EFFECT OF GRADED LEVELS OF BITTER LEAF (*Vernonia amygdalina*) EXTRACT ON THE PERFORMANCE, HAEMATOLOGICAL PARAMATERS SERUM BIOCHEMICAL AND SOME METABOLITES OF BROILER CHICKENS FED CHIKUN FEED IN MUBI NORTH LOCAL GOVERNMENT AREA OF ADAMAWA STATE NIGERIA

BY

PEACE HARRISON MUNAKUR
(SA/AP/HND/23/002)

DEPARTMENT OF ANIMAL HEALTH AND PRODUCTION, FEDERAL POLYTECHNIC MUBI, ADAMAWA STATE, NIGERIA

AUGUST, 2025

EFFECT OF GRADED LEVELS OF BITTER LEAF (*Vernonia amygdalina*) EXTRACT ON THE PERFORMANCE, HAEMATOLOGICAL PARAMATERS SERUM BIOCHEMICAL AND SOME METABOLITES OF BROILER CHICKENS FED CHIKUN FEED IN MUBI NORTH LOCAL GOVERNMENT AREA OF ADAMAWA STATE NIGERIA

BY

PEACE HARRISON MUNAKUR
(SA/AP/HND/23/002)

BEING A PROJECT SUBMITTED TO THE DEPARTMENT OF ANIMAL HEALTH AND PRODUCTION, FEDERAL POLYTECHNIC MUBI IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF HIGHER NATIONAL DIPLOMA IN ANIMAL PRODUCTION

AUGUST, 2025

DECLARATION

I hereby declare that this work which is titled "**Effect of Graded Levels of Bitter Leaf (*Vernonia amygdalina*) Extract on the Performance, Haematological Parameters Serum Biochemical and Some Metabolites of Broiler Chickens Fed Chikun Feed in Mubi North Local Government Area of Adamawa State Nigeria**". As a result of research effort and findings and to the best of my knowledge and belief that this work has never been submitted to any institution for the award of any certificate and various sources used has been duly acknowledged by the use of referencing.

…………..…………........................ ……..…………….....

PEACE HARRISON MUNAKUR Date

CERTIFICATION

This project entitled "**Effect of Graded Levels of Bitter Leaf (*Vernonia amygdalina*) Extract on the Performance, Haematological Parameters Serum Biochemical and Some Metabolites of Broiler Chickens Fed Chikun Feed in Mubi North Local Government Area of Adamawa State Nigeria**" meets the regulation governing the award of Higher National Diploma in Animal Production of the Federal Polytechnic, Mubi and is approved for its contribution to knowledge and literary presentation.

…………..………….....　　　　　　　　　　……..………….....
Mr. Daniel Teru　　　　　　　　　　Date
(Supervisor)

…………..………….....　　　　　　　　　　……..………….....
Dr. Kubkomawa H. Ibrahim　　　　　　　　　　Date
(Project Coordinator)

…………..………….....　　　　　　　　　　……..………….....
Dr. Raymond Habilu Gapsiso　　　　　　　　　　Date
(Head of Department)

…………..………….....　　　　　　　　　　……..………….....
External Examiner　　　　　　　　　　Date

DEDICATION

I dedicated this research work to my lovely parents for all their care, support and encouragement throughout my study.

ACKNOWLEDGEMENTS

My profound gratitude goes to God Almighty for his blessing and sparing my life up to this point, may he take all praise, honour, glory and adoration. I am highly grateful to my supervisor Mr. Daniel Teru for his tireless effort in ensuring the success and completion of this research work. I also acknowledge the Head of Department Dr. Raymond Habilu Gapsiso and the entire staff of Animal Health and Production Department for their guidance during this experimental work. I also want to appreciate my lovely parents for their love and care and for giving me the opportunity to be trained and achieve my dreams. Finally, I appreciate the efforts of my uncles Late. Cpl. Apagu Anaruwa and wife and Mr. Bzigu A. for their encouragement and support throughout the course of my study and also my friends and relatives, course mates and all well-wishers. I love you all, may the Almighty God bless you abundantly, Amen.

TABLE OF CONTENT

Content Page No.

LIST OF TABLES

ABSTRACT

A study was conducted at the poultry unit in the Teaching and Research Farm of the Federal Polytechnic Mubi to determine the effect of graded levels of bitter leaf extract on the performance, haematological indices, serum biochemical parameters and some metabolites of broiler chicken fed chicken mash. A total of 30 birds at three weeks were used for the study with an average initial weight of 265g. These birds were randomly allocated to 5 treatments and replicated 2 times. Each treatment contained 3 birds each and served as a replicate. The design of the experiment was conducted in a completely randomized design (CRD). Data collected was keyed into the computer and was analyzed using ANOVA (General Linear Model procedure of SAS, 2013) Version 9.4. Where significant difference exists, that was separated using Duncan Multiple Test at 95% ($p<0.05$) probability level. The effect of graded levels of bitter leaf extract on growth performance did not show significant difference ($P>0.05$) on the mean values of initial live weight and final live weight. However, Mean Values of daily feed intake, daily weight gain, final live weight and feed efficiency or feed conversion ratio revealed highly ($P<0.001$) significant difference among the treatments accessed. The mean values of haematological parameters were significantly influenced ($P<0.05$) except for Packed Cell Volume. Haemoglobin and red blood cells count were greatly ($P<0.01$) influenced. The mean values of serum biochemistry parameters and some metabolites were also highly influenced ($P<0.05$) by graded levels of bitter leaf extract except for potassium and sodium which were not influenced ($P>0.05$). However, chloride, albumin, urea, creatinine were highly ($P<0.001$) affected; while total protein and bicarbonate were greatly influenced ($P<0.01$). In general, there was no detrimental effect of graded levels of bitter leaf extract on growth performance, haematological indices, serum biochemistry and some metabolites. Bitter leaf extract should therefore be used by broiler farmers to maximise profit through weight gain, immunity improvement, feed efficiency ratio and reduced cost of production in terms of drug purchase.

Keywords: Performance, Broilers, Serum biochemical, metabolites.

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

Poultry farming plays a vital role in the Nigerian agricultural economy, contributing significantly to food security, income generation, and employment opportunities. Among poultry species, broiler chickens are highly valued for their rapid growth rate, high feed conversion efficiency, and substantial meat yield within a short production cycle (Oke *et al.,* 2021). However, the escalating cost of conventional feed ingredients, coupled with the rising concern over the use of synthetic growth promoters and antibiotics, has prompted a search for natural and cost-effective alternatives that can sustain poultry productivity without compromising animal and human health (Esonu et al., 2006; Nworgu *et al.,* 2014).

Bitter leaf (Vernonia amygdalina), a widely available and underutilized plant in many parts of sub-Saharan Africa, including Nigeria, is known for its medicinal properties and rich phytochemical content. The leaves are traditionally used for treating ailments such as fever, malaria, and gastrointestinal disorders due to their antimicrobial, antiparasitic, and antioxidative properties (Farombi & Owoeye, 2011). The bitter leaf contains bioactive compounds such as flavonoids, saponins, tannins, alkaloids, and terpenoids, which have been reported to enhance immune function and improve blood parameters (Akinmoladun *et al.,* 2007).

In poultry nutrition, the use of bitter leaf extract as a phytogenic feed additive is gaining attention for its potential to improve performance, modulate haematological parameters, and influence serum biochemical indices without the adverse effects often associated with synthetic additives (Oloruntola *et al.,* 2016). The integration of V. amygdalina into poultry diets, particularly at graded levels, may provide a natural alternative for enhancing growth performance, improving feed efficiency, and promoting health status in broiler chickens. This is particularly relevant in areas like Mubi North, Adamawa State, where resource constraints and feed scarcity necessitate the exploration of indigenous plant resources.

Chikun feed, a popular commercial poultry feed in Nigeria, provides a balanced nutrient profile suitable for broiler production. However, enhancing its efficacy through supplementation with natural additives like bitter leaf extract could offer a sustainable strategy to optimize broiler performance while reducing dependence on antibiotics.

Poultry researchers in Nigeria and other parts of sub-Saharan Africa have recently intensified investigations into the effects of *Vernonia amygdalina* on broiler chicken health and productivity. Studies have shown that supplementation of bitter leaf extract in broiler drinking water at moderate levels (50–90 ml/L) significantly improves haematological parameters such as packed cell volume (PCV) and haemoglobin concentration, while reducing serum urea and creatinine levels indicating enhanced metabolic efficiency and reduced kidney stress (Ikugbiyiyi *et al.,* 2024). These findings reinforce earlier suggestions that Vernonia amygdalina may act as a natural growth promoter with additional physiological benefits.

Beyond haematological improvements, *Vernonia amygdalina* supplementation has demonstrated antimicrobial and anticoccidial properties. A recent trial involving broilers experimentally challenged with *Eimeria* spp. revealed that bitter leaf extract at 20 ml/L not only improved weight gain and feed conversion ratio but also inhibited oocyst sporulation by up to 82% (Nwezeh *et al.,* 2025). Such results are significant because they suggest that bitter leaf could reduce the need for synthetic anticoccidial drugs, thus aligning with global calls for reduced antibiotic usage in poultry production.

Moreover, the inclusion of bitter leaf meal in finisher broiler diets at up to 75 g/kg has been reported to enhance live weight and reduce abdominal fat without adversely affecting carcass quality (Oke *et al.,* 2023). In addition, antioxidant studies have shown that bitter leaf supplementation increases activities of key antioxidant enzymes such as superoxide dismutase and glutathione peroxidase, thereby protecting tissues from oxidative stress, especially under challenging tropical production conditions (Oloruntola *et al.,* 2025). These findings collectively highlight the potential of Vernonia amygdalina as a multifunctional feed additive that supports growth, health, and disease resilience in broilers.

1.2 Statement of the Problem

The rising cost of poultry feed and the increasing resistance of pathogens to synthetic antibiotics have posed major challenges to poultry production in Nigeria. Synthetic growth promoters and antibiotics, though effective, have raised concerns due to their residual effects in animal products, which pose risks to public health (Okoli *et al.,* 2014). There is also growing pressure to ban or restrict the use of antibiotic growth promoters in animal agriculture globally. In Mubi North and similar regions, farmers struggle with high input costs and low productivity due to poor feed quality and disease outbreaks. While bitter leaf (Vernonia amygdalina) is readily available and known for its medicinal qualities, its potential as a dietary supplement in poultry production remains underutilized and under-researched.

Moreover, there is limited data on the effect of graded levels of bitter leaf extract on growth performance, haematological and metabolic responses of broiler chickens when fed with standard commercial diets like Chikun feed. Understanding this could provide a scientific basis for its application in poultry feeding systems.

1.3 Objectives of the Study

The General Objective is to evaluate the effect of graded levels of Vernonia amygdalina (bitter leaf) extract on the performance, haematological parameters, and serum metabolites of broiler chickens fed Chikun feed in Mubi North, Adamawa State, while the specific objectives are;

i. To determine the effect of different levels of Vernonia amygdalina extract on the growth performance of broiler chickens.

ii. To assess the influence of graded levels of bitter leaf extract on haematological parameters.
iii. To evaluate the effects of bitter leaf extract on serum biochemical indices in broiler chickens.
iv. To identify the optimal inclusion level of Vernonia amygdalina extract that maximizes performance and improves physiological health without adverse effects.

1.4 Justification of the Study

The increasing demand for antibiotic-free poultry products and the need to reduce feed costs necessitate the use of alternative and natural feed additives. Bitter leaf (Vernonia amygdalina) is abundant, affordable, and contains phytochemicals that have shown potential benefits in enhancing animal health and performance.

Investigating the effect of bitter leaf extract at different inclusion levels in broiler diets will help determine the optimal level that supports growth performance and improves blood and metabolic profiles. This is particularly significant for smallholder farmers in Mubi North and other resource-limited areas who require cost-effective and locally available feed supplements to improve poultry productivity.

Furthermore, this study aligns with global trends toward sustainable livestock production using natural growth promoters. The outcome could contribute to knowledge that supports the integration of phytogenic additives in commercial poultry feed formulations, with practical applications in the Nigerian poultry industry.

CHAPTER TWO
LITERATURE REVIEW

2.1 History and Domestication of Broiler Chickens

Broiler chickens are domesticated birds bred specifically for meat production. The domestication of chickens is believed to have originated from the red jungle fowl (Gallus gallus) in Southeast Asia over 8,000 years ago (FAO, 2010). In Nigeria, modern broiler production began in the 1960s with the introduction of exotic breeds and commercial poultry farming systems. With increased urbanization, population growth, and demand for animal protein, broiler production has become a key aspect of Nigeria's livestock industry (Adene & Oguntade, 2016).

Poultry domestication traces its deep origins to Southeast Asia, where the red junglefowl (*Gallus gallus*) was first tamed approximately 8,000 years ago (Wang *et al.,* 2020). Genomic analyses confirm that this initial domestication occurred around southwestern China, northern Thailand, or Myanmar, with subsequent hybridization involving grey, Sri Lankan, and green junglefowl subspecies as domestic chickens spread across Asia and beyond (Wang *et al.,* 2020; Liu *et al.,* 2024). This multi-origin genetic contribution helped establish the foundation for the wide phenotypic diversity seen in today's commercial broiler and layer lines.

The modern broiler industry, as distinct from general-purpose poultry, emerged in the mid-20th century. The "Chicken-of-Tomorrow" competition in the United States during the 1940s accelerated the formal breeding of meat-type chickens—with strong emphasis on traits such as rapid growth, muscle yield, and feed conversion efficiency (Smith & Dunning, 2023). Pedigree breeding programs launched in the 1950s and 1960s were then integrated into vertically managed operations, ultimately leading to the global dominance of specialized broiler genotypes like Cobb 500, Ross 308, and Arbor Acres by the 1970s–1990s (Smith & Dunning, 2023; Adeyemi & Cole, 2024)[2].

In Nigeria, the adoption of modern broiler genetics began in the 1960s, driven by urbanization, rising demand for affordable meat, and the importation of improved breeds from Europe and North America (Adene & Oguntade, 2016). More recently, Nigerian poultry systems have evolving constraints, including high feed costs, disease outbreaks (notably coccidiosis and Newcastle disease), and limited access to improved day-old chicks (DOCs), which undermine productivity (Abubakar *et al.,* 2020). Contemporary efforts now include deployment of tropically adapted genotypes like Noiler and FUNAAB Alpha to enhance resilience and profitability in smallholder systems (Ajayi *et al*., 2022).

2.2 Breeds of Broiler Chickens

Over the past decade, Nigerian researchers have evaluated the performance of common commercial broiler breeds such as Ross, Cobb, Arbor Acres, Marshal, and Anak under uniform environmental conditions. A study by Joachim et al. (2022) raised all five breeds on identical diets and management; Marshal exhibited the best feed conversion ratio (FCR) while Ross recorded the highest mortality (~34.6%) under similar local conditions. Anak performed well in lymphoid cell indices, suggesting immune resilience (Joachim *et al.,* 2022).

Comparative trials in Minna (Dikko *et al.,* 2023) found that Cobb and Anak strains consistently recorded superior growth performance metrics such as average weekly weight gain and total feed intake compared to Arbor Acres and Marshal when fed a popular commercial diet. Though statistical differences were not significant, Cobb had the best numerical values for most performance indices and highest profitability on that feed plan (Dikko *et al.,* 2023).

The Cobb 500, globally and in Nigeria, remains widely favored for its rapid growth and high meat yield. It reaches 2 kg body weight in approximately 33 days, with excellent FCR. However, concerns have risen over welfare issues such as leg disorders, ascites, and sudden death syndrome due to its fast-growth genetics (Smith & Dunning, 2023; Ross Poultry Group, 2025).

The Ross 308 similarly achieves impressive performance with rapid weight gain (~2.3 kg in 35 days) and strong breast meat yield, particularly in the typical "six-week game." It adapts reasonably well to variable climates, though respiratory and musculoskeletal afflictions are more prevalent under heat stress (Ross Poultry Group, 2025; Ifly2Canada Market, 2024).

Noiler, a Nigerian-developed dual-purpose strain, combines meat and egg production with adaptability to local agroecologies. On-farm trials across multiple zones showed Noiler outperforming other dual-purpose breeds in body weight gain by week 18, delivering up to 214.9% of the weight of indigenous chickens. Its survivability and resilience under smallholder conditions make it particularly attractive for rural farmers (Sorensen et al., 2020; Mosobalaje et al., 2021).

2.3 Importance of Broiler Chicken Production in Nigeria

Broiler chicken production continues to be a critical driver of Nigeria's livestock subsector, meeting an estimated 25–30% of the nation's poultry meat demand (FAO, 2022). Consumption of poultry meat has grown steadily, driven by population growth, urbanization, and increasing awareness of the nutritional benefits of white meat compared to red meat (Akinwumi et al., 2021). Broilers are especially important because they produce tender, lean meat with low cholesterol, aligning with current public health recommendations for healthier diets (Akinwumi *et al.,* 2021).

Economically, the broiler industry contributes significantly to Nigeria's GDP through value-chain linkages that include hatcheries, feed mills, veterinary services, processing plants, and distribution networks (Oladipo *et al.,* 2023). A well-developed broiler sector can reduce Nigeria's dependence on poultry meat imports, conserving foreign exchange and boosting rural economic development. Recent government interventions, such as the Central Bank of Nigeria's (CBN) Anchor Borrowers Programme for poultry farmers, have further highlighted the sector's economic potential (CBN, 2022).

Socially, broiler farming serves as a reliable livelihood option for both rural and peri-urban households. It generates employment for youth and women through farming, processing, and retailing activities (Dikko et al., 2023). Studies indicate that smallholder broiler projects can significantly raise household income levels, improve access to education, and reduce poverty incidence in rural communities (Ajayi et al., 2022).

Broiler production also has important environmental and resource-use implications. Modern broiler breeds exhibit high feed conversion efficiency (FCR ~1.5–1.8), which means they produce more meat per unit of feed compared to other livestock species (Smith & Dunning, 2023). This efficiency reduces the carbon footprint per kilogram of meat produced, contributing to sustainable livestock production goals. Furthermore, poultry manure from broiler farms is widely used as organic fertilizer, improving soil fertility and reducing the need for chemical inputs (Oke et al., 2023).

The sector also plays a strategic role in national food security planning. With Nigeria's projected population expected to surpass 250 million by 2050, the demand for affordable, safe, and high-quality protein will continue to rise. Broiler meat offers a scalable and rapidly renewable protein source that can be produced locally within short production cycles, making it a critical pillar in reducing protein deficiency and achieving Sustainable Development Goal 2 on zero hunger (FAO, 2022; Oladipo et al., 2023).

2.4 Nutrient Requirements of Broiler Chickens

Modern broiler strains such as Cobb 500 and Ross 308 have higher growth potential and thus require precise nutrient formulation to achieve optimal performance. Recent feeding trials in tropical regions show that starter diets containing 22–23% crude protein (CP) and metabolizable energy (ME) levels of 3000–3100 kcal/kg promote maximum early growth, while finisher diets with 18–19% CP and 3200–3300 kcal/kg ME improve carcass yield and feed efficiency (Oladipo et al., 2023). Precision feeding strategies now focus on digestible amino acids rather than total crude protein, with lysine, methionine, and threonine identified as the most limiting amino acids in maize–soybean-based diets (Adeyemi & Cole, 2024).

Energy remains the costliest component of broiler diets, and its balance with protein is critical. Studies have shown that energy levels exceeding 3200 kcal/kg in finisher diets increase abdominal fat deposition without significantly improving growth (Akinwumi et al., 2021). Conversely, insufficient dietary energy leads to poor feed conversion ratios (FCR) as birds compensate by increasing feed intake. Incorporating oil sources such as palm oil or soybean oil in tropical broiler diets has been shown to improve energy density and enhance the absorption of fat-soluble vitamins (Oke et al., 2023).

Vitamin and mineral supplementation remains vital for immunity, bone development, and metabolic functions. In hot-humid environments, higher dietary levels of antioxidant vitamins (especially vitamin E at 200–250 mg/kg) have been found to reduce oxidative stress and improve immune responses in broilers under heat stress (Oloruntola et al., 2025). Similarly, optimal calcium (0.9–1.0%) and available phosphorus (0.45–0.50%) ratios in finisher diets help maximize bone strength while avoiding metabolic disorders such as rickets and leg weakness (Ajayi et al., 2022).

Electrolyte balance, expressed as dietary electrolyte balance ($DEB = Na^{+} + K^{+} - Cl^{-}$), plays a key role in maintaining acid-base homeostasis in broilers, especially in hot climates. Studies recommend a DEB of 250–300 mEq/kg to support feed intake and growth during heat stress (Oladipo et al., 2023). Supplementation with potassium chloride and sodium bicarbonate during peak heat periods has been shown to improve survival rates and feed efficiency (Akinwumi et al., 2021).

Water, though often overlooked in nutrient requirement discussions, is essential for all physiological processes including digestion, nutrient transport, and thermoregulation. Broilers require approximately twice as much water as feed by weight under normal conditions, with intake increasing significantly under heat stress (FAO, 2022). Water quality is equally important, with salinity levels above 1000 ppm and microbial contamination known to reduce performance and increase mortality (Dikko et al., 2023).

2.5 Types of Feeds Available for Broilers

Recent advances in poultry nutrition emphasize precision feeding, where feed composition is closely matched to the bird's nutrient requirements at different growth phases to optimize performance and reduce waste. In Nigeria, the most common commercial feed brands—such as Chikun Feed, Top Feed, Vital Feed, and Hybrid Feed—are formulated according to National Research Council (NRC) standards but often adjusted for local ingredient availability (Oladipo et al., 2023). Feed quality and consistency are critical, as substandard feeds can lead to poor growth rates, high feed conversion ratios, and increased disease susceptibility (Ajayi et al., 2022).

Broiler starter feeds (0–3 weeks) are typically high in crude protein (22–24%) and metabolizable energy (~3000 kcal/kg) to support rapid muscle and organ development. Recent studies in tropical environments show that supplementing starter feeds with probiotics, prebiotics, or phytogenic additives like *Vernonia amygdalina* extract can enhance gut health and early growth performance (Oloruntola et al., 2025). The physical form of feed also matters—pelleted starter feeds have been shown to improve feed intake and body weight gain compared to mash, due to reduced feed wastage and better digestibility (Oke et al., 2023).

Grower feeds (4–5 weeks) are formulated with slightly lower protein levels (20–21%) and increased energy to support skeletal development and muscle growth. Research has shown that optimizing lysine and methionine levels during the grower phase can significantly improve breast meat yield and reduce abdominal fat deposition in fast-growing strains like Cobb 500 and Ross 308 (Adeyemi & Cole, 2024). Some Nigerian farmers also incorporate locally available protein sources—such as groundnut cake, fish meal, and soybean meal—into grower feeds to reduce costs without compromising performance (Akinwumi et al., 2021).

Finisher feeds (6–8 weeks) generally contain 18–19% protein and higher energy levels (3200–3300 kcal/kg) to promote final weight gain and carcass fattening. Studies indicate that feeding finisher diets with slightly higher energy-to-protein ratios in the last two weeks can improve dressing percentage and meat juiciness (Smith & Dunning, 2023). However, excessive energy levels during this phase may lead to undesirable fat deposition, affecting meat quality and consumer preference (Oke et al., 2023).

Feed presentation—whether mash, crumble, or pellet—also influences feed intake and conversion efficiency. Pelleted feeds, while more expensive to produce, often result in better feed efficiency and faster growth rates compared to mash. Crumbles are particularly beneficial during the transition from starter to grower feeds, as they encourage feed consumption without overwhelming young birds (FAO, 2022). In Nigeria, commercial feed producers have increasingly adopted pelleting technology to improve feed utilization, especially for intensive broiler production systems (Oladipo et al., 2023).

2.6 Management Practices for Broiler Chickens

Proper ventilation is a key component of broiler house management, particularly in tropical climates like Nigeria's, where high temperatures and humidity can cause heat stress and respiratory problems. Studies have shown that maintaining adequate air exchange rates (minimum of 0.71 m^3/min per 100 kg of live weight) improves feed intake, weight gain, and survival rates (Oke *et al.,* 2023). The use of fans, evaporative cooling pads, and open-sided houses with curtains are recommended strategies for maintaining optimal airflow and temperature, especially during hot afternoons (Ajayi et al., 2022).

Stocking density also plays a significant role in broiler performance and welfare. Excessively high densities (>12 birds/m^2) can lead to reduced growth, higher FCR, increased mortality, and higher incidence of diseases due to stress and litter moisture (FAO, 2022). Recent Nigerian studies recommend an optimal stocking density of 8–10 birds/m² for fast-growing breeds such as Cobb 500 and Ross 308, balancing productivity and welfare (Oladipo et al., 2023). Lower stocking densities have also been linked to better carcass quality and reduced footpad dermatitis (Smith & Dunning, 2023).

Biosecurity measures have become increasingly important in broiler production, especially with the resurgence of avian influenza outbreaks in West Africa. Preventive strategies such as footbaths at entry points, restricting visitor access, and disinfecting equipment regularly have been shown to significantly reduce disease incidence (World Organisation for Animal Health ((WOAH), 2023). Furthermore, integrating health monitoring systems with vaccination schedules—covering common diseases such as Newcastle disease, Gumboro, and coccidiosis—has been proven to improve flock immunity and overall performance (Akinwumi et al., 2021).

2.7 Types of Housing for Broilers

The choice of housing system significantly influences broiler productivity, welfare, and meat quality. In tropical countries like Nigeria, the deep litter system remains the most widely used due to its low cost and adaptability to local conditions. Recent studies show that, when managed properly with dry litter, adequate ventilation, and regular turning, the deep litter system can yield comparable growth performance to more intensive systems (Oke *et al.,* 2023). However, poor litter management can lead to high ammonia levels, coccidiosis outbreaks, and footpad dermatitis, which negatively impact feed conversion ratio (FCR) and carcass quality (Ajayi *et al.,* 2022).

The battery cage system, though costly to set up, offers better hygiene, reduced disease transmission, and more efficient feed utilization. Research in Nigeria found that broilers in well-managed battery cages recorded lower mortality rates and improved feed efficiency compared to those in deep litter systems (Oladipo et al., 2023). However, animal welfare concerns—such as restricted movement and limited opportunities for natural behaviors have prompted some markets to encourage more welfare-friendly systems (Smith & Dunning, 2023). In addition, battery cages require reliable power supply for ventilation and lighting, which can be a limitation in rural areas.

The free-range system is gaining attention due to consumer preference for "organic" or "naturally raised" poultry meat. Broilers raised under free-range conditions often have more developed muscles and potentially higher meat flavor scores, but growth rates are slower compared to intensive systems (FAO, 2022). A Nigerian study by Musa et al. (2021) found that free-range broilers had lower final body weights but higher profitability in niche markets where consumers are willing to pay premium prices. The system requires secure fencing, predator control, and adequate shelter to protect birds from adverse weather and disease exposure.

2.8 Common Diseases of Broiler Chickens

Respiratory diseases remain a major threat to broiler production in Nigeria, particularly Infectious Bronchitis (IB) and Avian Influenza (AI). Infectious Bronchitis, caused by a coronavirus, leads to poor weight gain, reduced feed conversion efficiency, and high culling rates. Avian Influenza, especially the highly pathogenic strain H5N1, has caused devastating outbreaks in West Africa, resulting in massive mortality and severe trade restrictions (World Organisation for Animal Health ((WOAH), 2023). Recent studies emphasize the importance of strict biosecurity measures, rapid outbreak reporting, and strategic vaccination programs to mitigate the impact of these respiratory diseases (Oke *et al.,* 2023).

Parasitic infections, particularly helminthiasis and ectoparasites such as mites and lice, can also affect broiler productivity. While intensive production systems reduce the risk of heavy parasitic infestations, poor litter management and overcrowding can still predispose birds to infestations. A study by Musa *et al.* (2022) in northern Nigeria reported that coccidiosis combined with helminth infections significantly reduced weight gain and increased mortality in broilers under deep litter systems. The authors recommended integrated parasite control strategies, including routine deworming, litter treatment, and improved hygiene protocols.

Metabolic disorders, including **ascites** syndrome and sudden death syndrome (SDS), have become more prevalent due to the genetic selection of broilers for rapid growth. Ascites, often linked to inadequate ventilation and high altitude rearing, results from pulmonary hypertension, while SDS is associated with cardiac arrhythmias in fast-growing males (Smith & Dunning, 2023). Preventive strategies such as optimizing stocking density, improving ventilation, and adjusting energy-to-protein ratios in diets have been shown to reduce the incidence of these conditions in commercial farms (Oladipo *et al.,* 2023).

2.9 Records and Record-Keeping in Broiler Production

Effective record-keeping is an essential component of profitable broiler production, as it enables farmers to monitor performance, identify inefficiencies, and make informed management decisions. Records on feed consumption, weight gain, mortality, vaccination schedules, and medication use help in evaluating the flock's health status and growth trends (Oladipo et al., 2023). Modern poultry management increasingly adopts digital tools, such as mobile applications and farm management software, which provide real-time monitoring and analytics, enabling faster corrective actions when performance deviates from expected targets (FAO, 2022).

Financial records are equally important, as they track input costs, sales revenue, and profitability, enabling farmers to assess the economic viability of production cycles. Research in Nigeria has shown that farmers who maintain detailed financial and production records achieve better feed conversion ratios (FCR), lower mortality rates, and higher profit margins compared to those without proper documentation (Ajayi et al., 2022). In addition, detailed records support access to credit facilities, as financial institutions often require documented proof of consistent production and sales before granting loans (Central Bank of Nigeria, 2022). Biosecurity and health records also play a critical role in disease prevention and control. Documenting vaccination dates, disease outbreaks, and treatments helps identify recurring health issues and evaluate the effectiveness of preventive measures (Oke et al., 2023). Such records are not only useful for on-farm decision-making but are also critical in meeting regulatory and export requirements, especially as global markets increasingly demand traceability of livestock products from farm to table (World Organisation for Animal Health [WOAH], 2023). By combining traditional record-keeping methods with digital solutions, broiler farmers can enhance operational efficiency, reduce losses, and ensure long-term sustainability.

2.10 General Performance Indicators of Broilers

Performance indicators in broiler production are crucial for evaluating flock efficiency, profitability, and overall farm management success. One of the most widely used indicators is body weight gain (BWG), which measures the increase in body mass over a production cycle. This parameter is directly influenced by feed quality, health management, genetics, and environmental conditions. According to Oladipo *et al.* (2023), maintaining optimal BWG within breed-specific targets is essential for meeting market demands and achieving high dressing percentages. Variations in BWG often signal nutritional imbalances, disease outbreaks, or suboptimal environmental conditions that require corrective action.

The feed conversion ratio (FCR) is another critical performance metric, indicating the efficiency with which birds convert feed into body mass. A lower FCR reflects better efficiency and profitability, as less feed is required for the same weight gain. Recent research in Nigerian broiler farms found that optimal FCR values for breeds like Cobb 500 and Ross 308 ranged between 1.5 and 1.8 under intensive production systems (Oke et al., 2023). Improvements in

FCR can be achieved through balanced nutrition, disease prevention, and efficient housing systems, with feed form (pellet vs. mash) playing a significant role in enhancing feed utilization efficiency (Ajayi et al., 2022).

Mortality rate and European Production Efficiency Factor (EPEF) are also important indicators for evaluating broiler performance. Mortality rates should be kept below 5% in commercial operations to maintain profitability (FAO, 2022). EPEF is a composite index that considers body weight, livability, feed conversion, and production duration, offering a holistic measure of flock performance. Musa *et al.* (2022) noted that farms tracking EPEF consistently were able to make targeted management adjustments, such as modifying stocking density and improving biosecurity, which led to significant improvements in overall productivity and economic returns.

2.11 Bitter Leaf (*Vernonia amygdalina*)

Bitter leaf (*Vernonia amygdalina*) is a perennial shrub widely distributed in tropical Africa, known for its characteristic bitter taste and extensive use in traditional medicine and nutrition. Its leaves contain a rich profile of phytochemicals, including alkaloids, flavonoids, tannins, saponins, and terpenoids, which contribute to its antimicrobial, antioxidant, and anti-inflammatory properties (Okolie *et al.,* 2021). In poultry production, these bioactive compounds have been associated with improved immune function, reduced oxidative stress, and enhanced disease resistance, making *V. amygdalina* a promising phytogenic feed additive in antibiotic-free production systems (Oloruntola *et al.,* 2021).

Nutritionally, *V. amygdalina* leaves are a good source of crude protein, fiber, vitamins (A, C, and E), and essential minerals such as calcium, magnesium, and iron. Recent studies have demonstrated that incorporating bitter leaf extracts or leaf meal into broiler diets can enhance feed utilization, weight gain, and survivability, particularly under conditions of heat stress and disease pressure (Eze *et al.,* 2023). The plant's high antioxidant content also helps mitigate lipid peroxidation in tissues, thereby improving meat quality and shelf life (Akinmoladun *et al.,* 2022).

Economically, the use of bitter leaf as a feed supplement offers a cost-effective strategy for poultry farmers in Nigeria and other resource-limited settings. Since the plant is widely available and grows easily without intensive agronomic inputs, it can reduce dependence on expensive synthetic additives and imported feed supplements (Musa et al., 2022). Its integration into commercial feeds like Chikun feed could not only lower production costs but also align with the global trend toward sustainable livestock production and consumer demand for natural, antibiotic-free poultry products (FAO, 2022).

2.12 Serum Biochemistry in Broilers

Serum biochemistry in broilers provides vital information on metabolic status, organ function, and overall health, making it an important diagnostic tool in poultry research and production. Parameters such as total protein, albumin, and globulin reflect protein metabolism, immune status, and liver function (Musa et al., 2022). Elevated total protein and globulin levels, for example, may indicate improved immune competence, while reduced albumin levels could be linked to malnutrition or hepatic dysfunction. Regular monitoring of these indices allows farmers and researchers to assess the nutritional adequacy of diets and the physiological impact of feed additives such as *Vernonia amygdalina* (Oloruntola et al., 2021).

Lipid profile indicators—including cholesterol, triglycerides, and high-density lipoprotein (HDL)—are important for evaluating fat metabolism in broilers. Recent studies have shown that phytogenic feed additives, including bitter leaf extract, can lower serum cholesterol and triglyceride concentrations while increasing HDL levels, which is desirable for both poultry health and meat quality (Eze et al., 2023). This lipid-lowering effect is attributed to bioactive compounds like saponins and flavonoids that interfere with lipid absorption and synthesis.

Lower cholesterol levels in broiler meat also meet the growing consumer demand for healthier animal protein sources (FAO, 2022).

Serum biochemical markers such as urea, creatinine, and glucose are critical for assessing kidney function, protein metabolism, and energy utilization. High serum urea and creatinine levels may indicate impaired renal function or excessive protein catabolism, while abnormal glucose levels can signal metabolic stress or dietary imbalances (Okoli et al., 2021). Research by Akinmoladun et al. (2022) demonstrated that supplementation with antioxidant-rich phytogenics like *Vernonia amygdalina* can help maintain stable glucose levels and reduce oxidative damage to vital organs. Thus, serum biochemistry serves as a valuable tool for evaluating the physiological impact of feed interventions and ensuring the health and productivity of broilers.

2.13 Metabolites in Broilers

Metabolites in broilers are biochemical substances produced during metabolic processes, serving as indicators of nutritional status, health, and physiological responses to dietary interventions. Key metabolites such as glucose, lactate, and uric acid provide insight into energy utilization, carbohydrate metabolism, and nitrogen excretion. Glucose levels are closely associated with energy supply and stress response, while elevated lactate concentrations may signal hypoxia or intense muscular activity (Musa et al., 2023). Uric acid, the primary nitrogenous waste in poultry, reflects protein metabolism efficiency, with abnormally high levels indicating excessive dietary protein or impaired renal function (Oke et al., 2023).

Lipid-related metabolites, including triglycerides, total cholesterol, and high-density lipoprotein (HDL), are important markers of fat metabolism and cardiovascular health in broilers. Dietary interventions with phytogenic additives such as *Vernonia amygdalina* have been shown to reduce serum triglycerides and total cholesterol while increasing HDL levels, thus improving meat lipid profiles and overall bird health (Eze et al., 2023). These effects are attributed to bioactive compounds like flavonoids and saponins, which inhibit cholesterol synthesis and enhance lipid catabolism. Monitoring these lipid metabolites provides valuable information for formulating diets that meet production targets while producing healthier poultry meat for consumers.

Protein metabolism markers such as total protein, albumin, and creatinine also play a crucial role in assessing broiler health. Total protein and albumin levels reflect protein synthesis and immune function, while creatinine serves as a measure of muscle metabolism and kidney health. Studies have indicated that supplementation with antioxidant-rich botanicals like *Vernonia amygdalina* can improve protein metabolism efficiency and maintain optimal creatinine levels, thereby supporting growth performance and reducing oxidative stress in broilers (Akinmoladun et al., 2022). Regular monitoring of these metabolites is essential in both research and commercial production to ensure dietary adequacy, detect early signs of metabolic disorders, and enhance overall productivity.

2.13.1 Importance of Metabolites in Broilers

Metabolites in broilers serve as essential indicators for assessing nutritional adequacy, physiological status, and health performance. They provide direct insight into how nutrients are digested, absorbed, and utilized in the body. For instance, metabolites such as glucose, total protein, and uric acid are widely used to evaluate energy status, protein metabolism, and nitrogen excretion in broilers (Musa et al., 2023). Regular monitoring of these biochemical markers allows poultry farmers and researchers to detect imbalances early, optimize feeding strategies, and ensure that birds are performing to their genetic potential (Oke et al., 2023).

In commercial poultry production, the measurement of lipid metabolites like cholesterol, triglycerides, and high-density lipoprotein (HDL) is critical not only for maintaining broiler health but also for producing meat with desirable nutritional profiles. Reducing serum cholesterol and triglyceride levels through dietary interventions—such as supplementing with phytogenic additives like *Vernonia amygdalina*—has been shown to improve cardiovascular health in broilers and enhance consumer acceptance of poultry products (Eze et al., 2023). These lipid-related metabolites are therefore essential for both economic and public health considerations.

Metabolites also play a key role in research and breeding programs aimed at improving broiler performance under different environmental conditions. Biomarkers like creatinine, lactate, and blood urea nitrogen (BUN) are used to assess muscle metabolism, stress levels, and kidney function (Akinmoladun et al., 2022). Understanding these metabolic profiles enables genetic selection for birds that are more efficient in nutrient utilization, more resilient to heat stress, and better adapted to local production systems. Consequently, metabolites are not just indicators of current health but also predictive tools for long-term productivity and sustainability in broiler production.

2.14 Blood and Its Importance in Poultry

Blood plays a crucial role in poultry physiology as it is responsible for transporting oxygen, nutrients, hormones, and metabolic waste products throughout the body. It is composed of plasma and formed elements such as red blood cells (erythrocytes), white blood cells (leukocytes), and platelets (thrombocytes), each with distinct functions in maintaining homeostasis (Akinola et al., 2022). In poultry production, blood analysis is widely used as a diagnostic tool for assessing the health, nutritional status, and physiological responses of birds to dietary interventions, environmental stress, and disease challenges (Oke et al., 2023).

Haematological parameters such as packed cell volume (PCV), haemoglobin concentration (Hb), red blood cell (RBC) count, and white blood cell (WBC) count provide valuable information on oxygen-carrying capacity, immune status, and general health. For instance, elevated WBC levels may indicate infection or inflammation, while reduced PCV and Hb values can be signs of anaemia, poor nutrition, or parasitic infestation (Musa et al., 2023).

Regular monitoring of these indices enables poultry farmers to make timely management decisions to prevent economic losses from disease outbreaks or poor flock performance.

Blood is also a vital tool in evaluating the safety and efficacy of feed additives, vaccines, and medications in poultry. Phytogenic feed additives, such as *Vernonia amygdalina*, have been reported to positively influence haematological indices by boosting immune responses and improving oxygen transport efficiency (Eze et al., 2023). This improvement in blood health contributes directly to better feed conversion efficiency, faster growth rates, and enhanced resistance to diseases, which are critical for sustainable and profitable poultry production. Therefore, blood evaluation is not only important for veterinary diagnostics but also serves as a key indicator of productivity in broiler and layer systems.

CHAPTER THREE
MATERIALS AND METHODS

3.1 The Study Area

The research was conducted in the teaching and research farm of the Federal Polytechnic Mubi, Adamawa State, Nigeria. Mubi town is located within the North-East basement complex of Nigeria. Its seasonal rainfall and nature of the wood and vegetation are derived from the basement complex, the Mandara Mountains. The region falls within the Guinea Savannah belts of Nigerian vegetation zones. The region is characterized by mean annual rainfall that ranges from about 700 mm to 1050 mm. The rainy season is about 6 months, May to October, and dry season of cool and hot for the rest of the 6 months.

Based upon the season of the area, the season is further divided into 3 distinct seasons: Thus, dry hot season (Feb–April), with temperature ranging from 39.8°C – 40.8°C; Wet season (May–October), with temperature dropping from 40.8°C – 31.0°C; less and dry cool season (Nov–Jan) with temperature less than 31°C (Olujeyemi and Roberts 2007). The performance of broilers will therefore be different at these different temperatures of these 3 distinctive seasons.

3.2 Experimental Birds / Sources

The experimental birds were sourced from Mubi town. The birds were between the ages of 3 weeks old purchased from a private farm.

3.3 Materials Needed

3.3.1 Bitter leaves (*Vernonia amygdalina*)

3.3.2 Water

3.3.3 Clean containers

3.3.4 Cheesecloth or a fine-mesh sieve

3.3.5 Measuring cups and spoons

3.3.6 Graduated syringe and needle

3.4 Preparation of Bitter Leaf Extract

Bitter leaves were freshly harvested from a clean environment. These were rinsed with clean water to remove the dirt and debris. Stems or woody parts were removed from the leaves. The leaves were chopped into smaller pieces. The leaves were then crushed using a mortar and pestle to release their juices. The crushed bitter leaves were then placed in a clean container.

1 liter of water was then added to every 100 grams of crushed leaves. This was stirred well and covered in a container. The mixture was allowed to steep for 2–3 hours and left overnight. The steeped mixture was strained through a fine-mesh sieve into another container that is clean. Then the solids were filtered again using a fine-mesh sieve to remove the remaining impurities. This was stored in a clean, airtight container and labeled with date, time, and contents. It was then stored in a cool, dry place to prolong its shelf life for use in graded levels at 0.50 ml, 0.75 ml, 1.00 ml, and 1.25 ml.

3.5 Management of Experimental Birds

All the birds used for the experiment were housed in research pens. Plastic drinkers and aluminium feeders were used to serve water and feed respectively. Feed was measured before serving in the morning and evening. The birds were given all the necessary medications and vaccination as at when due. Left over the quantity of feed served to determine feed intake. Containers of feed and water were made clear every morning throughout the period of the experiment.

3.6 Experimental Duration

The broilers were fed Chikun fed alongside inclusion of bitter leave extract at graded levels in their drinking water for 42 days during which records on daily feed and weekly feed intake body weight gain, feed conversion ratio and efficiency of feed conversion were recorded and calculated; haematological parameters, serum biochemistry and serum metabolites were determined.

3.7 Experimental Design

A total of 30 broilers at grower to finisher stage were used for the experiment with an average initial weight of 527.40g. these birds were randomly allocated to five (5) treatments. Each treatment group was further subdivided into 2 replicates, in a completely randomized design (CRD) such that the mean group weights were similar at the beginning of the experiment. T1 (Treatment 1) was a control; Treatment 2 (T2), Treatment 3 (T3), Treatment 4 (T4), and Treatment 5 (T5) with inclusion levels of bitter leaf extract at 0.00, 0.50, 0.75, 1.00, and 1.25 ml respectively.

3.8 Measurement and Method of Interpreting Results

3.8.1 Initial Weight (g)

This was determined by weighing the birds using a 20 kg scale to get the average initial weight similar within all the treatments.

3.8.2 Daily Feed Intake (g)

This was obtained by subtracting the quantity of leftover feed from the amount of feed served daily to all the treatments.

3.8.3 Live Weight Gain (g)

This was determined by subtracting the initial weight from the weight obtained weekly.

3.8.4 Feed Conversion ratio

This was obtained through calculation as follows:

$$Ratio\ between\ the\ total\ feed\ intake\ or\ consumer\ to\ the\ weight\ produced$$

$$\text{FCR} \quad = \frac{total\ feed\ intake}{total\ weight\ gain}\ \%$$

3.8.5 Efficiency of Feed Conversion Ratio

This was obtained as below;

$$\text{FCR} \quad = \frac{total\ weight\ gain}{total\ feed\ intake}\ \%$$

3.9 Haematological Parameters

Blood samples were taken with 5ml syringe and needle once from a total 10 broilers selected randomly. That is 2 broilers each from each treatment. The blood samples were collected from the wing web vein area which was cleaned with 95% V/V (methylated spirit). Xylol (xylene) was applied on the wing web vein to increase blood flow as reported by (Hoppe et al., 1969). Part of the blood collected was expelled gradually into labelled bijou bottles containing specks of dried ethylenediaminetetraacetic acid (EDTA) and were covered and mixed gently for about a minute by repeated inversion for haematological parameters determination, while the other part of the blood was expelled into bottles without EDTA. This part was thereafter used for serum biochemistry determination in the following ways:

3.9.1 Blood Parameters

3.9.2 Red Blood Cells (RBC) Count

The RBC's count was determined by using haemocytometer according to Perkins (2009).

3.9.3 Haematocrit (PCV)%

This was measured by capillary tubes, where the opposite end of the tubes were sealed and then centrifuged for 10 minutes at 3,000 rpm according to Bauer (1970).

3.9.4 Haemoglobin (Hb)%

The Hb was analyzed colorimetrically according to Van Kampen and Zijlstra (1983).

3.9.5 White Blood Cells (WBC's) Count

The white blood cells were counted ($\times 10^3$ µL) by using the haemocytometer according to Ewoola and Egbunike (2008).

3.9.6 Biochemical Parameters / Metabolites

The EDTA-free blood that was put into set of tubes were immediately covered and centrifuged. Serum separated, decanted, deep-frozen at 20°C until radioimmunoassay as referenced by Ewoola and Egbunike (2008) and Abraham et al. (1971). One part of the serum was used to determine the total protein, albumin, creatinine, urea, sodium, potassium, calcium, chloride and the serum enzymes; alanine-aminotransferase (ALT) and aspartate aminotransferase (AST).

Serum chloride (Cl^-), creatinine and urea were evaluated as described earlier by Gbore et al. (2006). The serum levels of sodium (Na^+) and potassium (K^+) were determined spectrometrically as described by Garba and Miller (1983). Serum enzymes, alanine aminotransferase (ALT) and aspartate aminotransferase were determined using the IFCC (International Federation of Clinical Chemistry) method as described by Bergmeyer et al. (1986).

3.10 Data Analysis

All the data obtained were keyed into the computer and subjected to analysis of variance (ANOVA) using General Linear Model procedure of SAS (2013), Version 9.4, where significant differences exist, mean separation was done using Duncan multiple range test of (1955) at 5% probability level.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Effect of Graded Levels of Bitter Leaf Extract (*Vernonia amygdalina*) on the Performance of Broiler Chickens Fed Chickpea Feed

The results of the effect of graded levels of bitter leaf extract on the performance of broiler chickens fed chickpea feed is as presented in table 1. The mean values initial weight and final weight did not depicted significantly (P>0.05) difference across the treatments. The mean values of average initial weight had the highest (266.05 ± 1.96 g) in T_5 and the lowest (264.50 ± 1.96 g) in T_1 (Control) and T_4 respectively. However, the mean values of the average initial weight differ numerically with different levels of graded bitter leaf extract. Similarly, the mean values of final live weight differ numerically and ranged from 12.950 ± 17.266 to 27.985 ± 17.266kg. Highest (27.985 ± 17.266kg) mean value was recorded at T_5 with inclusion of graded level of 1.25ml of bitter leaf extract.

However, the mean values of daily feed intake, daily weight gain, weekly weight gain, and feed conversion ratio (FCR) were highly influenced (P>0.001). The mean values of theses parameters increased numerically with definite pattern with increase in graded levels of bitter leaf extract increase. The mean values of daily and weekly weight gain recorded the highest (8.615 ± 0.361g and 60.295 ± 2.523kg) at T_5, and the lowest (7.115 ± 0.361g and 49.820 ± 2.523kg) respectively. This is in agreement with the earlier report by Oladejo *et al.* (2023) who reported that maintaining optimal body weight gain (BWG) within breed-specific is essential for meeting market demands and achieving high dressing percentage. This means that birds under research did not suffer nutritional imbalance, disease outbreaks or sub-optimal environmental conditions that require corrective actions. Total feed intake increased with increased bitter leaf extract graded levels. Highest (632.73 ± 55.619kg) mean value was recorded in T_5 with inclusion level of 1.25ml of bitter leaf extract and the lowest (401.31 ± 55.619kg) mean value recorded in T_1 (control) with 0.00ml of bitter leaf extract.

FCR is another critical performance metric indicating the efficiency with which birds convert feed into body mass. A lower FCR reflects better efficiency and profitability, as less feed is required for same weight gain. The results of FCR obtained from this study which ranged from (0.170 ± 0.029 to 0.225 ± 0.029) is lower than what was reported by Oke *et al.* (2023), who reported values of 1.5 and 1.8 under intensive production. This variation may be attributed to variation in feed, housing system, environmental conditions, etc.

Table 1: Effect of Graded Levels of Bitter Leaf Extract on the Performance of Broiler Chickens Fed Chikun Feed

Parameter	T1 (0.00ml BLE)	T2 (0.5ml BLE)	T3 (0.75ml BLE)	T4 (1.00ml BLE)	T5 (1.25ml BLE)	SEM	Level Sig
Average initial weight (kg)	264.50 ± 1.96^{b}	265.00 ± 1.96^{a}	265.00 ± 1.96^{a}	264.50 ± 1.96^{a}	266.05 ± 1.96^{a}	0.760	NS
Final live weight (kg)	12.950 ± 17.266^{a}	24.790 ± 17.266^{a}	26.225 ± 17.266^{a}	27.365 ± 17.266^{a}	27.985 ± 17.266^{a}	6.717	NS
Daily feed intake (g)	9.580 ± 1.297^{d}	11.520 ± 1.297^{c}	13.520 ± 1.297^{b}	14.550 ± 1.297^{a}	15.065 ± 1.297^{a}	0.505	***
Daily weight gain (g)	7.115 ± 0.361^{d}	7.600 ± 0.361^{c}	8.205 ± 0.361^{b}	8.400 ± 0.361^{a}	8.615 ± 0.361^{a}	0.141	***
Weekly weight gain (kg/WK)	49.850 ± 2.532^{d}	53.185 ± 2.532^{c}	56.285 ± 2.532^{b}	58.865 ± 2.532^{a}	60.955 ± 2.532^{a}	0.981	***
Total feed intake (kg)	401.31 ± 55.619^{c}	472.50 ± 55.618^{c}	521.73 ± 55.618^{b}	611.60 ± 55.619^{a}	632.32 ± 55.619^{a}	21.637	***
Average total weight gain (1kg)	20.925 ± 1.056^{d}	32.340 ± 1.058^{c}	33.640 ± 1.058^{b}	34.220 ± 1.056^{a}	35.325 ± 1.056^{a}	0.411	***
Feed Conversion Ratio	0.170 ± 0.029^{c}	0.190 ± 0.029^{c}	0.300 ± 0.029^{ab}	0.220 ± 0.029^{b}	0.225 ± 0.029^{a}	0.011	***

Means with different superscripts (a, ab, b,bc, c, d) are significantly different at $P < 0.05$ across the table.

BLE = Bitter Leaf Extract; *** = Significantly ($P < 0.001$) different.

4.2 Effect of Graded Levels of Bitter Leaf Extract on Haematological Parameters of Broiler Chickens Fed Chikun Feed

Phytogenic feed additives, such as *Vernonia amygdalina*, have been reported to positively influence haematological indices by boosting immune responses. Blood plays a crucial role in poultry physiology as it is responsible for transport of oxygen, nutrients, hormones, and metabolic waste products throughout the body. The results of the effect of graded levels of bitter leaf extract on haematological indices of broilers chickens fed chicken feed is as presented in Table 2. The results of red blood cells count (RBCs), Packed Cell Volume (PCV), white blood cells count (WBCs), Haemoglobin (Hg) and Lymphocytes revealed significant ($P < 0.05$) differences except for PCV which did not show significant ($P > 0.05$) difference among the treatments. RBCs depicted significant difference ($P < 0.01$). The highest ($4.100 \pm 0.521 \times 10^6/\mu L$) mean value for RBC was recorded in T4 with graded level of 1.00 ml of bitter leaf extract, while the lowest was recorded in T1 (Control) as it could only reveal a value of ($2.700 \pm 0.521 \times 10^6/\mu L$). However, there was no definite pattern in increase of the mean values for RBC with increased bitter leaf extract graded levels, although the mean values differ numerically.

The mean values of Packed Cell Volume (PCV) had the highest ($32.855 \pm 3.426\%$) at T_5 and the lowest ($28.650 \pm 3.426\%$) in T_1 (control). The white blood depicted significant ($P < 0.05$) difference with different levels of inclusion of graded levels of bitter leaf extract. Highest ($17.900 \pm 2.369 \times 10^3/\mu L$) mean value was recorded in T_2 with 0.50 ml inclusion of bitter leaf extract and the lowest ($14.850 \pm 2.369 \times 10^3/\mu L$) in T_1 (control). White blood cells provide information on oxygen carrying capacity, immune status, and general health. For instance, elevated WBC levels may indicate infection or inflammation. However, the results obtained in this study is within the normal range for healthy birds. The mean values of haemoglobin (Hg) obtained in this study was significantly ($P < 0.01$) influenced. Highest (10.800 ± 0.718 g/dl) mean value was recorded in T_5 with graded levels of 1.25 ml bitter leaf extract, and the lowest (7.400 ± 0.718 g/dl) mean value was recorded in T1 (Control). Hg is the iron-containing oxygen transport metallo-protein in the red blood cells of all vertebrates, with the exception of fish Chanrichthyldae as well as tissues of invertebrates. The results of Hg obtained in this study have been improved in the treatments except in T1 (Control). This is in conformity with the report by Eze *et al.* (2023) who reported that the use of phytogenic feed additives, such as *Vernonia amygdalina*, have been reported to positively influence haematological indices by boosting immune responses and improving oxygen transportation efficiency.

The mean values of lymphocytes as recorded in this study revealed significant ($P < 0.05$) difference. Highest mean value (76.200 ± 8.089%) was recorded in T_2 with 0.5 ml graded level of bitter leaf extract and the lowest (62.800 ± 8.089%) in T_3 with 0.75 ml of bitter leaf extract.

The positive influence of phytogenic feed additives (*Vernonia amygdalina*) had reflected improvement in blood health and contributed directly to better feed conversion efficiency, faster growth rates, and enhanced resistance to diseases, which are critical for sustainable and profitable poultry production.

Table 2: Effect of Graded Levels of Bitter Leaf Extract on Haematological Parameters of Broiler Chickens Fed Chikun Feed

Parameter	T_1 (0.00ml BLE)	T_2 (0.5ml BLE)	T_3 (0.75ml BLE)	T_4 (1.00ml BLE)	T_5 (1.25ml BLE)	SEM	Level Sig.
RBC ($x10^6/\mu l$)	2.700 ± 0.521^{c}	3.300 ± 0.521^{b}	3.200 ± 0.521^{bc}	4.100 ± 0.521^{a}	3.850 ± 0.521^{ab}	0.203	**
PCV (%)	28.650 ± 3.426^{b}	31.207 ± 3.426^{b}	28.750 ± 3.426^{b}	34.806 ± 3.426^{ab}	32.855 ± 3.426^{a}	1.333	NS
WBC ($x10^3/\mu l$)	14.850 ± 2.369^{c}	17.900 ± 2.369^{a}	16.950 ± 2.369^{bc}	17.200 ± 2.369^{abc}	17.600 ± 2.369^{ab}	0.743	*
Hg (g/dl)	9.400 ± 0.718^{c}	9.750 ± 0.718^{b}	10.200 ± 0.718^{b}	10.870 ± 0.718^{a}	10.800 ± 0.718^{a}	0.225	**
Lymph (%)	63.250 ± 8.089^{c}	76.200 ± 8.089^{a}	62.800 ± 8.089^{c}	73.650 ± 8.089^{b}	73.100 ± 8.089^{b}	3.147	*

Means with different superscript (a, ab, bc, c) are significantly different at ($P<0.05$)

Note: RBC = Red blood cells count; PCV = Packed cell volume; WBC = White blood cells count; Hg = Haemoglobin; Lymph = Lymphocytes; BLE = Bitter leaf extract; NS = Not significantly different ($P>0.05$); * = Significantly different ($P<0.05$); ** = Significantly different ($P<0.01$).

4.3 Effect of Graded Levels of Bitter Leaf Extract on Serum Biochemical Parameters and Some Metabolites of Broiler Chickens

The results of the effect of graded levels of bitter leaf extract on serum biochemical parameters and some metabolites are as presented on Table 3. Serum biochemical parameters are parameters of importance to nerve and muscle functions. In addition, they are vital for information on metabolic status, organ function and overall health status, making it an important diagnostic tool in poultry research and production as reported by (Musa *et al.,* 2023). These are substances that when dissolved in solution, will dissociate into their electrically charged components called ions (Frandson, 1981).

Regular monitoring of these indices allows farmers and researchers to assess the nutritional adequacy of diets and physiological impact of feed additives such as the *Vernonia amygdalina* (Oloruntola *et al.,* 2021). The biochemical substances produced during metabolic processes that serve as indicators of nutritional status, health, and physiological responses to dietary interventions are what is termed metabolites.

The mean values of albumin, chloride, creatinine and urea were significantly ($P<0.001$) influenced, while the mean values of total protein and bicarbonate were significantly ($P<0.01$) different among the treatments. However, Alani-Aminotransferase and Aspartate aminotransferase were significantly ($P<0.05$) affected. There were no significant ($P>0.05$) revealed in the mean values of Sodium (Na^+) and Potassium. However, on all the indices of serum biochemical parameters and metabolites, there were no definite pattern of increase with increase in the graded levels of bitter leaf extract probably due to environmental conditions. However, generally most of the mean values of serum biochemistry and metabolites under bitter leaf extract inclusion, improved organ function, health status and metabolic status as compared to the values obtained in T_1 (Control, 0.00ml of bitter leaf extract).

Table 3: Effect of Graded Levels of Bitter Leaf Extract on Biochemical Parameters and Some Metabolites

Parameters	T_1 0.00mL (BLE)	T_2 0.5mL (BLE)	T_3 0.75mL (BLE)	T_4 1.00mL (BLE)	T_5 1.25mL (BLE)	SEM	Level of Sig.
ALT (u/l)	23.700 ± 2.894^{c}	25.750 ± 2.894^{a}	24.500 ± 2.894^{b}	26.250 ± 2.894^{a}	18.650 ± 2.894^{d}	1.126	*
AST (u/l)	18.050 ± 5.855^{bc}	20.150 ± 5.855^{b}	22.550 ± 5.855^{b}	28.600 ± 5.855^{a}	16.150 ± 5.855^{c}	2.078	*
Albumin (g/dl)	1.875 ± 0.069^{d}	1.310 ± 0.069^{c}	0.975 ± 0.069^{e}	1.990 ± 0.069^{a}	1.520 ± 0.069^{b}	0.027	***
T. Protein (g/dl)	3.250 ± 0.488^{b}	3.400 ± 0.488^{b}	3.050 ± 0.488^{b}	4.350 ± 0.488^{a}	3.350 ± 0.488^{b}	0.189	**
Na^{+} (mEq/L)	130.10 ± 11.492^{a}	130.05 ± 11.492^{a}	135.400 ± 11.492^{a}	130.10 ± 11.492^{a}	132.00 ± 11.492^{a}	4.447	NS
K^{+} (mEq/L)	3.150 ± 0.521^{a}	3.05 ± 0.521^{a}	3.200 ± 0.521^{a}	3.300 ± 0.521^{a}	3.200 ± 0.521^{a}	0.203	NS
Cl^{-} (mEq/L)	92.20 ± 1.578^{c}	103.20 ± 1.578^{b}	90.70 ± 1.578^{c}	109.75 ± 1.578^{a}	103.70 ± 1.578^{b}	0.614	***
Creat (u/l)	126.95 ± 2.311^{c}	129.25 ± 2.311^{b}	131.15 ± 2.311^{b}	200.65 ± 2.311^{a}	102.70 ± 2.311^{d}	0.894	***
Urea (mg/dl)	4.550 ± 0.269^{bc}	4.750 ± 0.269^{b}	4.100 ± 0.269^{c}	6.750 ± 0.269^{a}	4.500 ± 0.269^{bc}	0.165	***
Biocarbs (mEq/L)	22.200 ± 1.047^{b}	22.050 ± 1.047^{b}	20.150 ± 1.047^{c}	26.100 ± 1.047^{a}	20.650 ± 1.047^{c}	0.147	***

Means with different superscript (a, b, bc, c, d, e) are significantly different at ($P<0.05$)

Notes: ALT = Alanine aminotransferase; AST = Aspartate aminotransferase; T. Protein = Total Protein; Na^{+} = Sodium; K^{+} = Potassium; Cl^{-} = Chloride; Creat = Creatinine; Biocarbs = Bicarbonates; BLE = Bitter Leaf Extract; NS = Not significantly different ($P>0.05$); * = Significantly ($P<0.05$) different; ** = Significantly ($P<0.01$) different; *** = Significantly different ($P<0.001$).

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the results obtained from this present study, the results of growth performance all revealed a significant difference, except for initial weight and final weight. In addition, the results of haematological parameters all showed significant difference, except for packed cell volume which was not affected by inclusion of graded levels of bitter leaf extract.

However, all the mean values of haematological indices obtained from this study were within the normal range for healthy broilers. The mean values of serum biochemical parameters and some metabolites namely alanine amino transferase (ALT), aspartate aminotransferase (AST), albumin (Alb), total protein (T. Prot), sodium (Na^+), potassium (K^+), chloride (Cl^-), creatinine (Creat), urea and bicarbonate were highly influenced, except for potassium and sodium although the mean values obtained were within the normal range for healthy chickens and for the normal functioning of the organ like Liver.

It could therefore be concluded that the use of phytogenic additives such as *Vernonia amygdalina* in production of broiler chickens at graded levels can improve the immunity system, improve oxygen circulation, enhance efficient feed conversion ratio and reduce cost of production.

5.2 Recommendations

Based on the results of the findings in this current study, the following recommendations could be made;

Bitter leaf extract at graded levels should be used by farmers in broiler chicken business to improve immunity, health status, oxygen circulation, efficiency of feed conversion ratio, weight gain and cost reduction in production. The use of this phytogenic additive should be adopted by farmers up to 1.25mls. Further studies should be conducted on this to achieve and attain optimal inclusion of this phytogenic additive in broilers.

REFERENCES

Adene, D. F., & Oguntade, A. E. (2006). The Structure and Importance of the Commercial and Village-Based Poultry Industry in Nigeria. FAO.

Akinmoladun, F. O., Akinrinlola, B. L., & Farombi, E. O. (2007). Chemical constituents and antioxidant activity of Vernonia amygdalina. *Journal of Medicinal Plants Research, 1(1), 19-22.*

Akinola, L. A. F., & Essien, A. I. (2011). Broiler Production in Nigeria: A Review. *Nigerian Journal of Animal Science,* 13(1), 43–52.

Bergemeyer, H., Horder, M. and Rej, R. (1986). Approved recommendation on International Federation of Clinical Chemistry. *Clinical Biochemistry,* 24: 497–495.

Bessman, J. D. (1970). *Numerical evaluation of red blood, white blood cells and platelets profile, haematology.* In: Clinical Laboratory Methods and Diagnosis (Frankel, S., Reitman, S. and Sonnenwirth, A. C. Editors), 9th Edn. The C.V. Mosby Co., Saint Louis, USA.

Duncan, D.B. (1955). Multiple Range and Multiple F. Tests. *Biometrics*, 11: 1–42.

Esonu, B. O., Emenalom, O. O., Udedibie, A. B. I., & Okoli, I. C. (2006). Performance, nutrient utilization and organ characteristics of broilers fed varying levels of dried Vernonia amygdalina leaf meal. *International Journal of Poultry Science,* 5(1), 39-43.

Etim, N. N., Offiong, E. E. A., & Ekaette, I. U. (2014). Serum Biochemistry of Broiler Chickens Fed Neem Leaf Meal. *International Journal of Poultry Science,* 13(12), 683–686.

FAO. (2010). Poultry Meat & Egg Production in Developing Countries. Food and Agriculture Organization.

FAO. (2020). Livestock Primary Database. Food and Agriculture Organization of the United Nations.

Farombi, E. O., & Owoeye, O. (2011). Antioxidant and Chemopreventive Properties of Vernonia amygdalina. *International Journal of Environmental Research and Public Health,* 8(6), 2533–2555.

Farombi, E. O., & Owoeye, O. (2011). Antioxidant and chemopreventive properties of Vernonia amygdalina and Garcinia biflavonoid. *International Journal of Environmental Research and Public Health*, 8(6), 2533–2555.

Gater, R., Conrel, Miller, R. (1983). Revision of the 1963 International Fed. Standard method for estimating phosphorus. Clinical Chemistry, 29: 134–138.

Gbore, F.A., Ogundele, M. and Esmonule, E.O. (2008). Effect of dietary *Tamarindus indica* on organ characteristics and some serum biochemical parameters of broilers. *Moor J. Agric. Res.* 7: 28–34.

Jain, N. C. (1993). Essentials of Veterinary Hematology. Lea and Febiger.

Khan, T. A., & Zafar, F. (2012). Haematological Study in Response to Varying Doses of Estrogen in Broiler Chickens. *International Journal of Poultry Science*, 4(10), 748–751.

NRC. (1994). Nutrient Requirements of Poultry, 9th Rev. Edition. National Academy Press.

Nwanta, J. A., et al. (2008). Evaluation of Common Antibiotics and Multivitamin Combinations in the Management of Poultry Diseases. *Journal of Animal and Veterinary Advances,* 7(6), 737–741.

Nworgu, F. C., Ogungbenro, S. D., & Solesi, K. S. (2014). Performance and some blood chemistry indices of broiler chickens fed bitter leaf extract (Vernonia amygdalina) as a natural growth promoter. *Agricultural Journal,* 9(5), 209–215.

Oke, O. E., Oso, A. O., & Akinleye, M. O. (2021). Alternatives to antibiotic growth promoters in poultry nutrition: A review. *Tropical Animal Health and Production,* 53(4), 1–15.

Okoli, C. G., Anyaegbu, B. C., & Ogundu, U. E. (2014). Antibiotic residues in meat and meat products: A review. *Animal Production Research Advances,* 10(3), 125–131.

Olomu, J. M. (2011). Monogastric Animal Nutrition: Principles and Practice. Jachem Publications.

Oloruntola, O. D., Ayodele, S. O., & Agbede, J. O. (2016). Effect of bitter leaf and scent leaf dietary inclusion on performance, blood profile, and antioxidant status of broiler chickens. *International Journal of Livestock Production,* 7(5), 37–43.

Oloruntola, O. D., Ayodele, S. O., & Agbede, J. O. (2016). Performance and Blood Profile of Broiler Chickens Fed Bitter Leaf and Scent Leaf Mixtures. *International Journal of Livestock Production,* 7(5), 37–43.

Oluyemi, J. A., & Roberts, F. A. (2000). Poultry Production in Warm Wet Climates. Spectrum Books Ltd.

Perkins, S. L. (2007). *Examination of the blood and bone marrow.* In: Wintrobe's Clinical Haematology (Greer, J. P., Foerster, J., Rodgers, G. M., Paraskevas, F., Glader, B., Arber, D. A. and Means, Sr., R. T. Editors), 11th Edn. Lippincott Williams and Wilkins, Philadelphia, USA. Chapter 1.

Rasaqda, E.O. and Esmonule, C.N. (2008). Haematological and Serum biochemical responses of young broiler birds fed dietary *Tamarindus indica*. Afr. J. Biotechnol. 7: 4294–4299.

SAS (2013). Version 9.4 - SAS for Windows (2013), Version 9.4. SAS Institute Inc. Cary N.C. USA.

Van Kampen, E.J. and Zillstra, W.G. (1983). Spectro-photometry of haemoglobin and haemoglobin derivatives. *Adv. Clin.*, 23: 197–259. P.O.