreover, juiciness is important in the tenderness of meat because it provides lubrication to the consumers, and enhance mouth feel (Owens *et al*., 2004). Tenderness had been reported as a major quality determinant and probably the most essential sensory characteristic of meat (Deatherage, 1963). Tenderness score followed a similar trend as juiciness and flavour. Quali (1990) and Smulders *et al*. (1991) reported that meat tenderization is a multifactorial process which depend on a number of biological and environmental factors. The utilization of treated sawdust increased the degree of tenderness as assessed by the taste panelists. This agreed with the findings of Omojola and Adesehinwa (2007) who reported that exogenous enzyme increased the degree of tenderness of breast meat from broiler chickens. However, the result for texture, colour and overall acceptability did not agree with the reports of the same authors who observed that these parameters were not affected by the inclusion of enzyme in the broiler chicken diets.

The dietary treatments influenced the economy of feed conversion of broiler chickens except in the cost of the feed/kg and price/kg live weight. The relative advantage or disadvantage of using any diet can be determined by the price of the feedstuffs at the time of use and the current prices of live and dressed chickens in such environment (Ojewola, 1993). However, there was reduction in the cost of the feed/kg in the study. This observation agreed with the reports of Duwa *et al*. (2014) who reported reduction in the feed cost ₦/kg as the level of banana peel meal increased in broiler chickens' diets. In addition, Apata and Ojo (2000) reported that the high cost of feed was generally due to the exorbitant price and scarcity of conventional feed ingredients and that this could be lowered by using non-conventional feed ingredients. The cost of production/broiler was higher in 50% ZTSD (₦1188.55/broiler chicken) compared with the results of other dietary treatments. This may be due to the high feed consumption recorded in this group. The rate of return on investment and economic efficiency had similar pattern across the dietary treatments. This observation was contrary to the findings of Zakaria *et al*. (2008). They reported that the calculations for the three budgets showed a reduction in gross margins and cost-benefit ratio when BergazymP and Hemicell-D were added to the birds' diets compared to control diet due to reductions in final body weight. The inclusion of treated sawdust as a replacement for wheat offal resulted in lowest values of rate of return on investment and economic efficiency compared with the control group and other dietary treatments. However, Zakaria *et al*. (2008) reported that the reduction in body weight in addition to the cost of adding enzymes resulted in economic losses to the producers.

At the starter phase, the birds fed 100% *Z. mobilis* treated corn cobs (100% ZTCC) had highest values for final body weight (738.00g/bird), average weight gain (684. 00g/bird) and daily weight gain (24.79g/bird). This may be due to the improvement in the nutrient composition of treated corn cobs as observed by Olagunju *et al*. (2013). The reduced feed intake in broiler chickens fed 100% ZTCC could indicate an adequacy of the energy content of the diet. The metabolizable energy of the treated corn cobs (2780.28kcal/kg) is comparable with the value (2764.10kcal/kg) reported for wheat offal (Aduku, 1993), therefore, it implies that it can replace wheat offal energy for energy in broiler chicken diet. Moreover, the improved feed conversion ratio (1.92) and protein efficiency ratio (2.43) observed in the birds fed 100% ZTCC compared to the control group (2.10 and 2.29) may be due to the improved nutritive value of the fermented corn cobs with *Zymomonas mobilis*. The total cost of feed consumed/bird and cost of feed/kg weight gain in 100% ZTCC are lower than the values obtained in the control and other diets. This may be due to the low cost of fermented corn cobs compared to the cost of wheat offal as at the time of the study. This observation was similar to the reports of Donkoh *et al*., (2003). Although, a higher mortality was recorded in the control group and 50% *Zymomonas mobilis* treated corn cobs (50% ZTCC), the result of post-mortem autopsy revealed that their death may be due to systemic infection from the hatchery. However, Donkoh *et al*. (2003) reported no death or health related problems when ground maize cobs was fed to broiler chickens.

At the finisher phase, the birds fed the control diet had highest value of final body weight (2133.00g/bird) which was similar to the value (2130.00g/bird) observed in 100% ZTCC. Also, they have the highest values of average weight gain (1397.00g/bird) and daily weight gain (49.89g/bird). This observation was contrary to the report of Donkoh *et al*. (2013), they reported that ground maize cobs did not have significant impact on weight gain of broiler chickens. The birds fed the control diet had highest value of average feed intake (4055.00g/bird) and daily feed intake (144.82g/bird). It may be due to higher body weight than other broiler chickens. There was declined feed intake across the other dietary treatments. The reduced feed consumption could be responsible for the lowered body weight gain recorded compared with the birds fed the control diet. The birds fed 100% ZTCC had lowest value for feed conversion ratio (2.51) and the highest value of protein efficiency ratio (1.80). Reduction in the feed conversion ratio may have resulted from higher protein content of diets having *Zymomonas mobilis* treated corn cobs compared with the control diet. Aftab *et al*. (2006) reported that protein functions mainly in the accretion of meat by broilers. This observation agreed with the observation of Alam *et al*. (2003) who reported an increase in growth rates, feed intake and better feed conversion ratio when broiler diet was supplemented with exogenous enzyme. Although, the fibre in the diet was within the recommended range (NRC, 1994), the performance of the birds may be due to the fact that as the birds grow older, they adapted to the high fibre diets, digested and utilized them better (Sikka, 1990). However, the total cost of feed consumed/bird and cost of feed/kg weight gain were lower than the values obtained in the control and other diets. This may have compensated for the reduced daily weight gain and feed intake. There was highest value for mortality in the control diet (4.80%) while similar values are obtained in 100% UTCC (2.40%) and 50% ZTCC (2.40%) with the lowest value in 50% UTCC (0.80%). Thus further confirmed the nutritional potential of *Zymomonas mobilis* treated corn cobs for broiler chickens. The mortality may not be related to the dietary treatments.

The trend of dry matter digestibility was proportional to the degree of lignification of the fibre in the diet (Gidenne *et al*., 1998) that is, higher fibre content improves the dry matter digestibility. This observation is in agreement with the report of Aboushour and Baraket (1986) that increased dietary fibre will lead to increase in dry matter intake and digestibility. The result obtained at the starter phase revealed that the inclusion of treated and untreated corn cobs had influence on the nutrient digestibility of starting broiler chickens. The starting broiler chickens fed 50% UTCC had highest values for the nutrient digestibility except in NFED. However, the values obtained in 100% ZTCC were comparable with the control diet. This may be due to the age and the gastro-intestinal tract of the broiler chickens. The industrial treatment of wheat offal and the crushing of the corn cobs might have contributed to the better utilization of the diets. This agreed with Khajaren and Khajaren (2003) who reported that physical treatments for instance, milling, chopping, soaking, before feeding of feedstuffs gave positive response in term of increasing feed intake and digestibility. Moreover, Daveby *et al*. (1998) reported better digestibility of nutrients of milled pea compared to crushed pea. The nutrient digestibility values obtained in 50% ZTCC were comparable to the values recorded in 100% ZTCC. This may be due to the fermentation of the corn cobs with *Zymomonas mobilis*. It might have reduced the possible non-starch polysaccharides in the corn cobs. Life-enzyme produced during fermentation could have brought unexpected benefits as observed by Adebiyi *et al*. (2009) for fermented cowpea seed hull. Enzymes have been shown in literature to improve nutrient digestibility when added to poultry bird diets containing cereals such as maize (Saleh *et al*., 2003), wheat (Fengler *et al*., 1988), oat (Friesen *et al*., 1992) and rye (Fengler and Marquardt, 1988). Bedford (2000) reported that Roxazyme G2G reduces gut viscosity and nutrient entrapment and lead to better digestion in broiler chickens. The broiler chickens fed 50% ZTCC had highest values for nutrient digestibility except for acid detergent lignin digestibility. However, most of the nutrient digestibility values obtained in 100% ZTCC were comparable with the control diet. The improved nutrient digestibility implied that the experimental broiler chickens were able to effectively digest and utilize the treated corn cobs which could have been excreted and decomposed in the soil. Also, Lazaro *et al.* (2003) reported that enzyme supplementation of wheat-based diets improved nutrient digestibility. The crude fibre digestibility and its component values were higher in the test diets than the control. It indicated that anti-nutritional factor (ANFs) levels in the test diets did not significantly impair the utilization of these nutrients. This agreed with the reports of Raji *et al*. (2015) who observed that African yam bean cake enhanced apparent nutrient digestibility of broiler finishers. In the present study, nutrient digestibilities were significantly influenced by the life-enzyme based diets. This agreed with the reports of Choct *et al*. (1995, 1999), who stated that starch and/or protein digestibility of poultry birds on xylanase treatment was better compared to those without xylanase treatment.

The poor nutrient digestibility recorded in broiler chickens fed 100% UTCC (untreated corn cob based diet) can be attributed to the gel forming capacity (viscosity) of non-starch polysaccharides which was responsible for low nutrient digestibility and/or availability (Bedford and Classen, 1992).

Bounous *et al*. (2000) reported that laboratory examination of blood variables will aid the diagnosis of several diseases and dysfunctions in livestock. It can provide reliable results and promote research studies on nutrition, physiology and pathology. Some authors had reported in their previous works that the blood variables (RBC, PCV, plasma protein and glucose) were most consistently affected by dietary treatments (Aletor, 1989; Aletor and Egberongbe, 1992). Duke (1985) had clearly established the functions of blood in circulating hormones, metabolites, as thermo-regulators and general hormeostasis in farm animals. Also, Veulterinora (1991) reported that diets have significant influence on haematological variables. The packed cell value and haemoglobin were not influenced by the dietary treatments at the starter phase. The PCV values (25.00 – 30.00%) are within the normal range of 22.0 - 35.0% for broiler chickens (Anon, 1980; Swenson, 1999). Church *et al*. (1984) and Babatunde *et al*. (1987) showed that PCV and Hb are correlated with the nutritional status of the animal which directly related to the nutritional balance of the diet fed to the animals. The birds on the control diet had higher value (3.70 x 10^{12L}) for red blood cell, followed by birds fed 100% ZTCC (3.00 x $10^{12/L)}$ but the birds on 50% UTCC (1.30 x $10^{12L)}$ and 50% ZTCC (1.20 x $10^{12/L}$) had similar lowest values. Olugbemi *et al*. (2010) reported that red blood cells are responsible for the transportation of oxygen and carbon dioxide in the blood as well as the manufacture of haemoglobin. Therefore, higher values indicate a greater potential for these functions and a better state of health.

The dietary treatments influenced the MCH and MCV but did not affect the MCHC. The values obtained for birds fed the control diet (24.00pg and 73.00fl), 100% UTCC (38.00pg and 119.00fl) and 100% ZTCC (33.00pg and 100.00fl) for MCH and MCV were within the normal range (33.00 - 47.00pg and 90.00 – 140.00fl) for broiler chickens (Jain, 1993). However, the birds fed 50% UTCC (64.00pg and 192.00fl) and 50% ZTCC (78.00pg and 233.00fl) had higher values for MCH and MCV. Seivered (1972) reported that high values of MCV, MCH and MCHC caused anaemia in livestock. On the other hand, MCH indicates the blood carrying ability of the red blood cell which may suggest that the birds on 50% UTCC and 50% ZTCC are more efficient in performing respiratory functions as reported by Soetan *et al*. (2013). The values of white blood cell count (11.80 – 18.20 x $10^{9/L}$) recorded in the dietary treatments are within the normal values (1.20 – 3.00 x 10^4µl) stated by Jain (1993). High WBC may be associated with inflammatory diseases, infection diseases or stress, or may be common in young birds (Fudge, 1997; Fudge, 2000 and Clark *et al*., 2009). The values for heterophil and lymphocytes were within the normal values (15.00 – 40.00% and 45.00 – 70.00%) for healthy broiler chickens (Jain, 1993). This suggested the resistance of the birds in disease condition. The corn cobs based diets influenced the serum metabolites except glucose. The inclusion of treated and untreated corn cobs in the diets depressed the total protein, albumin and globulin of the birds. This observation was in contrary to the report of Fasuyi and Aletor (2005). They reported that the total serum protein, albumin and globulin were not significantly affected when cassava leaf protein concentrate replaced fish meal in broiler diets.

At the finisher phase, the dietary treatments significantly influenced all the haematological parameters except MCHC which had similar values across the dietary treatments. The birds fed 50% UTCC had higher value (39.00%) of PCV while birds on 100% UTCC had higher value (78.00%) of lymphocytes, which was similar to the value observed in 50% ZTCC (77.00%). The values obtained in birds on 50% ZTCC for MCH (45.00pg) and MCV (135.00fl) were within the normal range (33.00 - 47.00pg and 90.00 – 140.00fl) reported by Jain (1993) and Benerjee (2004) but the values obtained in the other dietary treatments were higher than the normal values for healthy broiler chickens. The similar values of MCHC obtained in the dietary treatments revealed that replacement of wheat offal with treated and untreated corn cobs has no deleterious effect on the broiler chickens as they maintained their normal MCHC. The values of uric acid (2.80 – 5.00mg/dl) obtained in this study were lower than the normal value for urea (7.00 – 21.00mg/dl) reported in literature (Am. Met laboratory, 2001). The metabolism of uric acid is influenced by the quantity of protein and amino acids in the diet (Oduguwa *et al*., 1996). Serum uric acid (Morgensten *et al*. 1966) and creatinine (Eggum, 1970) can be utilized as an indirect measure of protein adequacy. High levels of AST and ALT may indicate an occurrence of liver damage/low plane of nutrition as observed by Ekpenyong and Biobaku (1986).

The corn cobs based diets significantly influenced live weight, dressed weight, eviscerated weight and dressing percentage. The birds fed the control diet had higher average live weight which led to higher dressed weight and eviscerated weight. But this was closely followed by the values from the birds fed 100% ZTCC. This could be attributed to the fact that the broiler chickens performed well on *Zymomonas mobilis* treated corn cobs based diet as well as on control diet. The findings agreed with the reports of Duruna *et al*. (2006). They reported differences on the live weight, eviscerated weight and dressing percentage of broiler chickens fed varying levels of *Anthronata macrophyla* seed meal. The highest value of dressing percentage obtained in the control was similar to the values recorded in 50% UTCC, 50% ZTCC and 100%

ZTCC. The values (69.13 - 77.28%) of dressing percentage were higher than the values (65.63 - 73.33% and 63.02 – 63.06%) reported by Adeyemo and Longe, (2007) and Akinleye *et al*. (2008) but lower than the values (79.00 – 81.00%) obtained by Donkoh *et al*. (2003). Higher body weight and lower offal weight reflect good performance characteristics of poultry birds (Plumber and Kiepper, 2011). The treated and untreated corn cobs based diets affected the cut-up parts of the broiler chickens expressed as the percentage of live weight. This was contrary to the reports of Donkoh *et al*. (2003) who reported no influence of ground maize cobs level on the carcass yield of broiler chickens processed at 56 days of age. The values of breast, thigh and drumstick obtained in 100% ZTCC compared to the control group revealed the adequacy of the treated fibrous feedstuff to replace wheat offal without retarding muscle development. However, Aduku and Olukosi (2000) observed that most of the cut-up parts are based on individual processors' knowledge and efficiency because there was no standard to follow in the fabrication of carcasses of slaughtered animals and poultry in most developing countries. The birds fed 50% UTCC (5.26%) and 100% UTCC (5.00%) had higher values for gizzard than birds fed the control (2.73%) and other diets (3.00 and 4.21%). This may be as a result of handling of bulky feeds. Rose (2001) reported that increase in the development of the gizzard will enhance its grinding role. The values of empty gizzards followed the same trend as the whole gizzards. The birds fed 100% ZTCC had highest value (21.00%) of gastro-intestinal tract compared to the other diets. This was contrary to the report of Yeroch and Danicke (1995), they reported that birds fed high-barley or high-wheat diets had elevated intestinal weight, which negatively affect the carcass yield but the negative effect was reduced after supplementation with appropriate enzyme.

The corn cobs based diets exerted influence on the ileal digesta viscosity of broiler chickens. Birds fed 100% UTCC (100% *Zymomonas mobilis* untreated corn cobs) had higher values (7.40cp) at 100rpm but the lowest value (3.03cp) obtained in the control diet was similar to values (3.30cp) and (3.90cp) recorded for broiler chickens fed 50% ZTCC and 100% ZTCC. This may be responsible for the depressed performance of the birds on 100% UTCC because of possible reduction in feed passage rate throughout the gastro intestinal tract (Yasar, 2003). Vidanarachchi *et al*. (2010) reported that ileal digesta viscosity increased in birds fed higher level of Undaria extract compared with the negative control. The inclusion of treated corn cobs in the diets of broiler chickens reduced ileal digesta viscosity in 50% ZTCC (3.90cp) and 100% ZTCC (3.30cp). This observation agreed with the report of Hew *et al*. (1998). They reported that exogenous xylanases increased the solubilisation of arabinoxylans, decreased digesta viscosity and led to improved nutrient digestion and absorption. The values obtained were greater than the values reported by Vidanarachchi *et al*. (2010) but the values recorded in the control group, 50% ZTCC and 100% ZTCC were within the values (5.0 – 11.6cps) reported by Yasar (2003).

The incorporation of untreated and treated corn cobs had influence on the sensory attributes of the meat. The taste panel score for colour recorded in 100% ZTCC was similar to the values obtained in the control diet and 50% UTCC and 100% UTCC. This might be due to the influence of ground corn cobs on the colour of the meat (Briedenstein and Carpenter, 1983). The values obtained in the 50% ZTCC and 100% ZTCC compared favourably with the control group. This is an indication that *Z. mobilis* treated corn cobs had positive influence on tenderness thereby affecting the overall acceptability by the consumers. Also, the untreated and treated corn cobs influenced the colour, juiciness and flavour of the meat. It can be inferred that corn cobs based diets might have led to improvement in collagen and myofibrillar solubility, therefore, improving the tenderness of edible muscles (Waskar *et al*. 2009). The corn cobs based diets generated broiler chicken meat with a greater degree of consumer acceptability.

The cost of feed/kg lowest value (₦173.89) recorded in 50% UTCC was similar to the values obtained in the control diet (₦174.89) and 100% ZTCC (₦174.39). This may be due to the cost of treated and untreated corn cobs compared to the cost of wheat offal. The highest cost of feed/kg observed in 50% UTCC (₦176.39) and 50% ZTCC (₦175.64) may be due the combination of wheat offal and treated and/or untreated corn cobs in the diets. The lowest cost of production/broiler recorded in 100% ZTCC (₦1312.34) had similar value in 50% ZTCC (₦1315.12), compared with the control diet (₦1413.25). The gross revenue/broiler (₦1917.00) recorded in the control diet was similar to the value in 100% ZTCC (₦1917.00) but was higher than other values in 50% UTCC (₦1764.00), 100% UTCC (₦1728.00) and 50% ZTCC (₦1719.00). The gross profit/broiler of ₦604.66 in 100% ZTCC was greater than ₦503.75 obtained in the control diet. This may be due to the nutritional adequacy of *Z. mobilis* treated corn cobs which supported the growth performance of broiler chickens. The additional cost of purchasing enzymes and incorporating them into feeds had been removed by the production of life-enzyme based feed. The rate of return on investment, economic efficiency and relative cost benefit followed the same trend as the gross profit/broiler. The inclusion of *Z. mobilis* treated corn cobs in the diet of broiler chickens yielded 13.92% relative cost benefit when compared with the control diet.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The following conclusion can be drawn from the present results:

- The replacement of wheat offal with untreated and treated soyabean hull improved the feed conversion ratio and protein efficiency ratio thereby promoted growth response of the broiler chickens.

- The apparent nutrient digestibility of the broiler chickens was improved by the replacement of wheat offal with 100% untreated and treated soyabean hull.

- UTSBH and ZTSBH increased the PCV, haemoglobin, red blood cell, total protein and glucose of the broiler chickens.

- The carcass characteristics of the broiler chickens were increased by the soyabean based diets. The cut parts were improved by 100% UTSBH and ZTSBH in the diets. The replacement of wheat offal with soyabean hull based diets promoted the development of the organs of the birds.

- 50% UTSBH reduced the ileal digesta viscosity of the broiler chickens.

- Moreover, the sensory attributes such as colour, juiciness and tenderness of the meat were improved by the 50% ZTSBH.

- The economy of feed conversion of broiler chickens fed soyabean hull based diets revealed that untreated and/or treated soyabean hull could replace wheat offal with increased gross profit and rate of return on investment.

- Untreated and treated cassava sifting influenced the feed conversion ratio and protein efficiency ratio of the starting broiler chickens but had no influence on FCR and PER of the finishing broiler chickens.

- Values of apparent nutrient digestibility increased as a result of the incorporation of *Z. mobilis* treated cassava sifting in the diets.
- Haematological parameters and serum metabolites of broiler chickens were positively improved by the cassava sifting based diets.
- Cassava sifting based diets increased the dressing percentage of the broiler chickens. The cut parts were adequately promoted without any deleterious influence on the organs of the broiler chickens.
- 100% ZTCS reduced ileal digesta viscosity which affected the nutrient absorption of the broiler chickens.
- 50% ZTCS increased the sensory attributes of the meat from the experimental birds.
- The economy of feed conversion of broiler chickens fed the 50% ZTCS showed higher gross profit and rate of return on investment.

- 50% untreated sawdust (UTSD) had improved FCR and PER at the starting phase but 50% ZTSD and 100% ZTSD promoted better PER at the finshing phase.
- Replacement of wheat offal by 50% and 100% ZTSD improved the apparent nutrient digestibility parameters.
- The inclusion of ZTSD improved PCV, Hb, RBC, total protein and blood glucose during the feeding trials.

- 100% UTSD depressed the carcass characteristics of broiler chickens but 50% ZTSD increased the major parts of interest such breast, thigh, drumstick and back of the broiler chickens.
- 100% UTSD, 50% and 100% ZTSD reduced the viscosity of the ileal digesta of the broiler chickens.
- The inclusion of 100% UTSD and 100% ZTSD increased the sensory attributes of the meat of the broiler chickens.
- The replacement of wheat offal with 50% UTSD and ZTSD increased the gross profit and rate of return on investment.

➢ The replacement of wheat offal with100% ZTCC improved feed conversion ratio and protein efficiency ratio of the broiler chickens at both phases.

➢ Values of apparent nutrient digestibility of the broiler chickens were improved by the corn cobs based diets.

➢ 50% UTCC and ZTCC promoted the haematological parameters and serum metabolites of the broiler chickens. Inclusion of 100% ZTCC improved the blood glucose of the birds.

➢ The carcass characteristics were not negatively influenced by the corn cobs based diets. Values of dressing percentage and cut parts were improved by the replacement of wheat offal by 50% UTCC and 100% ZTCC in broiler chicken diets.

➢ The sensory attributes of the meat were positively supported by the replacement of wheat offal with 50% ZTCC in the broiler chickens' diets.

- 50% ZTCC and 100% ZTCC reduced the ileal digesta viscosity of the broiler chickens.

- Corn cobs based diets improved the economy of feed conversion of broiler chickens. The birds fed 100% ZTCC had highest gross profit and rate of return on investment.

- ✓ The availability of these agro-industrial by-products in commercial quantity and *Zymomonas mobilis* from palm wine will assist in converting them to alternative fibrous feedstuffs in tropical environment.

6.2 **Recommendations**

As a result of the findings obtained in the present studies, it can be recommended that,

1. 100% untreated and 100% treated soyabean hull can be used to replace wheat offal in broiler chickens' diets.

2. 50% untreated and 100% treated cassava sifting can be used to replace wheat offal in broiler chickens' diets.

3. 50% untreated and 100% treated sawdust can be incorporated in the diets of broiler chickens.

4. 100% untreated and 100% treated corn cobs can replace wheat offal in broiler chicken diets without deleterious effects on the growth response and health status in the tropical environment.

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APPENDIX I: VACCINATION PROGRAMME FOR BROILER CHICKENS

S/N	DAYS	ACTIVITIES
1	1	Glucose, multivitamins (WSP), vitamin B complex, gentamycin, saline water- injection
2	2 – 5	Vitamin and Antibiotics
3	6	Vitamin only
4	7	1st IBDV (1st Gomboro)
5	7 – 9	Vitamin
6	10 - 12	Water only
7	13	Vitamin only
8	14	1st NDVL (1st Lasota)
9	14 - 16	Vitamin only
10	17 - 19	Anticocci
11	20	Vitamin
12	21	2nd IBDV (2nd Gumboro)
13	21 - 23	Vitamin only
14	24 - 28	Coccidiostat and Antibiotics in water
15	29 - 30	Water only
16	31	Vitamin only
17	32	2nd NDVL (2nd Lasota)
18	32 - 34	Vitamin only
19	35	Dewormer
20	36 - 38	Vitamin only
21	39 - 45	Water only
22	46 - 48	Vitamin only
23	49 - 56	Water only

APPENDIX II: SENSORY EVALUATION QUESTIONNAIRE

Instruction: Kindly assess the broiler chicken meat samples presented in the labelled plates A – E and award score using a nine (9) point Hedonic scale of:

1. Dislike extremely
2. Dislike very much
3. Dislike moderately
4. Dislike slightly
5. Intermediate
6. Like very much
7. Like moderately
8. Like very much
9. Like extremely

Parameters	**A1R1**	**A1R2**	**A1R3**	**B1R1**	**B1R2**	**B1R3**	**C1R1**	**C1R2**	**C1R3**	**D1R1**	**D1R2**	**D1R3**	**E1R1**	**E1R2**	**E1R3**
Colour															
Juiciness															
Flavour															
Tenderness															
Overall Acceptability															

General comment(s)…………………………………………………………………………………………….

Thank you sir/ma for your anticipated cooperation and understanding.

APPENDIX III: PRICE LIST OF FEEDSTUFFS, UNTREATED AND TREATED BY-PRODUCTS AS AT THE TIME OF THE STUDY 2014 – 2016

Ingredients	Price at the starter phase (₦/Kg)	Price at the Finisher phase (₦/Kg)
Maize	88.50 – 115.00	112.50 – 115.00
Soyabean meal	137.50 – 144.00	143.00 – 155.00
Groundnut cake	115.00 – 120.00	120.00
Fish meal (Imported)	825.00 – 850.00	850.00 -1150.00
Wheat offal	**49.00 – 65.00**	**60.00 – 65.00**
Untreated Soyabean hull	**10.00**	**10.00**
Treated Soyabean hull	**15.00**	**15.00**
Untreated Cassava sifting	**40.00**	**40.00**
Treated Cassava sifting	**45.00**	**45.00**
Untreated Sawdust	**10.00**	**10.00**
Treated Sawdust	**13.00**	**13.00**
Untreated Corn cobs	**20.00**	**20.00**
Treated corn cobs	**25.00**	**25.00**
Bone meal	50.00 – 55.00	50.00 – 55.00
Limestone	15.00	15.00
Lysine	750.00 – 800.00	750.00 – 800.00
Methionine	2,600.00 - 2,800.00	2,600.00 - 2,800.00
Toxin binder	700.00 – 875.00	700.00 – 900.00
Premix	700.00 – 900.00	800.00 – 975.00
Salt	65.00 – 70.00	65.00 – 70.00
Milling cost (₦/Kg)	3.50 - 4/00	3.50 – 4.00