EFFECT OF FERMENTATION TIME ON THE PERFORMANCE OF BROILER CHICKENS FED DIETS CONTAINING FERMENTED POULTRY DROPPINGS UNDER SINGLE PHASE FEEDING

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RIMBUT, Naldeya Napko
MTech/SAAT/2019/9400

DEPARTMENT OF ANIMAL PRODUCTION
FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA

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ABSTRACT

An experiment was conducted to investigate the effect of fermentation time on the performance of broiler chickens fed diets containing varying levels of fermented poultry droppings under single phase feeding. A total of 150 broiler chickens were used in this experiment. The birds were randomly allotted to five dietary treatments of three replicates with ten birds per replicate, in a completely randomized design. The experimental diets were designated as T1, T2, T3, T4 and T5; T1 served as the control, while T2, T3, T4, and T5 were treatment groups wih poultry droppings fermented for 24, 48, 72, and 96 hours respectively. Feed and water were supplied *ad libitum* throughout the period of the experiment which lasted for eight weeks. Data were collected on initial body weight, feed intake, final body weight, apparent nutrient digestibility, carcass characteristics, organoleptic properties and economy of feed conversion. Results showed that there was a significant difference ($P<0.05$) in the feed intake amongst the treatments with T3 having the highest feed intake (3943.97g), however, the lowest feed intake was recorded in T1 with 3111.63g. There was a significant difference ($P<0.05$) in final body weight with T5 recording the highest (1697.10g), while the lowest was recorded in T1 (1564.70g). There were no significant differences ($P>0.05$) among the parameters measured in apparent nutrient digestibility; rather a significant difference ($P<0.05$) was recorded for ether extract digestibility with T5 having the highest percentage (93.91%) while the lowest value was recorded in T1 with 89.16%. Significant differences ($P<0.05$) were observed in live weight, slaughtered weight, de-feathered weight, dressing weight and dressing percentage, nevertheless, the results of the carcass characteristics indicated that the fermented poultry droppings diets had no significant effect ($P>0.05$) on some cut up parts like back weight, breast, thigh, drumstick and wing. The results of the internal organs revealed no significant differences ($P>0.05$) among all the parameters measured. Similarly, the results of the organoleptic properties indicated no significant difference ($P>0.05$) in most of the parameters, However, significant differences ($P<0.05$) were observed in juiciness, aroma and overall acceptability. The economy of feed conversion revealed that broiler birds fed the control diet had the highest feed cost per kilogram, (₦290.21) with the corresponding highest feed cost per weight gain (₦578.22). Similarly, the lowest feed cost per weight gain was recorded in T5 with ₦526.37 respectively. From this study, it was concluded that different time fermented poultry droppings could be used up to 5% inclusion as a substitution for conventional protein feeding stuff in broiler chickens without any adverse effect on growth performance irrespective of the fermentation period adopted.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

The growth performance of broiler chickens has been spectacular over the last thirty years, mainly due to the genetic progress and improvement of nutrition and a controlled environment, so that it takes 33 days to reach a finishing average body weight of about 2 kg (Wilson, 2005; Choct, 2009). According to Ghaly and MacDonald (2012), the rearing of birds has improved from a side-line occupation into a fully-fledged commercial enterprises. Broiler chicken production is one of the fastest means of producing animal protein because of their short generation interval (Babatunde, 1980). Feed is a major component affecting the net return from the poultry because the cost of feed accounts for between 60 to 70 % of broiler production, and is a major factor that affects their production cost (Srivastava *et al.*, 2013). The cost of production of broiler meat has remained high due to the high cost of feed. Groundnut cake (GNC) has been used as a protein supplement in broiler diets but its price has continued to increase in our markets. This has necessitated the need for an alternative feed ingredient for groundnut cake as a protein supplement (Yahaya, 2014). Such choice of ingredient in the diet of monogastrics must have the ability to supply required protein, have an adequate amino acid profile, provide balanced energy: protein ratio and in addition possess the merit of easy storage, availability and low cost. Presently, a lot of emphasis is being placed on research on the use of agro-industrial by-products and animal wastes, which do not offer much competition as food for man and other animals. The poultry industries have produced 22 million tonnes of manure from over 18 billion populations of poultry (FAO, 2010). The high poultry waste production causes an adverse effect of ammonia pollution on the environment, and thus the need to recycle. Poultry waste (excreta rich in nitrogen, calcium, phosphorus, vitamins and energy) is capable of being utilized when materials are recycled by feeding (NRC, 1983).

Poultry waste has drawn attention as a potential feed ingredient due to its nutrient composition. Pure poultry droppings can be collected from cages, wire floors or slated floors to be treated after it has been collected, which could be used as a source of nutrient for various classes of poultry. Dried poultry waste as described here, refers to air and sun-dried droppings from poultry. However, poultry droppings have been used as partial feeding for broilers, (Ghaly and Macdonald, 2012) but limited information is available on the use of fermented poultry droppings for feeding broiler chickens. The fermentation process serves as a means of providing a source of nourishment for the large rural poultry population. It enhances the nutrient content of foods through the synthesis of protein, vitamins and essential amino acids. (Zhang *et al*., 2010). The effect of fermentation time on the performance of broiler chickens has not been fully exploited, and this forms the basis on which the research was conducted.

1.2 Statement of the Research Problem

Owing partly to the COVID–19 economic realities, the cost of commercially prepared or factory-produced feeds has increased beyond the reach of many average poultry farmers. The cost of processing ingredients has also gone very high, which has resulted in declining productivity and profitability, for intensive broiler production systems in Nigeria (Hassan *et al*., 2011). The alternative sources of proteins which include cattle, goat fish etc, has also skyrocketed beyond the reach of the average citizen, who are observed to consume very low level of protein at present (Ayanwale, 2006). The present groundnut and soya beans production level can no longer supply both human needs and for use as poultry feed ingredients. The situation has resulted in a rise in the prices of poultry chickens including broilers. Poultry droppings are a good source of supplemental protein, energy and minerals. In addition to offering an economic advantage, using livestock poultry droppings in feed also helps to utilize valuable nutrients such as phosphorus, potassium and other minerals elements, (Kim *et al.*, 2020). Poultry droppings has also been used to feed goats (Reddy *et al*., 2012., Ajayi *et al*., 2016) sheep (Bello and Tsado, 2013) and cattle (Alam, 2008) with great positive result. Indiscriminate disposal of poultry manure has been identified as a major source of environmental degradation in production areas through air and water pollution associated with nitrogen and phosphorus emissions and losses from manure, (Adeoye *et al.,* 1994). Therefore, considering the central roles broiler chickens play in Nigeria's diets, it becomes imperative to seek alternative sources of feed ingredients for the business to be sustained.

1.3 Justification for the Study

Fish meal and other animal protein sources are becoming increasingly expensive because of high demand during production and competition between humans and livestock. Poultry droppings have been reported to contain 21% crude protein and other macronutrients that can support broiler production (NRC, 1983). However, there is limited information on the use of fermented poultry droppings (FPD) which may provide an alternative way of recycling poultry waste products which would have constituted environmental pollution, but equally reducing the cost of broiler production through reduced cost of feeding.

1.4 Aims and Objective of the Study

The aim of this research study was to evaluate the effect of fermentation time on the performance of broiler chickens fed fermented poultry droppings under a single phase feeding regime.

The objectives of the study were to:

i. determine the effect of fermentation time on the growth performance of broiler chickens fed a diet containing fermented poultry droppings under single phase feeding;

ii. determine the digestibility of differently fermented poultry droppings fed to broiler chickens;

iii. assess the effect of fermentation time on the carcass characteristics of broiler chickens fed diets containing fermented poultry dropping under single phase feeding;

iv. examine the effect of fermentation time on the meat quality of broiler chicken fed diets containing fermented poultry droppings under single phase feeding;

v. evaluate the effect of fermentation time on the sensory properties of the meat of broiler chickens fed diets containing fermented poultry droppings under single phase feeding; and

vi. determine the effect of fermentation time on the economy of producing broiler chickens fed diets containing fermented poultry droppings under single phase feeding.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Animal Protein

The production of poultry in Nigeria is recognized among domestic animal production and impacts a significant amount of meat and eggs meant for human utilization (Onu and Madubuke, 2006). Alabi and Aruna (2005) opined that the enterprise has undergone a major increase over the years. For instance, poultry meat production in Nigeria has improved from 172, 000 metric tonnes in 1999 to 211,000 tonnes in 2005. Nevertheless, the rise is not steady with the demand owing to none supply of quality feed (Onu and Madubuke, 2006).

According to Defang *et al.* (2008), the price of conventional feedstuff which are key source of protein and energy in poultry diets has continued to increase due to their insufficient supply. Agbede *et al*. (2002) suggested that the rationale behind the high price of conventional feedstuffs such as soya beans, sorghum, maize and fishmeal is due to high competition between industrial processors, human consumers and other users for conventional feedstuffs. This has given rise to the high cost of feed, causing economic losses in poultry production in Nigeria (Aderolu *et al*., 2007), the author also suggested that there is a need to continue to search for alternative sources of protein and energy that are not probably not facing such competition and demand as the conventional feed stuffs. Onyimonyi and Onukwufor (2009), indicated that the main solution to the problem of the rising cost of energy and protein sources for monogastric is seeking new and using non-conventional resources which can replace conventional ones in diets without any deleterious effect on performance.

The fastest means for overcoming the protein supply-demand gap is dependable on the production of animals that bring quick returns and are capable of converting feed to flesh, having a short generation period, for instance, poultry, and the use of non-expensive and locally obtainable non-conventional feedstuffs within the reach in a well-defined feeding regime to lower the cost (Abdulmojeed *et al.*, 2010). Consequently, if poultry production must develop and the growth sustained, alternative energy and protein sources which are available and not in competition with other large-scale demands must be sourced (Ugwu and Onyimonyi, 2008; Mmerole, 2009). In the past decades, studies have been done to identify alternative and non-conventional feed resources which are less expensive and easily accessible for production (Aduku, 1993; Esonu *et al*., 2003; Amaefule and Iraonya, 2005)

As in the developed and other developing economies of the world, non-ruminant animal production especially the poultry industry plays a pivotal role; a predominant source of animal protein both in the form of eggs and lean meat production. More than 70% of the cost of production in the poultry industry is for feed provision, and hence, the profitability of this industry depends largely on the quality and economics of feed production (Afolayan and Afolayan, 2008; Banson *et al*., 2015). Expansion of the industry will therefore mainly be determined by the sufficient availability and affordability of good quality feed for the birds and subsequently good poultry products, such as eggs and meats for the consumers (Adejimi *et al.*, 2011). For intensive enterprises, inadequacies in nutrient supply often lead to a drop in egg production as well as a decline in growth performance on the part of broilers for meat production.

2.2 High Cost of Animal Feed

The rise in prices of feed can be considered the major key problem facing the production of poultry in Nigeria as well as underdeveloped Nations where the feed alone costs over 70% of total production (Uko and Kamalu, 2003). This challenge has made a lot of poultry farmers either reduce the level of their production or stop the entire production and increase the crisis of animal protein intake in the country (Hassan *et al*., 2011).

2.3 Protein Requirement of Livestock

By the findings of Ani and Omeje (2007) the expected mean level of animal protein utilization in Nigeria at 8g per day which is against the suggested intake by FAO of 65g/day of which 35g source of the protein should be from the animal (Atsu, 2002). Onyimonyi and Onukwufor (2009) indicated that the scarce and high price of animal protein has been provoked by the high cost of conventional feed ingredients and animal products, which can be ascribed to the low productivity of farm animals. Consequently, the use of non-conventional ingredients as substitutes for grains and other conventional feedstuffs has been recommended; hence the search for non-conventional ingredients has been the main active area of animal nutrition research in the tropical world. Ikani and Adesehinwa (2000) suggested that the solution to the problem of animal protein shortage and the high cost of conventional feed in Nigeria lies in the production of highly prolific animals that are efficient converters of feed to flesh and have short generation intervals, and also the use of cheap and locally available non-conventional feedstuffs to reduce the cost of production.

2.4 Poultry Manure as Animal Feed

The poultry industry is one of the largest and fastest-growing sectors of livestock production in the world with a 35% increase in egg production and meat between 2000-2008 (FAO, 2010). Rearing of birds has grown from backyard farming to a commercial enterprise with single farms housing thousands of birds. The 2020 world annual census data estimated the world flock to be over 33 billion birds with an estimated yearly output of over 46 billion tonnes of manure (FAO, 2023). This rapid expansion of the industry over the last several decades has increased the need to find economically viable and environmentally acceptable ways of utilizing such large quantities of waste. With the increasing production of poultry products, storage and disposal of raw poultry manure has become an environmental problem due to the associated air, water and soil pollution (Benali and Kudra, 2002).

Poultry manure begins to decompose immediately after excretion giving off ammonia in high concentrations, which has adverse effects on the health and productivity of birds as well as the health of farm workers (Amon *et al*., 2006; Zhang and Lau, 2007). Feacal droppings can also serve as a breeding ground for pathogenic microorganisms and as a medium for disease transmission among birds. Flies and other undesirable insects can breed on the manure leading to the health nuisances and misfortunes linked with them (Lay *et al*., 2011). Manure is also a source of odour caused by the activity of anaerobic microorganisms in the manure (Berry and Miller, 2005; Fares *et al*., 2005). It is, therefore, necessary to subject poultry manure to some treatments in order to improve its storage and handling properties and to minimize the risk of disease transmission and environmental pollution. Proper poultry manure management systems that will preserve the environment, contribute to both animal and human health and return a profit on investment to farmers need to be developed.

Poultry manure can be dried and used in animal feeding. Drying refers to the removal of moisture from the manure so that it is near equilibrium with atmospheric air. By drying, the rate of deterioration from chemical and biological activity is minimized and the environmental problems associated with raw manure can be prevented (Bernhart and Fasina, 2009). Drying also removes manure stickiness and hence allows for easier handling (Bernhart and Fasina, 2009). Drying with heated air offers several advantages over unheated air drying including a higher rate of oxidation and pathogen destruction (Ghaly and Mac-Donald, 2012). Drying with heated air can be carried out using a variety of heat sources such as solar energy, electricity, natural gas or other fossil fuels. However solar energy offers several advantages over other energy sources:

(a) it is available in abundance all year round,

(b) it has a higher rate of oxidation

(c) it results in good waste stabilization, odour control and pathogen destruction (Amine-Khodja *et al*., 2006; Asabe, 2009; Martens and Bohm, 2009).

Dried poultry manure has been used as an animal feed for monogastric animals (Alam *et al*., 2008; Ghaly and MacDonald, 2012). The use of poultry manure as animal feed could significantly improve the economics of poultry production. Savings in feed costs through nutrient recycling would be sufficient to justify the cost of drying while also protecting the environment. Spiehs and Goyal (2007) recommended that the best management practices to reduce pathogens in livestock wastes should be approached from three angles: reducing pathogens in the animals, during manure collection and storage and lastly during land application of manure. Contrarily, raw manure and improperly treated manure can serve as a source of pathogenic contamination causing soil, air and water pollution, which in turn will result in critical public health issues (Spiehs and Goyal, 2007).

2.5 Poultry Manure

The intensive poultry production establishments have a high production of poultry waste that is commonly used as fertilizer. At present, the use of such excrement (manure) for the feeding of monogastric animals has increased. Poultry manure is understood as the collection of faeces and urine of birds, plus food remains, drugs, chemicals, beddings, feathers, eggs and absorbent material. They are characterized as being materials of low energy value but high in proteins, fibre and minerals. The protein is presented with a high proportion of non-protein nitrogen, hence its use is exclusively for the feeding of ruminants (Brunton, 2012).

2.6 Features of Poultry Droppings

Poultry manure contains all the essential plant nutrients that are used by plants. These include nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), boron (B), iron (Fe) and molybdenum (Mo). The amounts of these nutrients can vary depending upon many factors including the age and diet of the flock, as well as the moisture content and age of the manure (Amanullah *et al.,* 2010).

2.7 Types of Poultry Manure

There are different types of poultry manure such as deep litter manure, broiler manure, cage manure and high-rise manure (Mohamed *et al.*, 2010).

2.7.1 Deep litter poultry manure

This refers to the manure produced by layers, broilers, cockerels etc. during the laying period. Deep litter for chickens usually consists of peanut hulls, rice husk or wood shavings in a layer 10-15 cm deep. During production, the accumulating manure gets mixed with the litter. When excreta are added, the litter becomes moist but remains aerobic. Aerobic fermentation occurs with the production of heat and loss of CO_2 and ammonia (Preusch *et al*., 2002).In this system, the poultry birds are kept in large pens of up to 250 birds each, on the floor covered with litter materials like straw, and sawdust or leave up to a depth of 20.32cm-30.45cm.. Suitable dry organic materials like sawdust, leaves, dry grasses, groundnut shells, broken-up maize stalks and cobs, and bark of trees in sufficient quantity to give a depth of about 6 inches in the pen should be used. The droppings of the birds gradually combine with the materials used to build up the litter (Preusch *et al.*, 2002). Deep litter and broiler manure have almost no difference, except broiler manure is changed more often and thus the loss of ammonia is reduced due to organic decomposition (Benjamin, 2019).

2.7.2 Cage manure

This manure contains 60-70% moisture since it is not mixed with litter materials. Litter is often not used when birds are used in cages or slots. Enormous loss of ammonia occurs in this manure if it is not used the earliest because of the high humidity of the resulting litter due to a lack of ground litter materials (Amanullah, 2010).

2.7.3 Deep pit or high-rise manure

The deep pit solid manure system, or high-rise building, has a concrete floor and masonry or concrete side walls and is typically constructed 0.61-1.83m below the ground. Pens or cages are then built on slotted flooring 2.44m or more above the pit floor. Because the pit is often built below ground level, care must be taken to ensure that surface and groundwater are not contaminated. Foundation drains and external grading to direct surface water away help to keep manure dry so that natural composting might occur. High rates of air movement from mechanical fans located in the pit help to keep the manure relatively dry. A benefit of the deep pit system is that manure can be stored for several months before removal pit (Overcash *et al*., 1983).

2.8 Nutrient Content in Poultry Manure

The chemical composition of poultry manure varies because of several factors such as the source of manure, feed of animals, age and condition of animals, storage and handling of manure and litter used (Mohamed *et al*., 2010). Nutrient values of poultry manure vary considerably depending upon the conditions under which it is processed. The ratio of litter to manure and the moisture content causes considerable variation among manures from different houses. In fresh poultry excreta, uric acid or urate is the most abundant nitrogen compound (40-70% of total N) while urea and ammonium are present in small quantities. The nutrient content of different types of poultry manure is furnished in Appendix II.

2.9 Nitrogen Content of Poultry Manure

Uric acid and urea are the predominant forms of organic nitrogen in poultry litter, comprising about 70% of its nitrogen content (Nahm, 2003). Uric acid excreted by poultry is rapidly degraded to urea and then ammonia by uricase and urease enzymes produced by litter microorganisms (Nahm, 2003). Urease-producing bacteria may be present in poultry litter at a concentration of 6 to 8 Logcfu/g (Rothrock *et al.*, 2008). The poultry litter is influenced by temperature, moisture content and pH, (Elliott and Collins, 1982). Elliott and

Collins demonstrated that elevated temperatures in poultry houses accelerated ammonia production and volatilization.

2.10 Microbial Composition in Poultry Manure

The chicken litter contains a large and diverse population of microorganisms. Microbial concentrations of chicken litter can reach up to 10^{10}cfu/g, and gram-positive bacteria, such as *Actinomycetes, Clostridia, Eubacteria and Bacilli/Lactobacilli* account for nearly 90% of the microbial diversity (Bolan *et al.,* 2010). Pathogens in chicken litter represent the major group of bacteria of special interest to litter processors. A variety of pathogens can be found in chicken litter or chicken litter base organic fertilizers such as Bordellia, comply lobacter, *E. coli, Listeria, Salmonella* e.t.c (Bolan *et al.*, 2010; Lu *et al.*, 2003; Stern *et al.*, 2003) while different microbes display different metabolic activities within the litter environment, high level background microflora may interfere with the survival and growth of pathogens in chicken litter.

2.11 Reuse of Poultry Waste

Intensive livestock production systems cause serious problems in waste management. The problem arises due to feeding animals huge amounts of high-density nutrient concentrates, plant biomass, and agro-industrial by-products. The concentration of large inputs in small areas results in unfriendly environmental issues regarding animal waste management. Komolafe and Sonaiya (2014) noted that since most of the livestock waste was produced in confinement units, the nearby land base became readily available to accommodate the waste in an environment-unfriendly manner. With the intensification of livestock production, manure has been viewed as a waste product in need of disposal as opposed to a source of fertilizer for integrated cropping and livestock production systems (McAllister *et*

***al*., 2011). Poultry waste (PW) is predominantly solid; which includes the faecal and urinary wastes, bedding material, wasted feed, feathers and non-degradable materials. Poultry industry wastes are non-consumables to humans but could be recycled and become consumables to livestock, thus entering the human food chain. Poultry waste is not a product of uniform quality (USEPA, 2000).

Pickard (2006) observed that recycling available nutrients for reuse in animal production rather than for disposal would go a long way in reducing the final volume of animal wastes released into the environment. In addition, effective use of animal waste resources might provide a partial, but still important, contribution to reducing net carbon (iv) oxide (CO_2) emissions (Ceotto, 2005). Earlier reports on PW processing as animal feed were based on individual waste being dehydrated by air-drying, oven-drying, autoclaving; sun-drying (Saleh *et al.,* 2002); composting and pelleting (Edens *et al.*, 2007). These methods require the skill or the technical know-how or high capital outlay making them not feasible for small-medium scale farmers. In addition, Ghaly and Alhattab (2013) reported that heating and drying processes are more efficient than deep stacking or fermentation in killing pathogenic bacteria. Processing litter by either air-drying, oven drying or autoclaving was not satisfactory for the control of odour, pathogens and nitrogen loss. On the other hand, sun drying may be have low-cost investment, but its resultant product is of low quality due to repeated wetting and re-drying, contamination from dust, birds and animals is a major disadvantage. The future success of the livestock sector in providing meat and other animal products may depend on the utilization and acceptability of animal waste by the major stakeholders as useful input recycled into the industry. This will bring economic benefits and support the efforts to reduce environmental degradation (Pickard, 2006).

2.12 Poultry Dropping used as Ruminant Feed

Poultry dropping, although not aesthetically pleasing, has been recognized as a safe, nutritionally valid and environmentally friendly animal feed, especially when combined with other feed sources as supplements. It refers to pure excreta from layers in batteries and poultry litter to the mixture of excreta and bedding material obtained largely from broiler houses and also from houses where pullets and layers are kept on deep litter systems. A small amount of feed spillage may be present in the material (Van Ryssen, 2015).

2.13 Uses of Poultry Droppings to Non-Ruminant Animals (Poultry)

In poultry diets it has been found that dried poultry manure can be included up to 5% for broilers, up to 20% for Leghorns and up to 40% for layers without adversely affecting production; however, feed efficiency was inversely proportional to the amount included in the diet. No difference in the performance of young pullets and layers when sun-dried poultry waste was compared to oven-dried (Coligado *et al*., 1982). The frequency of collection of broiler litter was not found to affect intake or digestion in cattle that it was fed (Wang *et al*., 1998). The high ash content of poultry litter needs to be considered when using it in the formulation of diets. Aflatoxin content was reduced in poultry litter when it was deep stacked (Jones *et al*., 1996). Poultry litter was found to be a viable supplemental crude protein source for broilers (Bagley *et al*., 1996). As the level of poultry dried waste increased (10 to 30 %) in the diets of broilers there was a decrease in body weight gains and feed conversion (Martin *et al*., 1985).

2.14 Uses of Poultry Manure to Crops

Land application of poultry manure to crop and forest land is an effective way of recycling the nutrients back into the land. There are some key steps to utilizing manure in an environmentally and economically sound manner:

i. Know the available nutrient content of the manure.
ii. Know the nutrient needs of the crop, and apply the manure at the correct rate and time to provide the nutrients using application and conservation practices.
iii. Movement of the nutrients from the field adjusts the use of supplemental fertilizer to compensate for the nutrients applied in the manure.

Applications of manure as a crop nutrient source may provide a portion, or all of the plant nutrient requirement, dependent on the rate of application and the relative content of the nutrients. Application rate decisions are usually based on either the nitrogen or the phosphorus content of the manure and environmental concerns are typically based on the amount of nitrogen, phosphorus, zinc, copper, or arsenic added to the soil.

Knowing the nutrient content of poultry manure is critical to using it as a crop nutrient source. Not knowing the nutrient content of the manure to be applied can result in large errors in application rate -- either too much or too little.

2.15 Poultry Droppings as Feed for Fishes

Poultry manure is a potential source of protein. It has attracted the attention of animal nutritionists all over the world because of its richness of protein (21 %), calcium (5.4 %), phosphorus as K_2O and magnesium as MgO (0.335 %) other minerals (SPFG, 1994).

Recently, fish farmers especially in the integrated farming system have been encouraged to recycle wastes from animal dung (especially poultry) as food for fish rather than discard them. Poultry manure is not only used as organic manure in the production of plankton but also directly consumed by fish in the culture system. Although this observation has been verified by many workers (SPFG, 1994), information on the effect of dung when incorporated into artificial fish diets is scarce. (Adewumi, 2011).

2.16 Poultry Waste as a Source of Protein

One of the main factors that contribute today to maintaining the quality of the environment is the use of by-products of animal origin, so it is a priority to look for alternative nutritional sources that reduce costs without adversely affecting production. Agro-industrial activities generate waste that can be reincorporated into the food chain, after physical-chemical treatment (Castañeda *et al*., 2010).

Within the last report made by INEGI-Mexico (2010), it was analyzed that the livestock products (Appendix I) obtained from cattle reported an annual production of 665 thousand tonnes/year, mainly in some regions where livestock is practised, in the intensive type of production; a part of the byproducts obtained is destined for export, mainly due to the high quality of the product (Abdul-Kalil *et al*., 2006). The pigs are produced in 28 states of the country through intensive and extensive farms; as well as 500 thousand tonnes of by-products of this species, which are used annually for national consumption. Concerning sheep and goats, the average national production is 10,000 and 11,000 tonnes/year respectively, in this case, the farms are extensive and they are carried out in 28 of the 32 entities of the country; there is only a slight deficit in the production of goats, which is covered by the import. The national production of consumer birds represents 30,000 to

40,000 tonnes/year, being one of the most technified in the country. Most of these farms are located in areas close to urban centres that consume most of this product (Gutiérrez *et al*., 2013). On the other hand, the existing deficit in the production of grains and the relative abundance of agricultural waste, make these along with other organic waste and livestock by-products become an acceptable and low-cost nutritional alternative that can be used in the feeding of ruminants as a source of non-degradable protein in rumen (Gómez, 2006). An answer to this situation is found in the poultry industry, which is the source of a great miscellany of by-products with an enormous nutritional potential, which is evident as long as the transformation technologies applied propitiate the bioavailability of its nutrients. Thus, the use of organic waste generated by this industry can contribute to the nutrient reduction cost in balanced feed for the preparation of ruminant diets (Ockerman and Hanen, 2005).

2.17 Fermentation

Fermentation is one of the oldest and most important traditional food processing techniques. Food fermentation involves the use of microorganisms and enzymes for the production of foods with distinct quality attributes that are quite different from the original agricultural raw material. Fermentation is the process of souring food used for many centuries by mankind as a means of processing and persevering foods. Most of the fermentation processes used are spontaneous. They occur without any deliberate effort to control or influence the reaction (Maud, 1990). There are two main applications of fermentation in animal feeding. The first is the preservation of feeds in the best possible nutritional condition for use when the original fresh material is not available (Ruurd, 2021). The second application is the enhancement of the nutritional value of feeds either by fermenting the feedstuff or by fermenting other materials that may be used as additives to supplement the original feed. The fermentation extends shelf life, inhibits spoilage and pathogenic microorganisms, imparts desirable sensory qualities, and improves nutritional value or digestibility (Harris *et al.*, 1995).

2.17.1 Anaerobic fermentation

Wastes are unwanted resources (Mukhtar *et al*., 2002). The broiler litter is a by-product resulting from the periodical cleanout of poultry production facilities. One possible alternative use of poultry litter is an economical source of energy for space heating or power generation either through combustion, gasification, co-firing, or pyrolysis (Keener *et al*., 2005; Kelleher *et al*., 2002; Mukhtar *et al*., 2002; McMullen *et al*., 2004; Lopez *et al*., 2005). The gasification of poultry litter or other organic feedstock may be accomplished either through a thermal or a biological process. The major advantage of thermal gasification is its ability to achieve total conversion of organic matter at rapid rates, but its limitation is the energy requirements related to the evaporation of moisture of the feedstock to achieve high temperatures. On the other hand, biological gasification or anaerobic digestion takes place at relatively low temperatures in wet or dry (diluted) feedstock but usually results in only 50% conversion of organic solids at significantly slower rates than those of thermal gasification (Chaynoweth and Isaacson, 1987). Anaerobic digestion of poultry litter yields a more stable product, removal of nuisance odours, maintaining the fertilizer value of the manure, and the production of a valuable fuel, methane (Kelleher *et al.*, 2002). Another benefit is that flies, rodents, and other vectors of disease are not attracted to the stabilized product from the digestion process. Another great benefit of anaerobic digestion is the reduction in pathogens. *Salmonellae*, faecal coliforms, oocysts

(*Eimeria tenella*), and fungal spores are all either greatly destroyed or inactivated in the anaerobic process. The thermophilic reactors tend to have greater pathogenicity reduction rates (Przemysław *et al*., 2020). As with most anaerobic digestion systems, the largest barriers to large-scale implementation are the high initial costs of an anaerobic reactor and the often unpredictable stability of the process (Kelleher *et al.*, 2002). The fuel potential of poultry litter and its economics are well documented by Reardon *et al.* (2001) and Ward (2003). Although the technology for anaerobic digestion of dairy and swine waste is commercially established and intensively researched (Demirci and Demirer, 2004), "none of the large scale anaerobic digestion plants worked as well as might have been predicted for poultry litter" (Callaghan *et al*., 1999). No previous review on the anaerobic digestion of poultry litter was found in the literature, and consequently, this review's scope requires that it contain successes and failures from the beginning of the implementation of this technology.

2.18 Nutrient Requirement of Broiler Chickens

The poultry can easily change feed into meat within the shortest possible time, competently and using less environmental influence in comparison with other domestic animals. The high nutrient requirements of the birds lead to a high rate of productivity. Poultry needs the availability of no less than thirty dietary nutrients in appropriate balance and concentrations (Kirk, 2018). The nutrient necessities of poultry are more accurately clear than those of other livestock as a result of their specific condition and the nature under which they are produced (Mbajiorgu, 2010).

2.18.1 Energy requirement of broiler chickens

The feed-taking and energy desires of birds differ by the temperature of the environment and the rate of action. Energy obtained through the feed supplied can be utilized by the animal, to provide body maintenance, egg production, growth, and important functions of the body along with its activities (John, 2008). Mainly, broilers chickens feed to acquire energy. Feed that gives energy to broilers can be adjusted to meet up with daily requirements.

By Aduku (2005) the energy necessary for broiler starter chickens is 2800 kcal/kg whereas for broiler finisher is 3000 kcal/kg, but Olomu (1995) suggested 2500 kcal/kg for broilers at the age of 0-28 days, as the standard recommended by NRC (1994).

2.18.2 Protein requirement of broiler chickens

The protein needed for a broiler at 0-4 weeks of age is 23% whereas that of the broiler at 5-8 weeks of age is 20% (Aduku 2005). Kekeocha (1985) indicated that 15% to 20% recommended for the finishers and 21% to 24% for the starter chicks. Protein requirements for poultry are truly requirements for the amino acids in the protein content of the diet. The Amino acids in the protein are utilized by birds to accomplish different functions such as feathers, skin, ligaments and bore matrix as well as the soft tissues, muscles and organs (NRC, 1994). The requirement of protein is critical in meeting the requirements of amino acids of the poultry which differs in the performance of the poultry as demonstrated by Nemovhola (2001).

2.18.3 Fats requirement of broiler chickens

When fat is been included in the diet of broilers, it can enhance the energy level along with increased output and feed effectiveness (NRC, 1994). Various sources of fat are animal carcasses, Vegetable oil and also from food leftovers.

2.18.4 Minerals requirement of broiler chickens

The report from NRC (1994) showed that minerals can be referred to as inorganic elements of tissues or feeds. These minerals are always classified into two types according to the quantity that is needed. Necessities for macro minerals are more often than not acknowledged as a percentage of the feed, while trace minerals requirements are indicated as mg per kg of the feed. Minerals are required for the development of the skeleton, for the osmotic balance within the body and co-factors of enzymes. Phosphorus and Calcium are necessary for the development and for maintaining the skeleton of the body while magnesium, sodium, sodium chloride, and potassium are considered necessary for body pH and osmotic relationship. The calcium needed for meat-type birds to be as 0.80% for (6-8 weeks) while 1.00% (for 0-3 weeks). The recommended percentage for potassium is 0.30% for broiler chickens, values for sodium chloride are 0.20% and 0.12% for broilers at the age of 0-4 weeks and 5-8 weeks respectively. Arbor (2009) recommended 1.05% calcium and 0.85% phosphorus for inclusion in broiler diet formulation. Likewise, Aduku (2005) suggested phosphorus and calcium to be 1.0%, while Olomu (1995) indicated magnesium oxide 0.01 – 0.3%.

2.18.5 Vitamin requirement of broiler chickens

Vitamins are natural substances that are wanted in minute quantity in the body in order to improve chemical activities. The Vitamins are usually divided into two: Water-soluble vitamins (C and D) and Fat soluble such as vitamins A, D, E, and K (NRC, 1994). Vitamins boost health status and growth, they are vital in most functions of the body which include growth, egg production and feathering in poultry.

2.18.6 Water requirement of broiler chickens

The provision of uncontaminated and cool water free of high concentrations of minerals and other potentially poisonous substances to birds at all times is very necessary. Water is fundamental for the productivity and growth of poultry. Some of the factors that deprive birds of taking water are; relative humidity, environmental temperature, and protein and salt concentration of the diet. The denial of water for a long period has negative effects on the growth of starters and egg production in layers. The increase in environmental temperature raises the rate of water intake (Aduku, 1992).

2.16.7 Meat quality characteristics

Meat quality is usually defined as a measurement of attributes or character that determines the suitability of meat to be eaten as fresh or stored for a reasonable period without deterioration (El-Masry *et al*., 2012). The quality of meat can be affected by several factors such as the genetic propensity of the animal, how the animal was reared, the age of the animal and the nutritional status during production. These factors are known to affect the fat, lean and connective tissue components of meat and therefore influence meat quality. The conditions at the slaughterhouse also influence meat quality. The way and manner in which animals are handled pre-slaughter affect *rigour mortis*. Similarly, applying electrical stimulation and how the carcass is chilled influence the rate of rigour mortis and subsequent meat quality.

2.18.7 The economy of feed conversion in broiler chickens

Very little information is available on the economic value of using poultry waste as feed ingredients in broiler diets. Jacob *et al*. (1971) reported that the economic aspect of producing dry poultry waste and inclusion in poultry rations requires a great deal of study Nonetheless, several workers have stressed the need to find alternative ways of reducing dehydration costs involved in drying poultry waste.

The greatest proportion of broiler production is accounted to feed, it has a direct impact on farm production levels are lower than broiler requirement production efficiency is negatively and significantly altered. Given diet with a higher nutrient level above the requirement will improve performance due to the higher cost of those diets, there will be economic losses. Josephine (1987) reported that 1.0% of oven-dried poultry waste appears to be the economical maximum limit of inclusion in the broiler diet. Malik *et al.* (2020) reported that the feed conversion ratio at the higher phase should not exceed 20% of non-conventional raw material (cowpea, milling waste, plantain peel meal) for optimum economy and also reported that the starter phase the same dietary inclusion for good economy feed conversion can be containing 30%. Cunningham and Lia (1974) reported on the effect of different dietary levels of dry poultry waste on broilers, he noted that feed conversion ratios indicate that dried poultry waste was lower in energy than he had estimated in formulating the rations. (ME 750 kcal/kg) which agrees with Rinehart *et al.* (1973), that dry poultry waste at high levels has limited value for broilers.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The experiment was conducted at the Animal Unit of the Teaching and Research Farm of the School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Gidan Kwano Campus. The experimental site lies in the Guinea Savanna Zone of North Central Nigeria on Latitude 9.5248^0 35'N and Longitude 6.4344^0 33'E. The average minimum temperature is 23^0C and the maximum average temperature is about 27.5^0C. (FMSN, 2015).

3.2 Collection and Preparation of Sample

3.2.1 Preparation of supernatant decanted solution.

Five kilogramme of maize (*Zea mays*) was cleaned and soaked in 6 litres of tap water in a bowl for three days. It was decanted and the grains were wet-milled before sieving with a muslin cloth and allowed to sediment. The impurities were discarded the starch suspension was allowed to sediment and the supernatant water was collected and used for fermentation.

3.2.2 Determination of pH

This is the measure of the degree of acidity and alkalinity of the supernatant decanted solution sample. A pH ranging from 1.0 to 6.0 indicates increasing acidity, 8.0 to 14.0 shows increasing alkalinity while a pH of 7.0 means neutral. Generally, the pH of supernatant decanted solution ranges from 4.0 to 6.0. The value was determined using a portable pH meter.

3.2.3 Preparation of fermented poultry droppings

The poultry droppings (PD) were sourced from a battery-caged poultry house within the Minna metropolis. The test material was sieved using a metal sieve with a mesh size of 5mm^2 to remove caked material and unwanted items such as feathers, metal objects, stones, etc. It was sun-dried, according to the method of Couch (2007) by allowing the wet samples to be air-dried under an open environment, while a modified fermentation process was equally adopted, and fermented using supernatant decanted solution (SDS) in the ratio of 5 kg of the poultry droppings to two litres of supernatant decanted solution with variation in the time of fermentation (24 hours, 48 hours, 72 hours and 96 hours) for T2, T3, T4, T5 respectively to produce fermented poultry droppings (FPD). A sample of the fermented poultry droppings was taken for biochemical analysis. After fermentation, it was again sundried for laboratory analysis for its proximate composition. Proximate analysis was carried out at the Department of Animal Production Laboratory, Federal University of Technology Minna to analyze for crude protein, crude fibre, ether extract and ash, Nitrogen free extract was calculated using the equation. NFE =100 - %CP+ %CF+ %EE+ %ASH. Metabolizable energy ME was calculated using the Pauzenga (1985) equation: ME (Kca/kg) = (35 x % CP) + (81.8 x % EE) + (35.5 x % NFE).

3.3 Laboratory Analysis of Fermented Poultry Droppings

Proximate analysis of the fermented poultry droppings was carried out at the Animal Production Laboratory, Federal University of Technology Minna, Niger State, Nigeria, following the procedures of AOAC (2000). Vitamins and Minerals were determined using atomic absorption spectrophotometer (Buck, 210 Model) at the Central laboratory of the Federal University of Technology Minna. While phosphorus was determined by automatic colourimetric according to the methods outlined by (AOAC, 2000). The phytochemical examination was carried out using the standard methods of Sofowora (1993) at the Department of Animal Production Laboratory, Federal University of Technology Minna.

3.4 Experimental Design

A completely randomized design was used. A total of 150-day-old chicks were used. Experimental birds were divided into five treatments, with 30 birds per treatment and were replicated three times with 10 birds per replicate.

3.5 Experimental Diets

Five experimental diets labelled T1, T2, T3, T4 and T5 were formulated to be isonitrogenous (22% CP) and isocaloric (2850kcal/kg, ME), where the fermented poultry dropping were included at 0, 5, 5, 5 and 5% for the 5 treatments, respectively. The diets were formulated to meet the nutrient requirements of broiler starter chicks as outlined by Oluyemi and Robert (2002), in a single phase feeding regime. The composition of the experimental diets is presented in Table 3.1.

3.6 Experimental Birds and their Management

A total of 150-day-old Olam broiler chicks were used for the experiment. On arrival, the birds were weighed and randomly allocated to the diets. All experimental birds were given feed and water *ad libitum.* The experiment lasted for 8 weeks. At the start of the experiment, the birds were allowed one week of acclimatization before the commencement of data collection. Similarly, they were administered vaccines as described by Oluyemi and Robert (2002).

Table 3.1: Gross Composition of the Experimental Diets and Calculated Nutrients

Ingredients (kg)	T1	T2	T3	T4	T5
Maize	58.93	54.09	54.12	54.31	59.09
Groundnut cake	29.07	28.91	28.88	28.69	23.91
Fish meal	3.00	3.00	3.00	3.00	3.00
Poultry dropping	-	5.00	5.00	5.00	5.00
Maize bran	5.00	5.00	5.00	5.00	5.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis					
Calcium	0.08	0.07	0.67	0.69	0.71
Phosphorus	2.15	1.43	1.39	1.39	1.37
Lysine	2.1	2.3	2.3	2.3	2.3
Methionine	1.6	1.6	1.5	1.6	1.7
Ether Extract	3.82	3.96	3.96	3.94	3.54
Crude Fibre	4.45	4.66	4.68	4.65	4.43
Crude Protein	22.08	21.66	21.72	23.11	23.45
ME (Kcal/kg)	2963.03	2911.05	2911.29	2912.80	2950.65

Each 2.5kg contains Vit. A- 10,000,000iu, Vit. D – 2,000,000iu, Vit. E- 20,000iu, Vit. K- 2,250mg, thiamine – 170mg, riboflavin – 5,000mg, Pyridoxine – 2,750mg, Niacin – 27,500mg, Vit. B12 – 15mg, Pantothenic acid – 7500mg, Folic acid – 7,500mg, Biotin – 50mg, Manganese – 80g, Zinc – 50g, Copper – 5g, Iodine – 1.5g, Selenium – 200mg and Cobalt – 200mg, FPD – Fermented Poultry Droppings, T1 (0 %), T2 (5 % FPD, 24Hr Fermentation), T3 (5 % 48Hr Fermentation), T4 (5 % 72 Hr Fermentation), T5 (5 % 96Hr Fermentation)

3.7 Data Collection

3.7.1 Growth parameters

Body weight gain: - This was measured as the difference between the final body weight and the initial body weight of the birds divided by the number of birds in each replicate

Feed intake: - The birds were given weighed amount of feeds daily and their corresponding leftovers were weighed and recorded. Daily feed intake was therefore calculated thus using the formula given by Owen *et al*. (2013) as the difference between the amount of feed fed and the leftover as described.

Feed intake (g) = feed given (g) – feed rejected (g)

Feed conversion ratio: - This was calculated as the rate of feed intake to live weight gain using the formula by Mohapatra *et al*. (2014) below:

$$\text{FCR} = \frac{\text{Feed intake (g)}}{\text{Weight gain (g)}} \tag{3.1}$$

Mortality: Mortality record was kept throughout the experimental period and was calculated thus using the formula given by Owen *et al*. (2013)

$$\text{Mortality (\%)} = \frac{\text{Number of bird dead}}{\text{Total number of birds.}} \times 100 \tag{3.2}$$

3.7.2 Apparent nutrient digestibility trial

Digestibility is a measure of the relative amount of nutrient present in the gut of an animal from a known quantity of feed consumed. The total collection method was used and it was conducted at the 8th week of the experiment. Two birds were randomly selected from each treatment, and used for digestibility studies. Droppings were collected after fasting for 12 hours (7.00 pm-7.00 am) in the metabolic cages but allowed access to fresh clean water, after which they were fed the respective diets for four days. At the end of the collection period, the faecal samples collected from each replicate per day were oven-dried at 80^0C until properly dried and recorded. (Mohapatra *et al*., 2014). Samples of the droppings were analyzed for nutrient digestibility using standard methods (AOAC, 2000) and the results obtained were used to calculate the apparent digestibility by using the formula as described by Muazzez (2016) below:

$$\text{Apparent digestibility} = \text{Nutrients intake in feed} - \frac{\text{Nutrients voided in faeces}}{\text{Nutrients in feed consumed}} \times 100 \qquad (3.3)$$

3.7.3 Carcass characteristics

At the end of 8 weeks, two birds per replicate were selected at random and starved for 12 hours to empty their gastrointestinal tract. They were slaughtered, plucked, and eviscerated. The carcass and internal organs (liver, heart, gizzard and intestines) were removed, weighed and expressed as a percentage of live weight as described by Muazzez (2016).

3.7.3.1 Meat quality characteristics

The method of El-Masry *et al*. (2012) was adopted to evaluate meat quality characteristics with specific reference to meat pH, hot carcass yield and sensory properties.

3.7.3.2 pH

This is a measure of the degree of acidity or alkalinity of the meat sample. A pH ranging from 6.0 to 1.0 indicates increasing acidity, 8.0 to 14.0 shows increasing alkalinity while a pH of 7.0 means neutral. Generally, the pH of meat ranges from 5.2 to 7.0. The values were determined twice using a portable meat pH meter (Hanna H199163) after slaughtering.

A proportion of 10g of meat was blended with 90ml of distilled water for two minutes. The pH meter was then inserted in it and the value was recorded using the method described by Bowker and Zhuang (2015).

3.7.3.3 Hot carcass yield weight (HCW)

Hot carcass weight is the unchilled weight of the carcass after slaughter. It was determined after the head, intestinal and internal organs of the chicken had been removed. This parameter was used to determine both the yield grade and dressing percentage. Two birds per treatment were selected to determine this parameter. This was done in line with the procedure as described by Barbera and Sonia (2006).

$$\text{HCW} = \frac{\text{Dressing percentage}}{\text{Live weight}} \times 100 \qquad (3.4)$$

3.7.3.4 Sensory properties of meat

This parameter determines the overall acceptability of the nearby consumers. About 100g of lean meat was taken from the breasts of the birds in each replicate. These meat samples were boiled at 80 ^{o}C for 30 minutes in water with salt seasoning added and then allowed to cool. A 20-member semi-trained panel of tasters were drawn from the University Community and about 15 g of the boiled meat was served to each one. These evaluations were done according to the method described by Grunert *et al.* (2004). This sensory property was evaluated using a 9-point hedonic scale.

The meat samples given to the panelists were evaluated for their organoleptic properties such as appearance, juiciness, taste, tenderness, flavour, aroma, texture and general acceptability. Bottled water was provided for the panelists to rinse their mouths to reduce carryover effects.

3.7.4 Economic analysis of feeding fermented poultry dropping to broiler chickens

A record of all expenses for the purchase of feed ingredients was kept throughout the experimental period and the cost-benefit was calculated, this was done in line with the procedure as described by Banrie (2013).

$$\text{feed cost per unit gain} = \frac{\text{Feed cost}}{\text{Unit gain}} \tag{3.5}$$

3.8 Data Analysis

All data obtained from the experiment were subjected to One Way Analysis of Variance (ANOVA) using SPSS 2016 version where significant differences were observed, the means were separated using Duncan's Multiple Range Test (Duncan, 1955) described by Steel and Torrie (1980). The results were interpreted based on the outcome of the statistical analyses.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

4.1.1 Proximate composition of differently processed poultry droppings

The results in Table 4.1. shows the proximate composition and calculated energy values of the experimental diets, from the Table it was shown that dry matter ranged between 93.67 (T2) to 94.67 % (T1), similarly the crude protein values were between 21.66 (T1) to 23.42 % (T4), crude fibre ranged from 17.98 to 18.42 % (T2), ether extracts were between 02.04 (T2) to 02.18 % (T3), ash values varied from 06.98 to 07.31 % (T4). On the other hand, the calculated nitrogen free extract values ranged from 42.94% (T4) to 45.47 % (T1) respectively. The metabolizable energy was between 2837.30 (T2) to 2875.10 (T1) kcal/kg across the treatments.

4.1.2 Microbial load of fermented poultry droppings

The microbial count of the various fermented poultry droppings is shown in Table 4.2. The bacteria load of the droppings show T2 (2.90 cfu/g) has the highest count and varies significantly ($P<0.05$) when compared to the rest samples with the unfermented dropping having the lowest count of (1.87 cfu/g). However, for the fungal count, a significant $P<0.05$ high value was recorded for T1 (3.22cfu/g) making a significantly different $P<0.05$ when compared to the remaining treatments while T2 and T3 (1.15 and 1.00 cfu/g) respectively.

Table 4.1: Proximate Composition and Calculated Energy Value of Differently Processed Poultry Droppings

Parameters (%)	T0	T1	T2	T3	T4
Dry matter	96.38	94.67	93.67	93.96	93.82
Crude protein	19.91	21.66	21.72	23.11	23.42
Crude fibre	20.13	18.12	18.42	17.98	18.32
Ether extracts	2.53	02.11	02.04	02.18	02.12
Ash	7.85	07.31	06.98	07.04	07.02
Nitrogen	45.93	45.47	44.51	43.65	43.94
Free extract					
ME (kcal/kg)	2861.3	2875.10	2837.30	2866.60	2845.20

T0= poultry droppings unfermented
T1= poultry droppings fermented for 24 hours
T2= poultry droppings fermented for 48 hours
T3= poultry droppings fermented for 72 hours
T4= poultry droppings fermented for 96 hours
Kcal=kilocalorie
Kg=kilogram
ME= Metabolizable energy

Table 4.2: Microbial Level of the Various Fermented Poultry Droppings

Sample	Bacterial cfu/g	Fungi cfu/g
T0	1.87 ± 0.02^{c}	3.22 ± 0.13^{a}
T1	2.50 ± 0.10^{b}	1.05 ± 0.05^{c}
T2	2.90 ± 0.05^{a}	1.15 ± 0.05^{c}
T3	2.90 ± 0.10^{b}	1.00 ± 0.00^{c}
T4	2.50 ± 0.05^{b}	1.35 ± 0.05^{b}

a,b,c Means on the same column with the same superscript sample are not significantly different (P>0.05)
All results obtained were diluted to $x10^{6}$

T0 = poultry droppings unfermented
T1= poultry droppings fermented for 24 hours
T2= poultry droppings fermented for 48 hours
T3= poultry droppings fermented for 72 hours
T4= poultry droppings fermented for 96 hours

4.1.3 Minerals and vitamin contents of fermented poultry droppings

The minerals and vitamin contents of fermented poultry droppings are shown in Table 4.3. The Sodium (Na) content of the samples shows no significant difference (P< 0.05) when compared to each other. While for magnesium (Mg) and calcium (Ca) content of the samples show T0 to be significantly different (P<0.05) when compared to the rest samples with sample T4 having the lowest value (0.69 mg/100g) for Mg and sample T3 (1.06 mg/100g) for calcium (Ca). This trend was also observed for Vitamin A and C, with no significant difference (P<0.05) observed between T0, T3 and T4 when compared to each other respectively.

4.1.4 Proximate composition of experimental diets

Table 4.4 shows the proximate composition of experimental diets. Diet T1 containing no poultry droppings is the control, while diets T2-T5 contained poultry droppings fermented for 24, 48, 72 and 96 hours respectively. The results showed that dry matter values ranged from 90.60 to 92.00 %, crude protein values were between 20.30 (T%) to 21.70 % (T1), crude fibre ranged from 04.31 to 05.50 % (T3), ether extracts were between 05.89 to 08.848 %, ash values varied from 06.32 to 08.14 %, while calculated nitrogen free extract values ranged from 50.40 to 54.11 % across the five dietary treatments. With the increase in the length fermentation period the crude protein content increases.

Table 4.3: Minerals and Vitamin Content of Fermented Poultry Droppings in mg/100g

Sample	Na	Mg	Ca	Vit A	Vit C
T0	1.83 ± 0.02^{a}	1.00 ± 0.02^{a}	1.62 ± 0.13^{a}	0.52 ± 0.13^{a}	1.47 ± 0.13^{a}
T1	1.33 ± 0.00^{a}	0.97 ± 0.01^{a}	1.29 ± 0.00^{a}	0.35 ± 0.00^{c}	1.21 ± 0.00^{b}
T2	1.43 ± 0.02^{a}	0.92 ± 0.00^{b}	1.20 ± 0.00^{ab}	0.62 ± 0.01^{a}	1.01 ± 0.00^{c}
T3	1.41 ± 0.01^{a}	0.71 ± 0.00^{c}	1.06 ± 0.00^{c}	0.43 ± 0.01^{c}	1.11 ± 0.01^{c}
T4	1.41 ± 0.00^{a}	0.69 ± 0.01^{d}	1.21 ± 0.10^{b}	0.34 ± 0.001^{c}	1.10 ± 0.01^{c}

a,b,c,d Means on the same column with different superscripts are significantly different (P<0.05).

T0 = poultry droppings unfermented
T1= poultry droppings fermented for 24 hours
T2= poultry droppings fermented for 48 hours
T3= poultry droppings fermented for 72 hours
T4= poultry droppings fermented for 96 hours

Table 4.4: Proximate Composition and Calculated Energy Values of the Experimental Diets

Parameters	T1	T2	T3	T4	T5
DM	91.80	92.00	90.80	90.60	91.60
CP	21.70	20.25	20.25	21.05	20.53
CF	04.86	04.31	05.50	04.93	05.11
EE	06.84	05.89	06.33	06.08	06.22
ASH	07.28	07.44	06.32	08.14	07.49
NFE	51.12	54.11	52.40	50.40	52.48
ME (Kcal/kg)	3144.62	3121.58	3096.87	3033.82	3092.49

Key

T0 = diet without fermented poultry droppings (control)
T2= diet containing 5 % poultry droppings fermented for 24 hours
T3= diet containing 5 % poultry droppings fermented for 48 hours
T4= diet containing 5 % poultry droppings fermented for 72 hours
T5= diet containing 5 % poultry droppings fermented for 96 hours
DM=dry matter
CP= crude protein
EE= ether extracts
CF= crude fibre
NFE=nitrogen free extract
ME= Metabolizable Energy

4.1.5 Growth performance of broiler chickens fed diets containing fermented poultry droppings

Table 4.5 shows the growth performance of broiler chickens fed diets containing fermented poultry droppings. The average initial body weight (AIBW) ranged between 38.42 g (T3) to 38.44 (T1, T2 and T5) with no significant (P>0.05) differences, average feed intake (AFI) ranged between 3043.30 g (T3) to 3298. 30 g (T2) with no significant (P>0.05) differences, while mortality rate (MRT) ranged between 10.00 % (T1) to 03.33 % (T4 and T5) without any significant differences (P>0.05).

However, there were significant (P<0.05) differences in the values obtained for average final body weight (AFBW), average body weight gain (ABWG) and feed conversion ratio (FCR). Broilers fed a diet containing FPD for 96 hours had the highest average final body weight (1735.50 g), this was followed by those fed a diet containing FPD for 72 hours (1685.50 g), while the lowest value was recorded on broiler birds fed the control diet. (1603.10 g).

The highest average body weight gain (ABWG) was recorded in broiler birds fed diets containing FPD for 96 hours (1697.10 g) (T6) which was statistically similar to that of broiler birds fed diet containing poultry droppings fermented for 72 hours (1647.00 g), and the least average body weight gain (1564.70 g), was obtained in broiler chickens fed the control diet. Broiler birds fed with a diet containing FPD for 48 and 96 hours had the best feed conversion ratio (1.90), which was similar to the efficiency of the broiler birds fed a diet containing poultry droppings fermented for 72 hours (01.94). Broiler chickens fed a diet containing FPD for 24 hours had a feed conversion ratio (2.00).

Table 4.5: Growth Performance of Broiler Chickens Fed Diets Containing Fermented Poultry Droppings

Parameters	T1	T2	T3	T4	T5	SEM	P-value
AIBW (g/bird)	38.44	38.44	38.42	38.43	38.44	00.01	0.79
AFBW (g/bird)	1603.10[c]	1658.60[bc]	1641.40[bc]	1685.50[ab]	1735.50[a]	14.72	0.02
ABWG (g/bird)	1564.70[c]	1620.10[bc]	1602.90[bc]	1647.00[ab]	1697.10[a]	14.72	0.02
ADWG (g/bird)	27.94[c]	28.93[bc]	28.62[bc]	29.41[ab]	30.30[a]	00.26	0.02
AFI (g/bird)	3111.63	3298.30	3943.97	3193.90	3217.57	36.61	0.23
FCR	01.99[ab]	02.04[b]	01.90[a]	01.94[ab]	01.90[a]	00.02	0.05
MRT (%)	10.00	06.67	06.67	03.33	03.33	01.31	0.51
Cost/kg feed	290.21[a]	279.21[b]	279.19[b]	279.10[b]	277.71[b]	01.24	0.01
Cost/kg WT gain	578.22[a]	568.43[ab]	530.20[c]	541.23[bc]	526.27[c]	06.53	0.01

[a, b, c]: Means with different superscripts in the same row differ significantly ($P<0.05$)
T0 = diet without fermented poultry droppings (control)
T2= diet containing 5 % poultry droppings fermented for 24 hours
T3= diet containing 5 % poultry droppings fermented for 48 hours
T4= diet containing 5 % poultry droppings fermented for 72 hours
T5= diet containing 5 % poultry droppings fermented for 96 hours
%=Percentage
AIBW= average initial body weight
ADWG= average daily weight gain
ABWG= average body weight gain
AFBW= average final body weight
AFI= average feed intake
FCR= feed conversion ratio
MRT= mortality rate
SEM= standard error of mean

4.1.6 Nutrient digestibility of diets containing fermented poultry droppings fed to broiler chickens

Table 4.6 shows the result of the apparent nutrient digestibility of broiler chickens fed diets containing fermented poultry droppings. Dry matter digestibility values ranged from 81.06 (T5) to 82.72 % (T3) with no significant (P>0.05) differences, crude protein digestibility values were between 82.40 (T5) to 85.35 % (T1) with no significant differences (P>0.05), crude fibre digestibility ranged from 24.48 (T2) to 46.56 % (T4) with no significant differences (P>0.05), ash digestibility values varied from 26.32 (T3) to 44.06 % (T4) with no significant (P>0.05) differences and calculated nitrogen free extract values ranged from 87.67 (T2 and T3) to 90.62 % (T5) respectively.

However, there were significant (P<0.05) differences in the values obtained for ether extract. Ether extract digestibility was significantly (P<0.05) higher (93.91 %) in broiler birds fed with diets containing FPD for 96 hours, this was closely followed by those fed with diets FPD for 72 hours (93.82 %), and the least ether extract digestibility value was recorded on broiler birds fed the control diet (89.16 %).

4.1.7 Carcass characteristics of broiler chickens fed diets containing fermented poultry droppings

The results of the carcass characteristics of broiler chickens fed diets containing fermented poultry droppings are presented in Table 4.7. From the results, it was observed that the experimental diets had no significant influence (P>0.05) on cut-up parts of economic importance (back, breast, thigh, drumstick and wing). However, there were significant differences (P<0.05) in live weight, slaughtered weight, de-feathered weight, dressing weight and dressing percentage. Broiler birds fed with diets containing FPD for 96 hours had the highest values for live weight (1691.10 g), slaughtered weight (1644.20 g), de-feathered weight (1520.50 g), dressed weight (1115.50 g) and dressing percentage (65.97 %), and the least value for the live weight (1630.60 g), slaughtered weight (1583.20 g), de-feathered weight (1434.00 g), dressed weight (1043.50 g) and dressing percentage (64.08 %), was recorded on broiler birds fed the control diets.

4.1.8 Internal organs of broiler birds fed diets containing fermented poultry droppings

Table 4.8 shows the internal organs of broiler birds fed diets containing fermented poultry droppings. The results showed that there were no significant differences (P>0.05), in the values obtained for gizzard, intestinal weight, heart, liver, lungs, abdominal fat, crop, gall bladder, and proventriculus across the five dietary treatments as expressed in percentage of dressed weight, broiler birds fed with poultry droppings fermented for 96 hours had the highest value for intestine weight (8.35 %) and crop (1.25 %), while those fed diets containing FPD for 72 hours had the highest value for gizzard (2.97 %), liver (2.33 %), abdominal fat (1.83 %), gall bladder (0.23 %), and proventriculus (0.87 %), while those fed control diet (T1) and FPD based diet fermented for 48 hours (T3) had the highest heart value (1.08 %) and lungs (0.69 %) respectively.

4.1.9 Organoleptic properties of broiler chickens fed diets containing fermented poultry droppings

The results of the organoleptic properties of broiler chickens fed diets containing fermented poultry droppings are presented in Table 4.9. From the results, it was observed that the experimental diet had no significant influence (P>0.05) on the colour, appearance flavour and tenderness of the broiler chicken meat. However, there were significant differences (P<0.05) in juiciness, aroma and overall acceptability of the meat samples tasted. The highest values for juiciness were observed on broiler birds fed diets containing FPD for 72 hours (7.00) (T4,) and the lowest value was recorded by broiler birds fed diets containing FPD for 42 hours (6.20). Broiler birds fed with diets containing FPD for 24 hours had the highest aroma value (7.10) while broiler birds fed with diets containing FPD for 48 hours had the lowest aroma value (5.80). Broiler birds fed with diets containing poultry droppings fermented for 96 hours had the best overall acceptability (7.70), this was followed by broiler groups fed with diets T1 and T4 respectively while the low overall acceptability value was recorded on broiler birds fed the control diet (6.50).

4.1.10 Economics of broiler chickens fed diets containing fermented poultry droppings

Table 4.10 shows the cost- of broiler chickens fed diets containing fermented poultry droppings benefit ratio of broiler chickens fed diets containing FPD. The results showed that there were significant (P<0.05) differences in the total feed intake, cost of feed intake, feed cost per kilogram, feed conversion ratios and feed cost per weight gain. The cost per kilogram tends to decrease as the levels of FPD increase, with T1 recording the highest feed cost per kilogram (₦290.21), which decreases progressively with a significant difference (P<0.05). The cost of feed consumed by the birds followed a similar pattern with a significant difference (P<0.05) with T1 recording the highest cost of feed intake (₦904.71) while the least values were obtained in T4 (₦891.41) respectively.

Table 4.6: Apparent Nutrient Digestibility of Broiler Chickens Fed Diets Containing Fermented Poultry Droppings

Parameters	T1	T2	T3	T4	T5	SEM	P-value
DM	81.63	80.23	82.72	81.20	81.06	00.77	0.94
CP	85.35	83.05	83.40	84.38	82.40	00.75	0.84
CF	44.26	24.48	42.16	46.56	29.65	04.06	0.38
ASH	33.92	33.71	26.32	44.06	33.73	03.10	0.61
EE	89.16^{b}	92.07^{ab}	92.69^{ab}	93.82^{a}	93.91^{a}	00.66	0.05
NFE	87.93	87.66	88.67	87.34	90.62	00.55	0.39
TDN	71.82^{b}	70.23^{b}	72.23^{a}	72.95^{a}	71.40^{b}	0.32	0.001

$^{a, b}$: Means with different superscripts in the same row differ significantly ($P<0.05$)

T1 = diet without fermented poultry droppings (control)
T2= diet containing 5 % poultry droppings fermented for 24 hours
T3= diet containing 5 % poultry droppings fermented for 48 hours
T4= diet containing 5 % poultry droppings fermented for 72 hours
T5= diet containing 5 % poultry droppings fermented for 96 hours
%=Percentage
DM=dry matter
CP= crude protein
CF= crude fibre
EE= ether extract
NFE=nitrogen free extract
SEM= standard error of mean

Table 4.7: Carcass Characteristics of Broiler Birds Fed Diets Containing Fermented Poultry Droppings

Parameters	T1	T2	T3	T4	T5	SEM	P-value
Live wt (g)	1630.60^{b}	1649.50^{ab}	1666.30^{ab}	1679.50^{a}	1691.10^{a}	08.40	0.05
Slaughtered wt (g)	1583.20^{b}	1608.50^{ab}	1625.00^{ab}	1638.50^{ab}	1644.20^{a}	08.95	0.05
Defeathered wt (g)	1434.00^{b}	1460.50^{ab}	1478.50^{ab}	1496.50^{ab}	1520.50^{a}	11.31	0.05
Dressed wt (g)	1043.50^{b}	1057.00^{ab}	1093.50^{ab}	1092.50^{a}	1115.50^{a}	10.12	0.05
Dressing %	64.01	64.08	65.64	65.04	65.97	00.37	0.38
Cut up parts (% dressed weight)							
Back	11.92	12.64	12.48	12.31	12.10	00.30	0.97
Breast	22.47	22.85	22.13	22.35	22.18	00.17	0.81
Thigh	14.04	13.91	14.22	13.24	13.62	00.17	0.50
Drumstick	11.11	11.21	10.97	11.59	11.42	00.15	0.79
Wing	12.40	13.14	12.62	12.51	12.46	00.21	0.89

$^{a,\ b}$: Means with different superscripts in the same row differ significantly ($P<0.05$)

T1 = diet without fermented poultry droppings (control)
T2= diet containing 5 % poultry droppings fermented for 24 hours
T3= diet containing 5 % poultry droppings fermented for 48 hours
T4= diet containing 5 % poultry droppings fermented for 72 hours
T5= diet containing 5 % poultry droppings fermented for 96 hours
SEM= standard error of mean

%= percentage
Wt= weight
g= gramme

Table 4.8: Internal Organs of Broiler Birds Fed Diets Containing Fermented Poultry Droppings

Parameters (% of dressed weight)	T1	T2	T3	T4	T5	SEM	P-V
Gizzard	2.39	2.22	2.52	2.97	2.24	0.11	0.15
Intestinal weight	5.80	6.19	6.68	6.72	8.35	0.55	0.76
Heart	1.08	0.94	0.69	0.91	0.85	0.10	0.86
Liver	1.53	2.04	1.92	2.33	1.61	0.17	0.66
Lungs	0.53	0.62	0.69	0.64	0.58	0.03	0.45
Abdominal fat	1.77	1.42	1.46	2.37	1.83	0.30	0.93
Crop	0.33	0.71	0.32	0.59	1.25	0.13	0.08
Gall bladder	0.19	0.18	0.14	0.23	0.22	0.02	0.47
Proventriculus	0.72	0.80	0.64	0.87	0.76	0.03	0.30

T1 = diet without fermented poultry droppings (control)
T2= diet containing 5 % poultry droppings fermented for 24 hours
T3= diet containing 5 % poultry droppings fermented for 48 hours
T4= diet containing 5 % poultry droppings fermented for 72 hours
T5= diet containing 5 % poultry droppings fermented for 96 hours
SEM= standard error of mean
P-V= P value
%= percentage

Table 4.9: Organoleptic Properties of Broiler Chickens Fed Diets Containing Fermented Poultry Droppings

Parameters	T1	T2	T3	T4	T5	SEM	P-value
Colour	5.80	5.90	6.40	6.40	5.80	0.11	0.19
Juiciness	6.30^{b}	6.70^{ab}	6.20^{b}	7.00^{a}	6.50^{ab}	0.10	0.05
Appearance	6.30	5.20	5.90	6.80	6.60	0.13	0.25
Flavour	6.20	6.80	6.50	6.60	6.90	0.13	0.49
Aroma	6.20^{ab}	7.10^{a}	5.80^{b}	6.30^{ab}	6.50^{ab}	0.15	0.05
Tenderness	6.70	6.60	6.60	6.60	6.70	0.12	0.10
Overall acceptability	6.50^{b}	7.00^{ab}	6.60^{b}	7.00^{ab}	7.70^{a}	0.12	0.01

$^{a, b}$: Means with different superscripts in the same row differ significantly (P<0.05)
T1 = diet without fermented poultry droppings (control)
T2= diet containing 5 % poultry droppings fermented for 24 hours
T3= diet containing 5 % poultry droppings fermented for 48 hours
T4= diet containing 5 % poultry droppings fermented for 72 hours
T5= diet containing 5 % poultry droppings fermented for 96 hours
SEM= standard error of mean

Table 4.10: Cost Analysis of Broiler Chickens Fed Diets Containing Fermented Poultry Droppings

Parameters	T1	T2	T3	T4	T5	SEM	P-value
TWG (g/bird)	1564.70^{c}	1620.10^{bc}	1602.90^{bc}	1647.00^{ab}	1697.10^{a}	14.72	0.02
TFI (g/bird)	3111.63	3298.30	3943.97	3193.90	3217.57	36.61	0.23
CFC (₦)	904.77^{ab}	920.92^{a}	849.84^{b}	891.41^{ab}	893.40^{ab}	09.91	0.05
Cost/kg feed (₦)	290.21^{a}	279.21^{b}	279.19^{b}	279.10^{b}	277.71^{b}	01.24	0.01
FCR	01.99^{ab}	02.04^{b}	01.90^{a}	01.94^{ab}	01.90^{a}	00.02	0.05
Cost/kg WTG (₦)	578.22^{a}	568.43^{ab}	530.20^{c}	541.23^{bc}	526.27^{c}	06.53	0.01

Key

$^{a, b, c}$: Means with different superscripts in the same row differ significantly (P<0.05)

T1 = diet without fermented poultry droppings (control)
T2= diet containing 5 % poultry droppings fermented for 24 hours
T3= diet containing 5 % poultry droppings fermented for 48 hours
T4= diet containing 5 % poultry droppings fermented for 72 hours
T5= diet containing 5 % poultry droppings fermented for 96 hours
SEM= standard error of mean

TWG= total weight gain

TFI= total feed intake

CFC= cost of feed consumed

FCR= feed conversion ratio

kg= kilogramme

g= gramme

WTG= weight gain

4.2 Discussion

4.2.1 Proximate composition of fermented poultry droppings

The result of the proximate composition of fermented poultry droppings showed high dry matter of 93.67 to 94.67 %. This is an indication that the fermented poultry droppings were properly dried. Similar dry matter of 90.30 % was reported by Usman *et al*. (2019), for sundried poultry droppings. Crude protein (21.34 %), ether extract (2.61 %), and crude fibre (16.09 %), values reported for sundried poultry droppings reported by Usman *et al*. (2019), were also similar to those observed in this study. However, the nitrogen free extract (21.51 %) value reported by the author was smaller and the ash (28.83 %) value was higher compared to those observed in this study. Variations obtained in the values of nitrogen free extract and ash could be attributed to the sources of the poultry dropping. Dropping from the layer may have higher ash content than broilers and caged may have lower ash content compared to dropping from litter birds because of the litter materials. Also the ratio of the faeces excreta to the litter. The proximate composition values of dry matter (58.80 %), ash (34.90 %), crude protein (16.80 %), ether extract (1.90 %), crude fibre (14.90 %) and nitrogen free extract (26.50 %) reported by Komolafe and Sonaiya. (2014), for broiler litters are not in line with the proximate composition value observed in this study. Variation may be due to fermentation and the higher moisture content of their broiler litter droppings.

4.2.2 Proximate composition of the experimental diets

The proximate composition of the experimental diet showed that crude protein values were between 20.30 to 21.70 % across the five dietary treatments. These ranges were in agreement with the 20 to 22 % and 22 to 24 % recommended by Akinmutimi *et al*. (2018) as crude protein requirements for broilers at both starter and finisher phases.

4.2.3 Microbial loads

There is no doubt that raw materials may contain pathogenic organisms. However adequate processes render the waste free of pathogens or with a much reduced profile of organisms capable of causing disease (Komolafe and Sonaiya, 2014). A collective collection of bacteria and fungi pathogens was carried out in these studies. The microbial load of the various samples shows different counts as the fermentation period proceeds. A microbial count is carried out in order to estimate the level of their presence or contamination. The bacteria/fungi count of the various samples shows (T0) to have the lowest count while T2 appear to have the highest count with a reduction in the bacteria load as the fermentation time increases. The increase in the count at T2 could be attributed to the organism observing the exponential phase (period of rapid growth) (Pepper *et al.*, 2015). This result is in agreement with the work of Josephine Nambi (1987) who reported a reduction in the microbial load of sundried poultry droppings. A similar report was made by Komolafe and Sonaiya (2014) and Adesehinwa *et al.* (2010) on bacteria (cfu/g) of 2.8 $x10^6$ (cfu/g) and a lower fungi (cfu/g) of 1.1 x 10^2 (cfu/g) in caged litters respectively.

4.2.4 Growth performance of broiler chickens fed fermented poultry droppings

As shown in Table 4.3, the observed significant (P<0.05) increase in body weight gain of broiler chickens fed with diets containing fermented poultry droppings may be due to the presence of fermentation enzymes that helps in making positive impacts on the gut health and growth performance (Alshelmani, *et al*., 2017; Zhang *et al*., 2016). It is feasible that at various fermentation periods of poultry droppings, these fermentation enzymes were able to create a harmonious gut environment suitable for the release and assimilation of digestive nutrients necessary to enhance growth. Feed intake of the control group was lower compared to those fed FPD-based diets. A possible reason for differences observed in the average feed intake of broiler birds fed with diets containing fermented poultry droppings over the control group may be due to the fact that fermentation enzyme speeds up the flow of the digesta in the digestive system of broilers (Sundu, 2009). It is not difficult to justify this finding because the digestive tract on heavier broilers is bigger and thus could accommodate more digester (Bamidele, 2022). The result of these findings agrees with that of Obeidat *et al*. (2011), who reported that increasing broiler litter levels in the diet did not reduce feed intake. The feed conversion ratio was significant (P<0.05) better in broiler chickens fed with diets containing poultry droppings fermented for 48, 72 and 96 hours over the control groups. The results are in line with the findings of Uchewa and Onu (2012), who noticed a better feed conversion ratio on broiler birds fed fermented commercial diets over other groups when they evaluated the effect of feeding wet and fermented feed on the performance of broiler chick. The mortality of broiler chicken fed diets containing FPD showed no significant difference among the treatment groups. The mortality per cent of different experimental birds was not affected significantly by treatment (fermented poultry droppings). The non-significant effect of fermented poultry droppings on mortality rate is an indication that fermented poultry droppings employed in this study are not detrimental to the health of the experimental birds. The health benefits associated with fermented foods are often attributed to the bioactive peptides that are synthesized in the microbial degradation of proteins by the bacteria involved in fermentation (Walther and Sieber, 2011).

4.2.5 Apparent nutrient digestibility of broiler birds fed diets containing fermented poultry droppings

Apparent nutrient digestibility of dry matter, crude protein, crude fibre, ash, and nitrogen free extract were not significantly (P>0.05) affected by dietary treatments. Significant (P<0.05) differences observed in ether extract digestibility with broiler birds fed diets containing fermented poultry droppings having significantly (P<0.05) higher values over the control groups be due to the fermentation processes that help in breaking down nutrients in poultry droppings making it easier to digest than the unfermented counterpart (control). Better digestibility recorded among broiler birds fed with diets containing fermented poultry droppings may be due to the fact that fermentation increases the digestibility of proteins and carbohydrates, and the bioavailability of vitamins and minerals (Hwang *et al*., 2017). Fermentation has also been proven to enhance the nutrient digestibility of organic matter, fibre and calcium (Canibe and Jensen, 2012), and the palatability of feedstuff (Shahowna *et al*., 2013).

4.2.6 Carcass characteristics of broiler birds fed diets containing fermented poultry droppings

Carcass and cut-up parts showed the same trend just as the growth performance results. Birds fed diets containing fermented poultry droppings had significantly (P<0.05) higher live weights, slaughtered weight, de-feathered weight, dressed weights and dressing percentage than those fed the control diet. This may be due to the presence of beneficial microbes that help in degrading poultry droppings into protein with increased nutritive value that can easily be utilized by the birds, which will in turn improve broiler chicken growth (Liu *et al*., 2023). However, there were no significant (P>0.05) differences in drumsticks weight percentage, breast weight percentage, back weight percentage, thigh weight percentage and other cut-up parts. It can be said that fermentation of poultry droppings favours breast meat, drumstick, thigh and back which are the choosy parts of broiler chickens. The significant ($P<0.05$) increase observed in the carcass characteristics of the broiler chickens fed fermented poultry droppings-based diets in the current study might be a result of the fact that fermentation may have effectively degraded poultry dropping into a product that provides a better absorption and digestibility of some nutrients such as vitamins and minerals making poultry droppings more digestible to the broiler chickens (Liu *et al*., 2023). This might have promoted a more efficient utilization of poultry droppings by broiler chickens for better carcass yield. According to Powell *et al*. (2014), the nutritional regimen can stimulate the proliferation and differentiation of satellite cells and may increase some cut yields. The results of these findings are consistence with those of Mohammad *et al*. (2018), who reported that increasing broiler litter levels in the diets of layers increases crude protein digestibility. Also, Negesse *et al.* (2007), reported that crude protein digestibility was influenced by increasing broilers litter level in the diet. However, on ether extract digestibility the findings of Mohammad *et al*. (2018), negate the findings of this research, they reported no significant ($P>0.05$) differences. Variation between both results may be due to the fermentation process employed in this study.

4.2.7 Organoleptic properties of broiler birds fed diets containing fermented poultry droppings

Consumers' acceptability of meat products was based on organoleptic (sensory) qualities such as taste, juiciness, colour and aroma (Schivazappa and Virgili, 2020). Consumers' first physical assessment of meat is based on its appearance. This assessment depends on how attractive or otherwise the colour of the meat appears on sighting (Wideman *et al*., 2016). The type of feed given to broiler chickens during the rearing period has been suggested to contribute to the appearance of the meat from such animals which eventually influences consumer's preference for the product (Kim *et al*., 2014). The quality of free amino acid present in animal feed has been suggested to contribute greatly to the flavour and taste of meat from animals (Ma *et al*., 2019). The impressive organoleptic properties observed on broiler birds fed diets containing fermented poultry droppings from this study could be attributed to the presence of free amino acids and their derivatives in the fermented poultry droppings as a result of fermentation (Ma *et al*., 2019).

4.2.8 Economics of broiler chickens fed diets containing fermented poultry droppings

These results showed that fermented poultry droppings could be included in broilers' diets up to 5 % (weight for weight) in gross feed composition. Beyond this level, a continuous reduction in the price of feed per kilogram diet will be obtained. A significant reduction ($P<0.05$) in feed cost per weight gain was observed in broiler chickens fed diets containing fermented poultry droppings when compared with the control and feed price per kilogram reduces as the fermentation period increases. Also, the cost per kilogram weight gain was observed to be lower in broiler chickens fed diets containing fermented poultry droppings over those fed with conventional feed ingredients (control). The variation may be due to the cheaper nature of unconventional feed because most unconventional feed is cheaper and available due to lack of competition. The result of these findings is in line with that of Elemam *et al*. (2019), who reported that cow performance and economic efficiency were improved by consuming diets containing broiler litter. Mohammad *et al*. (2018), also reported that increasing broiler litter levels in the diets of Qizil fattening lambs decreased production costs.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the results obtained on the use of the supernatant decanted solution for fermentation of poultry droppings from this study, it is concluded that:

Feeding of differently timely fermented poultry droppings at 5% (weight for weight) substitution in broiler diets improved broiler chicken's performance such as average feed intake, average body weight gain, feed conversion ratio and average final body weight gain when fermented for 72 and 96 hours respectively.

Similarly, the inclusion of differently processed fermented poultry droppings at 5% (weight for weight) substitution in broiler diets improved the digestibility of crude protein, crude fibre, ether extracts, nitrogen free extracts and ash with better nutrient availability with significant difference ($P<0.05$) on the extract and nutrient digestibility.

The crude protein level increases with an increase in the duration of fermentation. Different time duration of fermenting poultry droppings in broiler diets reduced the cost of feed per kilogram weight which translated into reduced feed cost per weight gain (₦/kg).

5.2 Recommendations

Based on the above conclusions, the following are recommended:

poultry droppings fermented for 72 (T4) to 96 (T5) hours could be used at a 5 % inclusion (weight for weight) level for conventional protein feeding ingredients in broiler chicken production without adverse effects on growth performance, apparent nutrient digestibility, carcass characteristics and cost-benefit ratio.

Further work should be carried out on the effect of feeding fermented droppings obtained from other classes of animal (cattle, sheep and goat) to assess their production and economic benefits.

Further investigation on the effect of fermented poultry droppings on other animals for economic and healthy meat should be carried out.

Increasing the level of inclusion and extending the fermentation period should also be carried out.

5.3 Contribution To Knowledge

The research gave an insight on the effect of fermentation time on the performance of broiler chickens fed a diet containing fermented poultry droppings. The results obtained from the study showed that broiler birds fed fermented droppings at 72 and 96 hours had a better growth performance (1685.50 and 1735.50 g) and dressing weight of 1092.5 and 1115.50 g respectively of broiler chicken when compared with the control diet (1043.50 g). The research has broadened the scope of improving the nutritional content of feed for broilers through fermentation and as well as by reducing the cost of feeding in broiler production. The cost of feed consumed significantly reduced from ₦904.77 in the control (T1) to ₦891.41 and ₦893.40 in T4 and T5 respectively.

Additionally, the cost per kilogramme of feed was also reduced from ₦290.21 for the control (T1) to ₦279.10 for T4 and ₦277.71 for T5. The inclusion of fermented poultry droppings was found to be a cheaper potential source of alternative feed for poultry.

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APPENDICES

APPENDIX A

LIVESTOCK BY-PRODUCTS AND USES

Animal Species	By-products	Use
Commercial flocks	Faeces, viscera, feathers, bones	manure, meal, poultry manure
Bovines	Faeces, milk	Bovine manure, fertilizers, serums
Ovine	Faeces	Ovine manure, fertilizers
Rabbits	Faeces	Rabbit manure, fertilizers
Fishes	Bones, skin	Meal

Source: INEGI-Mexico (2010)

APPENDIX B

NUTRIENT COMPOSITION OF DIVERSE POULTRY MANURES

Particulars	Deep litter manure	Broiler house	Battery cage manure
Total N (%)	1.70-2.20	2.40-3.60	3.63-5.30
Total P_2O_5 (%)	1.41-1.81	2.56-2.80	1.54-2.90
Total K_2O(%)	0.93-1.30	1.40-2/31	2.5-2.90
Fe (ppm)	930-1380	970-1370	790-1450
Zn (ppm)	90-308	160-315	80-172
Cu (ppm)	24-42	27-47	80-172
Mn (ppm)	210-380	190-350	370-590
Ca (%)	0.90-1.10	0.86-1.11	0.80-1.02
Mg (%)	0.45-0.68	0.42-0.65	0.40-0.56

Source: Amanullah *et al.* (2007)