THE EFFECT OF THE COMPOSITE LEAF OF *ALOE BARBADENSIS, ALOE ARBORESCENS* AND *ALOE FEROX* AS NATURAL FEED ADDITIVE ON BROILER CHICKEN PRODUCTION

BY

LISEBO SALECIA LETEKETA
201502329

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ANIMAL SCIENCE (ANIMAL NUTRITION OPTION)

DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, THE NATIONAL UNIVERSITY OF LESOTHO

OCTOBER 2024

DECLARATION

I, Lisebo Salecia Leteketa, hereby declare that this Thesis is my original work, approved and supervised by my Supervisor Prof O. I. A. Oluremi, and carried out by me, and has not been submitted to any University or similar institutions for the award of any degree or certificate.

Name of student: ……………………… Registration No: …………………………..

Signature: …………..…………….

Date: ……………………………

DEDICATION

I dedicate this study to the Almighty God for his help and guidance that have seen me through two glorious years of learning. I am ever grateful for his love, guidance and protection all through these years and finally for the grace for this study. This study is also dedicated to my family members, friends and my late parents for their commitment to putting me on the right track. They have been a source of inspiration and encouragement for me.

THESIS APPROVAL

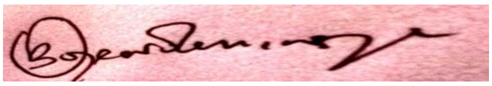
We the undersigned certify that the work in this thesis was done by ‘Lisebo Salecia Leteketa’ under my supervision and be accepted as fulfilling part requirements for the award of degree of Master of Science in Animal Science (Animal Nutrition):

Supervisor:
Prof. O.I.A. Oluremi
Department of Animal Science
Faculty of Agriculture
The National University of Lesotho, Roma, Lesotho.

Signature: ……………………………**Date**: ……………………….

Head of Department:
Assoc. Professor S. M. Molapo
Department of Animal Science,
Faculty of Agriculture,
The National University of Lesotho, Roma, Lesotho.

Signature: …………………………………..**Date**: ………………………………………….

External Examiner: …..………

Date: …………26/10/2024………………

ACKNOWLEDGEMENTS

Firstly, I would like to thank God for his love and wisdom that has helped me sail through this study. I also wish to acknowledge my supervisor, Prof.O.I.A. Oluremi, for his perseverance, sound wisdom, and commitment to help me finish my research. His helpful advice, direction and support made this journey to end well.

I sincerely appreciate the invaluable contributions of all my Postgraduate class lecturers in molding me academically. I also acknowledge the Head of Department A/Prof S. Molapo for the provision of my research materials, and Dean of the Faculty Prof P.M. Dawuda for the provision of enabling study environment for students in the Faculty, of which I am a beneficiary. I would also like to thank the laboratory instructors and demonstrators Mr. Jobo and Mrs. Khati for their insights and assistance during my laboratory work.

Further, I want to express my profound gratitude to NUL farm manager Mr Mahlaha Mahlaha and the staff for their tremendous support.

I also appreciate my colleagues, particularly Mrs. Mabahlakoana Keele, Mr. Sechabasemaketse Qobolo, Mr. Motlatsi Ramochela, Mr. Mona Maphathe and Ms. Makarabo Makhaleme who were highly supportive in the course of my study.

I want to convey my gratitude to my friend Ms. Tiiso Mokonyana for her selfless support in ensuring that this journey became a success. Most importantly, I wish to thank my husband Mr. Mokholoane Sepaee and the entire family for their unwavering support and encouragement during difficult times in my study.

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COVID-19 – Coronavirus disease of 2019

GDP - Gross domestic product

HIV – Human immunodeficiency virus

SI – Small intestine

LI – Large intestine

GIT – Gastrointestinal tract

% DW – Percent dressed weight

% FLW – Percent fasted live weight

mRNA – Messenger ribonucleic acid

ABSTRACT

The study was conducted on the Livestock farm of the National University of Lesotho, Roma, Maseru District, Lesotho to determine the effect of the composite leaf of *Aloe barbadensis*, *Aloe arborescens* and *Aloe ferox* as natural feed supplements on broiler chicken production. 180-day-old Cobb 500 broiler chicks were randomly separated into four groups with a mean body weight of 43.00 g. One group each was randomly assigned to one of four experimental dietary treatments, with three replicates of 15 birds each/treatment. Treatment C was the control where the chicks received 0 mg/L composite leaf powder of aloe species supplement, while treatments T1, T2 and T3 received *Aloe barbadensis*, *Aloe arborescens* and *Aloe ferox* composite leaf powder, respectively mixed with drinking water at the rate of 500 mg/L. These aloe species supplements were administered twice per week on the first day and midweek during a 49-day trial. The three aloe species were analyzed for their nutrient composition, and growth performance, carcass yield, and economics of production data collected were subjected to the One-Way Analysis of Variance (ANOVA) to test for statistical significance at 5% level of probability. *Aloe barbadensis*, *Aloe arborescens* and *Aloe ferox* supplements had no significant ($p>0.05$) effect on the final live body weight, feed intake, body weight gain, feed conversion ratio, mortality rate and the economics of production/benefit cost at the starter, grower and finisher phases. At the finisher phase the *A. barbadensis, A. arborescens* and *A. ferox* had no significant ($p>0.05$) effect on dressed weight, dressing percentage, % DW of back and neck, thigh, drumstick and wing, but had significant ($p<0.05$) effect on breast. Also, *A. barbadensis, A. arborescens* and *A. ferox* had no significant effect ($p>0.05$) on all visceral organs except the % fasted live weight of liver, which varied significantly ($p<0.05$). The use of the composite leaf power of *A. barbadensis, A. arborescens* and *A. ferox* as a dietary supplement in broiler chicken production at a rate of 500 mg/L did not enhance growth and benefit cost. Further research is necessary to investigate the best supplementation level for each of *A.barbadensis, A. arborescens* and *A. ferox* in the broiler chickens diet to enhance broiler chickens performance and economics of production.

Keywords: *A. barbadensis, A. arborescens, A. ferox,* broiler chickens, performance, benefit cost.

CHAPTER ONE

1.0 INTRODUCTION

1.1 FOOD SECURITY STATUS IN DEVELOPING COUNTRIES

The most fundamental necessity for humans is food (Tonukari and Omotor, 2010). Food security is accomplished when all people have physical and economic access to adequate, safe, and nutritious food for a healthy and active life at all times (Donovan, 2000). Food availability, access, quality and ability to utilize are important components of food security. However, food insecurity, which is defined as the lack of food security, can refer to a wide range of events, including starvation, persistent hunger, and unstable food supplies. Population expansion and urbanization, poor health, an outmoded farming system, and political instability are all contributing factors of food insecurity. It is prevalent in poor countries. Food insecurity and poor nutrition affect both rural and urban poor people, and are driven majorly by poverty and absence of nutritional balance in the diets they can access. Deficiencies in micronutrients like iron and vitamin A affect a much broader population. Malnutrition and food insecurity contribute to major public health issues and the underutilization of human potential in emerging nations. Malnutrition prevents populations from leading normal lives and makes them less productive economically and socially, which is a major hindrance to economic and social progress (Tonukari and Omotor, 2010).

Due to high rates of urbanization, urban food insecurity and malnutrition are concerns even in regions with low levels of urbanization, such as Africa and Asia. Millions of urban poor, on the other hand, are sensitive to price increases or significant drops in income, such as those caused by illness or the loss of a primary source of income. High rates of malnutrition and rising rates of diet-related illnesses like diabetes and hypertension in developing nations are caused by a number of factors, including a lack of adequate dietary protein sources, foods high in anti-nutritional elements and toxins, an excessive amount of highly digestible high glycaemic index carbohydrates that make up the staple foods like yams, maize, and rice, and a lack of suitable substitutes (Tonukari and Omotor, 2010). Furthermore, socio-economic factors such as urbanization and migration to urban areas have resulted in modification in lifestyle involving the consumption of imported processed foods as well as alteration in eating patterns and food habits. Protein malnutrition, as well as inadequate vitamin and mineral intake, are challenges in many rural areas. These issues are exacerbated by poor prenatal nutrition, which causes deficiencies in both mothers and children. The nutrient requirements of postpartum nursing mothers are frequently unmet, which results in undernutrition in children (Tonukari and Omotor, 2010).

According to Food and Agricultural Organization (2002), food security in Lesotho is dependent on the availability of employment opportunities as well as adequate supplies. The most food insecure households in Lesotho are those that struggle to generate enough income to meet their food needs. The findings show that from July to September 2020, about 26% of Lesotho's population (380,000 people) will experience severe food insecurity, necessitating immediate humanitarian assistance (Integrated Food Security Phase Classification, 2020). In addition, there are approximately 350,000 people in Crisis and 33,000 people in Emergency (Integrated Food Security Phase Classification, 2020). Lesotho macroeconomic and social problems have been made worse by climatic shocks, unstable political conditions, and sluggish economic growth. COVID-19 has already had devastating economic effects on the nation and will probably continue to do so, including an increase in unemployment as well as declines in income and purchasing power (Integrated Food Security Phase Classification, 2020).

World Food Programme (2023) reported that the El Nino-induced drought has caused a severe food security crisis in Lesotho. Crop failures in successive years, low incomes, and high food prices have made the situation worse, with 41% of rural families now spending more than half their income on food. Lesotho is extremely vulnerable to the effects of climate change, with droughts already affecting harvest yields and resulting in significant livestock losses (World Food Programme, 2023). In rural Lesotho, more than 70% of the population is engaged in subsistence agriculture. From 1990s, productivity has declined as a result of unpredictable weather. Chronic malnutrition costs Lesotho 7.13 percent of its GDP, and approximately 33 percent of children under the age of five are stunted, with low height for their age (World Food Programme, 2023). HIV affects nearly a quarter of the population, with women being disproportionately affected due to gender-based violence (World Food Programme, 2023). Food and Agricultural Organization (2023) has reported that, livestock plays an important role in developing-countries farming systems, providing food and income, draught power, fertilizer and soil conditioner, household energy, and a way to dispose of otherwise unwanted crop residues. It is a significant industry and 12% of the global population relies solely on livestock for a living. Animal products account for approximately 60% of dietary protein in advanced nations, relative to 22% in developing countries (Food and Agricultural Organization, 2023).

Animal products have several advantages over crops. Meat and milk, for example, can be produced year-round and are less seasonal than cereals, fruit and vegetables, and animals particularly small ones, can be slaughtered as needed for food or income (Food and Agricultural Organization, 2023). Furthermore, milk can be preserved as clarified butter, curd, or cheese, and meat can be preserved by drying, curing, smoking, and salting. At the farm and national levels, livestock play a significant economic role. They give farmers what they need such as liquid resources, protection against inflation, technique for lowering crop risks when applied to mixed farming systems, a way for landless households to earn additional money by raising pigs, chickens, and rabbits (Food and Agricultural Organization, 2023). Also, a regular source of income from the sale of milk and meat, the sale of live animals, hides, wool, and meat as a source of sporadic income as well as draught power, transportation, and breeding services, both for the farmer's own use and for rental and possibilities for processing both on and off-farm to increase employment. Increased domestic production of livestock products will lessen the demand for high-cost imports (Food and Agricultural Organization 2002, 2023; Falvey 2015). Livestock has been reported to provide approximately 20% of food energy and 30% of protein (Falvey, 2015).

According to a Technical Report, the best estimate for an average population requirement is 105 mg N/kg body weight per day, or 0.66g protein/kg body weight per day, though protein intake falls far short of this level in many underdeveloped countries (Schonfeldt and Hall, 2012). The two most significant sources of protein in industrialized nations are animal products and cereals, and in poor nations it is the reverse (Schonfeldt and Hall, 2012). As a measure of the composition of diets in low-income nations, just three percent of total dietary energy comes from meat and offal, eleven percent from roots and tubers, six percent from pulses, nuts, and oilseeds. The remaining food energy is primarily sourced from basic foods with a cereal base (Schonfeldt and Hall, 2012). Although animal output has expanded in developing nations, protein consumption is steadily declining. In the poor world, undernutrition which includes insufficient protein consumption has remained a persistent issue (Schonfeldt and Hall, 2012). According to Rothman *et al*. (2018), in Lesotho dried beans are the protein source that over 50% of women in rural and urban areas consumed virtually every day, and participants from cities consume much more chicken, eggs, and full-cream milk.

Thornton (2010) reported that the potential for increased production, increased efficiency, and genetic gains in farm animal production will continue to be influenced by advancements in breeding, nutrition, and animal health. The increase in livestock product yield that has been seen in recent decades has majorly been largely attributed to domestication and the application of traditional livestock breeding methods. For a number of reasons, including the expanded use of technologies like artificial insemination and the increased emphasis on selection for objective traits like milk yield, rates of genetic change have increased in recent decades in most species in developed countries (Thornton, 2010). Dairy cattle have made less progress than poultry and pigs, in developed and some developing countries with more industrialized production systems. Better management of some of the trade-offs that occur at high levels of animal performance, such as those linked to lower reproductive performance, may result from a better understanding of the processes involved in animal nutrition. This study investigated the potential of aloe plant as a phytogenic feed additive in broiler chicken production.

1.2 PROBLEM STATEMENT

Most poultry farmers in Lesotho are challenged with high feed costs, resulting in declining poultry production and the ability to generate table meat to meet and satisfy consumer demand at affordable cost. To close the supply gap, a large amount of poultry meat is therefore imported. Many synthetic and artificial growth promoters, including antibiotics, probiotics, prebiotics, antioxidants, and coccidiostats have been identified. However, the use of growth promoters is restricted or outrightly prohibited due to its harmful residues in animal products which affect meat quality and its ultimate effect on consumer health. Consequently, it is necessary in order to stimulate growth, to identify natural plant resources with significant nutrient ability to enhance meat production and quality, and improve the health of broiler chickens.

1.3 JUSTIFICATION FOR THE STUDY

Aloe plant is rich in many bioactive nutrients, including essential vitamins and minerals which have health benefits such as reduced blood sugar levels and inflammation, and improved antioxidant defenses. The study was to elucidate the potential of the composite leaf of aloe species, a readily available plant resource in Lesotho, as a natural nutrient supplement in place of artificial growth promoters, which are costly and add to the already highly prohibitive cost of feeding broiler chicken. Furthermore, when compared to other livestock industries, the poultry industry is fast yielding in terms of production turnover rate and meat yield.

1.4 OBJECTIVE OF THE STUDY

1.4.1 General objective

To evaluate the effect of the composite leaf of different aloe species as a natural feed additive on broiler chicken growth response.

1.4.2 Specific objectives

a) To determine the nutrient composition of the composite leaf of different aloe species.

b) To assess the effect of composite leaf of aloe species on growth response of broiler chickens.

c) To determine the effect of composite leaf of aloe species on broiler chicken carcass yield.

d) To determine the effect of composite leaf of aloe species on economics of production.

1.5 HYPOTHESES

1.5.1 Null hypothesis: Composite leaf of different aloe species has no effect on broiler chicken growth performance.

1.5.2 Alternative hypothesis: Composite leaf of different aloe species has effect on broiler chicken growth performance.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Broiler Chicken Production in Lesotho

Broiler chickens are birds raised specifically for meat (Myers, 2020). Commercial chicken production has been introduced in Lesotho for decades for production of quality animal protein for human consumption. Both urban and rural small scale poultry farmers are engaged in broiler production for income generation, though production and marketing are still a problem (Rantlo and Bohloa, 2022). Furthermore, chicken meat imports contribute negatively to gross investment in poultry production and the income of farmers is the greatest variable to clarify investment in poultry production (Bello *et al*., 2009). High mortality rate of 9% to 12.7% and condemnation of carcasses due to high incidence of diseases in production stage have been reported to cause very large farmers income losses in Lesotho (Kuleile *et al.*, 2020).

2.2 The Concept of Nutrient Requirements

The observation and description of a nutrient requirement have changed from originally being a requirement, as a percent of a diet, to preventing a nutrient deficiency, to now being a requirement to enhance growth or egg production response per unit of nutrient intake (Applegate and Angel, 2014). Table meat chickens grow quickly, and their nutrient requirements change daily and increasing the number of diets to meet table meat nutritional requirements more precisely improves the efficiency of production (Moss *et al.*, 2021). Tikate *et al*. (2021) justified that multiple phase-feeding improved broiler growth performance. Abdollahi *et al*. (2019) opined that feed form influences nutrient requirements and there is a need to determine the nutrient requirements of broilers using pelleted diets.

2.2.1 Nutrients Requirement for Broiler Chicken Production

The nutrient requirements of broiler chickens from week 0 to 8 are presented at Table 2.1.

Table 2.1: Nutrient requirement of broiler chickens

Nutrients	**Weeks**		
	0-3	**3-6**	**6-8**
Energy Kcal ME/kg	3,200	3,200	3,200
Crude protein %	23.00	20.00	18.00
Lysine %	1.10	1.00	0.85
Methionine %	0.50	0.38	0.32
Linoleic acid %	1.00	1.00	1.00
Calcium %	1.00	0.90	0.80
Phosphorus %	0.45	0.35	0.30
Vitamin A IU	1,500	1,500	1,500
Vitamin D_3 IU	200	200	200
Vitamin E IU	10	10	10
Vitamin K mg	0.50	0.50	0.50

NRC (1994)

2.2.1.1 Protein

Protein is an important nutrient in broiler production (Selim *et al.*, 2016). This is supported by Paraskeuas and Mountzouris (2019) where broiler performance was adversely affected by a reduction in crude protein (CP) in the diet. According to Azevedo *et al.* (2021); Hien *et al.* (2017), proteins maximize economic returns by improving growth performance, immune response and carcass characteristics (El-Katcha *et al*., 2017). Amino acids are building blocks of protein and play a role in regulation of body protein turnover (Zeitz *et al.*, 2019). They are necessary in improving the immunity of broiler chicken (Toghyani *et al.*, 2019). Trophic amino acids such as threonine, arginine and glutamine are necessary for modulation of intestinal physiology and control of immune system activity (Bortoluzzi *et al*., 2018; Ji *et al*., 2019). On the other hand, sulphur-containing amino acids are required for broiler welfare and performance (Ghavi *et al.*, 2020, 2021). Essential amino acids also play a role in nutrient digestibility and carcass quality of table meat chicken (Opoola *et al.*, 2017).

2.2.1.2 Carbohydrates

Energy is highly required by the intestines of broiler (El-Katcha *et al*., 2017; Bortoluzzi *et al.*, 2018). This is supported by Paraskeuas and Mountzouris (2019) who opined that broiler performance was adversely affected by a reduction in dietary ME. Energy improved growth performance (Hien *et al.*, 2017), immune response and carcass characteristics (El-Katcha *et al*., 2017). Fermentable dietary fibre increases production of short chain fatty acid concentrations in broiler (Walugembe *et al.*, 2015). According to Rostamkhani *et al*. (2024), early feeding of highly available carbohydrate source dextrose improved successive growth performance and carcass indices of broiler chickens. Karunaratne *et al*. (2023) suggested that b-glucanase in diet can improve the health of broilers fed wheat-based diets without medication. The refined functional carbohydrates and antibiotic growth promoters group significantly improved average daily gain of broiler chickens during day 22 to 45 compared to control (Zhen *et al*., 2023).

2.2.1.3 Minerals

Calcium is significant in the growth, bone development and other body functions in animals (Tancharoenrat and Ravindran, 2014). According to Lu *et al*. (2020), broilers can perform well on reduced levels of trace minerals in the form of organic trace minerals which are beneficial for broiler performance, economics, and mineral retention. The use of coated trace minerals on a descending pattern can save supplemental Cu by 80%, Zn and Mn by 72%, without negative impact on performance, carcass traits and footpad health (Ruangpanit *et al.*, 2023). The dietary supplementation of 500 ppm organic minerals along with 2,000 ppm betaine produced significant improvements in growth performance (Nollet *et al.*, 2007) and mineral digestibility of broiler chickens, despite the prevailing thermal conditions (Saleh *et al.*, 2023). Bao *et al*. (2007) added that supplementation with 4 mg of Cu and 40 mg each of Fe, Mn, and Zn from organic sources could be adequate for normal broiler growth to avoid high levels of trace mineral excretion. The combination levels of minerals and vitamins supplementation might improve the effects of heat stress on broilers chickens (Saiz del Barrio *et al.*, 2020). In addition, supplementation of 100 mg Zn/kg of diet and 300 mg - tocopheryl acetate/kg of diet would improve lipid oxidation in broiler tissues along with increase in humoral and cellular immune responses without any adverse effect on fatty acids profile of meat (Akbari *et al.*, 2016). Kim *et al*. (2017) reported that increasing Ca concentrations from 6.0 to 10.0 g/kg in phytase-containing diets had negative effects on growth performance of broiler chickens during 21 days post-hatch, possibly due to decreased feed intake and following phytase intake. Groff-Urayama *et al*. (2023) reported that the inclusion of 150 ppm Cu hydroxychloride has the possibility to improve the FCR and decrease leg injuries. Sholikin *et al*. (2023) suggested that clay minerals can be used as a growth promoter, specifically during the finisher phase, without harmfully affecting feed intake, liver function, and mineral metabolism in broiler chickens. Zha *et al*. (2023) suggested that palygorskite-based composite might increase growth performance, antioxidant capacity, and meat quality of broilers, and its recommended dosage is 1,00mg/kg.

2.2.1.4 Fat

High oleic full-fat soybean meal might help as a valuable alternative feed ingredient to the conventional solvent extracted soybean meals in broiler diets, providing additional energy while providing amino acids and more oleic acid to improve poultry meat products (Ali *et al.*, 2024). Elmore *et al*. (2023) supported the use of refined, bleached, and deodorized soy oil, ExPress soy oil, and mechanically - processed soy oil products to stimulate performance and digestibility as compared to saturated C16:0 and C18:0 fatty acids products. According to Aprianto *et al*. (2023), growth performance and carcass characteristics of broiler chicken that received 1% black soldier fly larvae oil calcium salt were not negatively affected but experienced reduced fattening in meat and increased blood biochemical profiles.

2.2.1.5 Vitamins

Vitamin A influenced growth performance, meat quality, immune function in progeny broilers (Wang *et al.*, 2020), serum low-density lipoprotein content and the activity of aspartate aminotransferase and creatine kinase and reduced the levels of serum phosphorus, uric acid and alkaline phosphatase in necrotic enteritis-challenged birds (Guo *et al.*, 2023). Vitamins C and E and minerals Zn and Se enhanced the performance of birds due to a lower FI resulting in better FC (Laganá *et al*., 2007). The use of NMV in the diet of broiler chickens could increase the growth performance of broiler chickens at the starter period (Samani *et al.*, 2016). The combination of vitamins E and A supplementation provided a good management practice to decrease heat stress-related decreases in broiler performance (Sahin *et al*., 2001). Supplementation with Vitamin C at 40mg/bird/day in drinking water decreased the impact of heat stress significantly and increased the performance of broilers under the tropical conditions of Cambodia (Vathana *et al*., 2002). Similar results were obtained by Lohakare *et al*. (2005) where supplementation of ascorbic acid at 200 ppm improved the performance and immunity and exploited the full genetic potential of the commercial broilers. Vitamin C supplement was reported to be most effective than Vitamin E, and their combination to overcome thermo-physiological responses of the broiler chickens (Ijadunola *et al*., 2020). Broilers supplemented with folic acid had reduced fat deposition (Liu *et al.*, 2023). Kumar *et al*. (2023) observed that long-term vitamin D3 (21 days) supplementation in broiler chicken dietresulted in progressive emaciation, elevated haemoglobin, hypercalcemia, hypophosphatemia, and increased alkaline phosphatase activity.

2.3 Use of Phytogenic Feed Additives/supplements in Livestock and Poultry Production

Herbs are intensively investigated as feed supplements that can be used to substitute antibiotics in order to enhance poultry immune response (Darabighane *et al*., 2015; 2017). These supplements can be incorporated in poultry feeds or drinking water to improve the growth rate and well-being of birds (Amber *et al.*, 2021). Phytobiotics can be used as essential oils, part of the plant or the whole plant (Singh *et al*., 2013). Meimandipour *et al*. (2017) added that herbal extracts are used to improve feed conversion efficiency of poultry through their antimicrobial effects and stimulation of digestion. Gowri *et al*. (2023) stated that additives from herbal origin can be used in place of synthetic feed additives to counteract the effects of heat stress in broiler chicken. Moreover, Darabighane *et al*. (2015) said that feed additives have been used to improve the immunity and pathogen resistance of broilers. Some of the herbal supplements such as peppermint have been used for their antioxidant, antitumor, anti-allergy, antiviral, antibacterial and fungicidal characteristics and treatment of both internal and external parasites as well as digestive diseases such as coccidiosis in broiler (Darabighane *et al*., 2015). Aloe vera plays a role in fighting inflammatory condition, stimulation of immune response and control of coccidiosis in chickens (El Hawary *et al*., 2017). Phytomedicines are found to be cheap, affordable, safe and impose minimum side effects (Sharma *et al*., 2018). Rosemary plant has been reported to function in prevention of both enzymatic browning and microbial growth in cultures due to its chemical composition, antioxidant effect and anti-infectious properties (Hattingh *et al.*, 2023). *Aloe ferox* is used for commercial purposes including use as a food additive (Goge *et al*., 2023). Phytogenic feed additives improved plasma and meat total antioxidant capacity, reduced plasma cholesterol (Paraskeuas *et al.*, 2016) and are used to correct effects of ME and CP deficiency (Paraskeuas and Mountzouri, 2019). The inclusion of *Anoectochilus roxburghii* extract in the diet did not have any significant effect on meat yield. However, reduced abdominal fat deposition and improved meat quality were observed by Wu *et al*. (2023). Ye *et al*. (2017) found out that *Anoectochilus roxburghii* is mainly composed of polysacchides, flavonoids, glycosides, organic acids, volatile compounds, steroids, triterpenes, alkanoids and nucleosides. Geravand *et al*. (2021) found that 200 mg of lavender essential oil increased feed intake, weight gain and FCR compared to 400 mg lavender essential oil and control groups. Body weight gain and FCR were enhanced by *Yucca schidigera* extract (Allam Abd El-Dayem *et al.*, 2021). Garlic powder at the concentration of 0.3% increased body weight, body weight gain and feed conversion ratio (Kairalla *et al.*, 2022). Qin *et al*. (2023) reported that mulberry leaf extract can be engaged as a viable fat loss feed supplement in fast-growing broiler diets since it reduces abdominal fat deposition and changes the fatty acid profile in female Arbor Acres broilers. Mahasneh *et al.* (2024) observed that olive oil and its derivatives incorporated in broiler diets (up to 10%), are a valuable constituent of the growth-promoting effect. Liu *et al*. (2023) found that dietary monoglycerides enhanced chicken performance, health and feed nutrient utilization at early ages by regulating gut microbiota, intestinal development and serum biochemical indices. Organic acids supplemented to broilers improved performance (Shabaan, 2017). Adil *et al*. (2010) indicated that organic acids supplementation had positive effect on broiler chickens' performance regardless of the type and level. The addition of organic acids in water or feeds improved growth performance in broiler chickens compared to the control (Paul *et al*., 2007; Woong *et al.*, 2015; Mustafa *et al*., 2021), health status (Adhikari *et al*., 2020; Ali *et al*., 2020; Sureshkumar *et al.*, 2021), and no significant differences on carcass characteristics (Hrnčár *et al.*, 2012). Enzymes such as phytase and non-starch polysaccharide degrading enzymes alleviate the negative effects of phytic acid and non-starch polysaccharides found in plants used to make feeds (Woyengo *et al.*, 2019). Leyva-Jimenez *et al*. (2024) observed that supplementation of multi carbohydrase enzymes to energy-reduced broiler diets maintained growth performance and showed positive effects to improve breast yield. However, the grain type, fibre, and multienzyme supplement did not affect growth in broilers (Njeri *et al.*, 2023). Enzymes (carbohydrases and phytase) supplementation in broiler diets helped to decrease feed energy levels without affecting performance parameters, apparent metabolizable energy corrected for nitrogen, and morphometry characteristics of the jejunum (de França *et al.*, 2023). Also, phytase and nonstarch polysaccharides degrading enzyme function synergistically in the gastrointestinal tract of broiler, resulting in better digestion and absorption of nutrients (Poernama *et al.*, 2021). In addition, phytase supplementation in broiler production alleviated the negative effects on growth performance, improved phosphorus digestibility and bone ash content (Cozannet *et al*., 2023; Dersjant-Li *et al*., 2018) and reduced total mineral excretion (Gulizia *et al.*, 2022). Dai *et al*. (2023) stated that dietary supplementation of phytosterols may increase the growth performance and decrease the abdominal fat yield of broilers by altering their intestinal epithelial structure, lipid metabolism and bacterial community. In addition, dietary supplementation with *Bacillus subtilis*, *Astragalus membranaceus*, and enzymes additives may increase the growth performance of broilers during specific phases (Tian *et al*., 2023). The addition of microalgae with or without xylanase to broiler's diet may stimulate growth performance (Chaudhary *et al.*, 2023) gut health parameters (Mishra *et al.*, 2023) and had no effect on serum immunoglobulins and cecal short-chain fatty acids production in broilers (Mishra *et al.*, 2024). Supplementing broiler chicks with a dietary *Dunaliella salina* and *Spirulina* combination improved their productive performance and immunity (Alghamdi *et al.,* 2024). Supplementation of wheat bran diets with multi-enzyme increased FCR, blood serum, and decreased cholesterol (Idan *et al.*, 2023). Liu *et al*. (2023) found that dietary polyherbal mixtures supplementation increased growth performance and immune status of yellow-feathered broilers. Kithama *et al*. (2023) reported that low-bush wild blueberry improved body weight during the starter phase, while organic American cranberry improved body weight in the grower phase. Zdanowska-Sąsiadek *et al*. (2016); Sadiq *et al*. (2023) reported that vitamin E supplementation did not influence growth performance and immunity in broiler chickens but improved sensory attributes and quality of chicken meat (Pompeu *et al.*, 2018). However, Selvam *et al*. (2017) reported that supplementation of vitamin E at 70 g/ton could successfully reverse the negative effects of high stocking density, and increase broiler performance. Khalifa *et al*. (2021) stated that dietary Vitamin E and Selenium supplementation significantly enhanced broiler growth performance and carcass composition, and reduced heat-related mortality (Calik *et al.*, 2022).

2.4 Distribution and Agronomic Description of Aloe Species

Among the *Asphodelacea* family, aloe is the largest genus and it is found in more than 400 species (Fayisa and Mirete, 2022). Aloe is found naturally in Africa and the Indian Ocean islands (Hamdeni *et al*., 2022a), and South Africa and South America (Mukherjee *et al*., 2023) and well distributed in Egypt (El Sayed *et al.*, 2016). Aloe species are perennial succulent plants that can grow into forbs, shrubs or trees at varying altitudes. They are mostly characterized by bulgy fleshy leaves which have spikey edges and boat-shaped cross-sections (Adetunji *et al*., 2022). They have regular flowers with free tepals (Fayisa and Mirete a, 2022) and short stems (Zhao *et al.*, 2016). The most extensively cultivated species of aloe are *Aloe barbadensis*, *Aloe arborescens* according to Lucini *et al.* (2015) and *Aloe ferox* according to Fan *et al.* (2018). Aloe vera also known as medicinal aloe is a species of succulent plants that probably originated in south half of the Arabian Peninsula, Northern Africa, Cape Verde. Aloe vera grows in arid climates and is widely distributed in Africa (Abdollahi *et al*., 2014). Aloe vera is easily available during summer (Gowri *et al*., 2023).

2.4.1 Aloe vera

Aloe barbadensis Mill belongs to the *Liliaceae* family (Shahrezaee *et al.*, 2018) and is the most known species of the genus Aloe (Lavanya *et al.*, 2019), which comprises more than five hundred species including several medicinal plants (Hamdeni *et al.*, 2022b). It is a perennial plant and grows up to a height of about 80 to 100 cm and dispersing with root shoots (Mukherjee *et al*., 2023). It is composed of thick, fibrous root system in nature (Lavanya *et al*., 2019). It has thick leaves with sharp points, spiky edges and are up to 18 inches long and 2 inches wider at the base of the leaf that is triangular in shape (plate I). El Hawary *et al.* (2017) observed that the younger plant leaves have dotted surface. These leaves are characterized by a thick epidermis preserved by a cuticle consisting of cells with thinner walls, creating the parenchyma and chlorenchyma cells (Rajesh *et al.*, 2023). The parenchyma cells in the fleshy part of Aloe vera leaves contain the gel that consists principally of water (> 98%) in which a variety of polysaccharides are dissolved (Singh *et al*., 2022) including acetylated polymannose (*aloverose*) according to Hattingh *et al*. (2023). High content of water gives the plant the capacity to survive for extended years (Lavanya *et al.*, 2019). The top layer referred to as the rind, contains the phloem, xylem, and vascular bundles that transport nutrients (Khan *et al.*, 2023). El Hawary *et al.* (2017) discovered that mature aloe vera plants bear yellow flowers.

Plate I: Aloe vera (*Aloe barbadensis*)

2.4.2 Bitter aloe

Aloe ferox commonly known as Cape Aloe or Bitter Aloe belongs to the *Asphodelaceae* family, and it is a South African indigenous medicinal plant with more than 900 species ranging from small shrub-like plants to large trees (Goge *et al*., 2023). It is mostly found in Eastern Cape Province of South Africa (Jia *et al.*, 2008). It is characterized by single tree- like stem and fleshy leaves surrounded by reddish spines. In addition, flowers have white tipped inner petals, carried in large flower-head. These flower heads are carried by branches ranging in number from five to eight (Puia *et al.*, 2021) (plate II). It has erect racemes of red, yellow and orange or rarely white flowers with curved thorny leaves (O'Brien *et al.*, 2011).

Plate II: Bitter aloe (*Aloe ferox*).

2.4.3 Candelabra aloe

Aloe arborescens belongs to the family *Asphodelacea* and it is abundant in South Africa (Lazzara *et al.*, 2023), Malawi, Lesotho, Mozambique and Zimbabwe (Maliehe *et al.*, 2023). It is a perennial fleshy flowering plant which grows in a wide range of environments to about 3 to 5 meters (Lazzara *et al*., 2021; 2023). The shrub has many greyish-green branched-leaves with yellow margins (plate III). The leaves are composed of the rind (outer part) and parenchyma (inner part) (Maliehe *et al*., 2023). The leaves produce exudate and inner mesophyll or gel. Moreover, the leaves grow in alternative pattern in dense rosettes at the branch apex with the length of about 50 to 60 centimeters (Lazzara *et al.*, 2021). The leaves from the median section of the plant are larger with a high number of spikes, epidermis and heavier gel. The inflorescences are distinguishably inverted-cone shaped, and the flowers are pencil-shaped and quite long. The flowers have a colour ranging scarlet to yellow, through many hues of red, orange, light salmon-pink, and apricot.

Plate III: Candelabra aloe (*Aloe arborescens*).

2.5 Chemical and Nutritive value of Aloe Species

Aloe species contain phenolic molecules that may have biological and toxicological properties, including flavonoids, simple and complex polysaccharides, minerals, vitamins, hydrocarbons, fatty acids, indoles, pyrimidines, aldehydes, ketones, dicarboxylic acids and alkaloids (Tizazu and Bekele, 2024). They are characterized by antioxidant, anti-inflammatory and anti-bacterial properties. The anti-microbial qualities in aloe species prevent or stop the multiplication of germs due to a number of chemicals they contain. These diverse phytochemicals make them useful for medicinal purposes (Tizazu and Bekele, 2024).

2.5.1 Aloe vera

Aloe vera is characterized by a significant number of biologically-active compounds (Singh *et al*., 2013). Gowri *et al*. (2023) reported that aloe vera contains an array of free fatty acids, steroids, polysaccharides such as acemannan, saponins, lignin, anthraquinones, salicylic acid and vitamins A, B1, B2, B3, B6, B12, C, E, folic acid, choline, and minerals calcium, copper, iodine, iron, and magnesium. It also consists of hormones auxins and gibberellins, and four types of plant steroids cholesterol, campesterol, β-sitosterol, and lupeol (Lavanya *et al*., 2019). Aloe vera produces monosaccharide such as glucose and fructose, glycoproteins with antiallergic properties known as alprogen and anti-inflamatory compound C-glucosylchromone. The intermediate layer known as “sap” (aloe latex) contains a bitter liquid that takes the form of a yellow substance (Khan *et al*., 2023). The yellow exudate is used as a laxative and cathartic (Ahl *et al.*, 2023). Aloe vera gel’s solid component has an average pH of 4.55 (Khan *et al*., 2023).

2.5.2 Bitter aloe

It consists of barbarloin (Goge *et al*., 2023), polysaccharides, phenolic substances, vitamins, minerals, sugars, proteins and saponins (Khan *et al*., 2023). Chang *et al*. (2011) observed that there was high glucose content in gel juice and galactose from the skin juice, two of which constitute neutral polysaccharides. Juices from gel and skin contain acidic polysaccharides such as glucuronic acid, galactose, glucose, mannose and xylose. It is characterized by the leaves consisting of two main parts; inner leaf gel contains polysaccharides and the exudade which contains chromones and anthrones (Viljoen *et al*., 2022). It contains polyphenols which have antioxidant properties (Tizazu and Bekele, 2024). Bitter aloe possesses laxative effects, antibacterial, anti-inflammatory, anticancer and antioxidant activities (Brendler and Cock, 2022).

2.5.3 Candelabra aloe

Aloe arborescens leaf extracts have antioxidants properties, anti-inflammatory therapeutic properties (Tizazu and Bekele, 2024), anticancer, immunomodulator and antidiabetic activities (Nazeam *et al*., 2017). It possesses wide array of chemicals including phenolics, polysaccharides, glycoproteins, carboxypeptidase enzyme (Nazeam *et al*., 2017) and high content of aloinin (Cardarelli *et al*., 2017). It also contains free carbohydrates and organic acids (Olennikov *et al*., 2009). Maliehe *et al*. (2023) reported that the leaf extract has the ability to serve as a source of antibacterial and antioxidant compounds. Furthermore, it has wound healing properties, anti-ulcer, anti-inflammatory, anti-cancerous and alopecia-relieving properties. In addition, *Aloe arborescens* possesses antimicrobial and scab healing properties (Fernandes *et al*., 2020).

2.6 Processing of Aloe Species for Use as Feed Additive

Aloe vera can be processed using traditional hand filleted, whole leaf and total process aloe vera processing (Ramachandra and Rao, 2008). Aloe vera can be harvested every six to eight weeks by cutting three to four leaves per plant (Chandegara and Varshney, 2013). According to Onyeji *et al*. (2022), the mature leaves are harvested by cutting them at base with the pocket knife and can be prepared by cutting its leaves vertically to extract the gel. The gel is then sun dried and ground to produce fine powder (Rashid *et al.*, 2014). Whole leaf aloe vera processing begins by placing the whole leaf in a Fitz Mill grinding unit that crushes the entire leaf into a soup-like structure (Ramachandra and Rao, 2008). Whole leaf aloe vera can also be processed by freeze-drying technology (Chen *et al*., 2017). Oven drying can be employed to produce aloe vera gel by first removing gel pulp from the epidermis using a knife. The pulp is then cut into smaller pieces and the gel is extracted by squeezing the pulp. A nylon cloth is then used to filter the gel. The filtered gel is then mixed with 95% ethanol and the mixture is dried at 60^0 C in the oven for 24 hours (Otálora *et al.*, 2021). According to Mohamed *et al*. (2017), mature whole fresh aloe vera leaves were collected and cleaned using tap water, placed in 105^0 C heated oven to dry and ground in to powder.

2.7 Limitations to the Use of Aloe species

Meimandipour *et al*. (2017) reported that use of herbal extracts has limitations due to the reactive and volatile characteristics of bioactive compounds and their negative effects on palatability and feed intake due to feed taste alteration. According to Lavanya *et al*. (2019), aloe vera cause intestinal problems. The aloin present in aloe vera and aloe ferox is believed to cause diarrhea due to increased gastric motility (Nalimu *et al*., 2021). *Aloe ferox* harvesting and global trade statistics are lacking (Goge *et al*., 2023). There is also lack of information to farmers based on cultivation, agricultural practices and economic benefits of aloe vera (El Hawary *et al*., 2017).

2.8 Effect/Utilization of Aloe as a feed additive on the production of broiler chickens

Most studies on aloe have focused more on the effect of aloe vera on poultry performance, whereas studies on bitter aloe and candelabra aloe were conducted in human beings for medicinal purposes. *Aloe ferox* has medicinal and pharmacological properties (Goge *et al*., 2023), such as anti-inflammatory, laxative, antibacterial and antifungal and prevents the development of cardiovascular diseases, diabetes, cancer and other inflammatory diseases (Mhaladi *et al*., 2013).

2.8.1 Growth performance of broiler chickens

Specific feed additives can be incorporated into poultry feeds to achieve high levels of production and feed conversion efficiency (Shabaan, 2017). Darabighane *et al.* (2017) explained that the use aloe vera could improve the health of digestive system microflora, creating a healthy intestinal environment, therefore, enhancing growth performance and improving the birds' immune response. This is due to the positive influence they exert on the morphology of the intestines and improved absorption of nutrients (Quaye *et al*., 2023). Gowri *et al*. (2023) evaluated that feed intake declined in herbal treated groups in the first weeks of the trial, however, in weeks 5 and 6, feed intake increased significantly in treated groups than the untreated group. Water intake was reduced in the presence of aloe vera treated group than the untreated and other treatment groups. The body weight gain of broilers at week 4 was significantly higher when fed aloe vera (122g/bird) compared to other treatments (99, 103 and 121g/bird for control, rough lemon juice and amla juice, respectively). Similar results were obtained by Akhtar *et al.* (2012) where aloe vera increased body weight gains and antibody titres. Aloe vera powder at 1.5% concentration of basal diet resulted in higher weekly feed intake and body weight gain, higher body weight and better feed conversion ratio (Bhargande *et al.*, 2022). However, Mohamed *et al*. (2017) reported that aloe vera leaf powder did not affect growth performance. Darabighane *et al*. (2017) found out that grower broilers that received medicinal plants had higher feed intake, body weight gain and dressing percentage than the untreated group. In the study, aloe vera gel came second to the use of antibiotics in producing high body weight gain, but the differences between treatments were not significant. A lower FCR was observed in aloe vera gel when compared with the use of antibiotics, and a non-significant difference with the control group. Feed and water intake, body weight gain and FCR were not significantly different in oxytetracycline and two levels of aloe vera extract (0.5% and 1%) treated groups (Quaye *et al*., 2023). Gowri *et al.* (2023) observed that FCR was better in aloe vera treated group compared to the other treatments of rough lemon juice and amla juice.

It was revealed that increasing both nanoencapsulated and non-encapsulated herbal extracts to 0.05% in finisher diets enhanced body weight gain in the time period of 28-42 days. However, in that period, birds fed a diet containing nanoencapsulated dill extract had a significantly higher body weight gain compared with the antibiotic group. Feed conversion efficiency was enhanced by all treatments of nanoencapsulated and non-encapsulated herbal extracts with only nanoencapsulated nettle producing significant increase compared to the antibiotic group (Meimandipour *et al*., 2017). Quaye *et al*. (2023) found out that internal organs' weights were not different between oxytetracycline and aloe vera at different concentrations. Body weight gain and FCR were enhanced by aloe vera gel (Khan *et al.*, 2023).

2.8.2 Carcass yield of broiler chickens

A group of broilers supplemented with aloe vera showed higher dressing percentages than the control and drug-treated groups (Singh *et al*., 2013). Birds fed aloe vera gel had significantly higher dressing percentage compared to the control group (Darabighane *et al*., 2017). Meimandipour *et al*. (2017), reported that there was no significant effect on different carcass traits and relative organ weight, including percentages of carcass, breast, thigh, liver, intestines and total gastrointestinal tract for both non-encapsulated and nanoencapsulated extracts in the diet whereas, the nanoencapsulated and non-encapsulated extracts increased liver weight compared to untreated and antibiotic groups. Carcass traits were not significantly different in oxytetracycline and two levels of aloe vera extract (0.5% and 1%) treated groups (Quaye *et al*., 2023). Similarly, aloe vera leaf powder did not affect carcass traits (Mohamed *et al*., 2017).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site and Geographical Location

The study was carried out at National University of Lesotho Livestock Farm in Roma, Maseru District, Lesotho. It is about 34 kilometers from Maseru the capital of Lesotho (Vusi, 2019). Roma is located in Lesotho's lowlands and lies between 1400 m and 1800 m in altitude (Lesotho Meteorological Services, 2022). The area experiences a hot summer from September to April and a cold winter from May to August (RCRC, 2021). It has an average yearly temperature of 12.8°C and an average monthly temperature range of 15°C (November to March) to 6°C (June to July) according to Climate Change Knowledge Portal (2021). The average yearly precipitation is 761.2 mm, with the heaviest rainfall falling from October to April and the lowest amounts of precipitation falling from May to September. During summer thunderstorms, high winds of up to 20 m/s might be expected (Climate Change Knowledge Portal, 2021).

3.2 Experimental Animals and Management

The feeding trial involved 180-day-old Cobb 500 broiler chicks bought from a reliable hatchery. The experimental pens were cleaned and disinfected before the arrival of chicks, and light source and heaters installed. Heating equipment was turned on just before the chicks arrived and adjusted to offer the recommended poultry house temperature for the chicks. On arrival, the average live body weight was determined by weighing them with a sensitive balance scale (Electronic Floor Scale, FLS and FLC SERIES). They were then divided into groups of 15 chicks of equal weight and randomly allocated to 12 deep litter experimental pens with wood shavings as bedding. Clean water in water troughs was provided with anti-stress and coccidiostat when the birds arrived. Clean water and diet treatments were served *ad libitum* for a 7-weeks feeding trial. The feeders were cleaned and disinfected weekly.

3.3 Experimental Diets and Treatments Preparation

Commercial brand feed types were purchased from a reliable vendor to guarantee the birds' health and biosecurity. For the broiler starting phase, a commercial brand's crumb type feed was utilized, while commercial brand pellet type feed was used in grower and finisher phases. Feed ingredients and nutrients level in the feed types were identified by the feed tag on the bag. The composite leaves of aloe used as natural feed additive in the powdered form were obtained from aloe vera (*Aloe barbadensis*), candelabra aloe (*Aloe arborescens*), and bitter aloe (*Aloe ferox*). Mature fresh leaves of aloe vera (*Aloe barbadensis*), candelabra aloe (*Aloe arborescens*) and bitter aloe (*Aloe ferox*) were gathered at Matlameng in Leribe District and at Mafikeng and Thoteng in Maseru District. Their leaves were cut at the base of the stem with a clean sharp knife and collected in plastic bag. Thereafter, the leaves were washed and placed on clean flat surface to remove sharp spines along the edges. The aloe leaves were sliced into smaller pieces with the knife and oven-dried at 165 degrees Celsius for 10 hours giving a dark brown colour and 7% moisture content. Thereafter, they were pulverized using a grinder and mixed with water at a rate of 0 mg/L in the control treatment (C) group and 500 mg/L of *A. barbadensis* in dietary treatment 1 (T1), 500 mg/L of *A. arborescens* in dietary treatment 2 (T2) and 500 mg/L of *A. ferox* in dietary treatment 3 (T3) for each growth phase.

3.4 Design of the experiment

One hundred and eighty (180) experimental chicks were randomly separated into four groups on similar body weight of 43 g and one group each randomly allotted to one of four experimental treatments: C, T1, T2, and T3. Each experimental group included three replicates of 15 birds. Group C represented the control where the chicks received 0 mg/L natural feed additive, T1 received aloe vera powder, T2 received candelabra aloe powder and T3 received bitter aloe powder each mixed with drinking water at the rate of 500 mg/L. These aloe species were administered twice per week on the first day and midweek.

3.5 Collection of data

Data were collected on chemical nutrients of the aloe species, and growth response, carcass yield and economics of production in meat type chickens. Also mortality was recorded.

3.5.1 Proximate composition of aloe species

Proximate composition of the aloe species was carried out using Haque *et al*. (2014) procedures.

a) Moisture

% Moisture = $\frac{100(W1-W2)}{W2}$

W_1: weight of sample before drying

W_2: weight of sample after drying.

b) Dry matter

Dry matter =100 - % moisture content

c) Ash

Ash content was as described by Haque *et al*. (2014).

d) Crude fibre

Crude fibre was determined using Bello *et al*. (2020) procedure.

% Fibre = Dry weight – Ash weight x 100

e) Crude fat

Fat content was determined using Soxhelt apparatus.

% Crude fat = $\frac{100(X-F)}{W}$

X = flask weight with fat and chips

F = weight of flask and chips

W = sample weight

3.5.2 Mineral analysis

The minerals of aloe species were analyzed using the procedures of AOAC (2000).

a) Phosphorus was determined using spectrophotometer.

Formula:

P = $(Abs * CF * DF * DF)/Atomical\ weight\ of\ phosphorus$

CF = Absorbent reading of the spectrophotometer

DF = Conversion factor

CF = 0.61 DF = 25

b) Calcium was determined using EDTA methods.

Formula:

% Ca = $\frac{TV*0.01}{20ml} * 1000$

TV = Titre volume of calcium

0.01 = standard EDTA concentration

1000= unit measurement

20 = Aliquot sample

3.5.3 Growth performance

a) The initial and final live weights of chickens per replicate were taken at the start and at the end of the experiment, respectively using an Electronic Floor Scale, FLS and FLC SERIES weighing scale. Furthermore, live body weight per replicate was taken weekly.

b) Average body weight gain (ABWG) was calculated per replicate weekly by the difference between the live weight of the current week (LBWc) and body weight of the previous week (LBWp) divided by the number of birds (N).

ABWG = $LBWc - \frac{LBWp}{N}$

c) The total body weight gain (TBWG) was determined using the difference between the final live body weight (LBWf) and initial live body weight (LBWi).

TBWG= $LBWf - LBWi$

d) Feed intake (FI) was determined by difference between weight of feed supplied (FS) and weight of the feed leftover (FL).

FI =$FS - FL$

e) Average feed intake (AFI) was calculated as

$$FS - FL/N \times 42$$

Where,

N = Number of birds

42 = Number of experimental days

f) Feed conversion ratio (FCR) was computed using average feed intake and average weight gain by the birds in each replicate using the formula;

FCR = $AFI/ABWG$

g) Mortality in percent:

$$\% \text{ Mortality} = \frac{Number\ of\ dead\ chicken}{Number\ of\ chicken\ per\ replicate} \times 100$$

3.5.4 Carcass evaluation

Carcass evaluation was done at the end of the feeding trial/finisher phase. Two birds from each replicate per treatment were selected based on the average group body weights as indicated by Galadima *et al.* (2020). Birds were deprived of feed for 18 hours but supplied drinking water. Fasted live body weight was taken and chickens bled by ventral neck cut with a knife, then was manually de-feathered after scalding with hot water (70˚C) for 20 seconds. De-feathered birds were weighed and eviscerated. The eviscerated weight was also taken. Carcass was cut into prime parts; breast, thigh, drumstick, wing, neck and back. These parts were weighed and expressed relative to the dressed weight. Dressing percentage was calculated using the formula;

$$\text{Dressing } \% = \frac{Dressed\ weight}{Live\ weight} \times 100$$

The weight of each of empty gizzard, liver, proventriculus, lungs, visceral fat and gastrointestinal tract was taken and expressed relative to the fasted live body weight. The length of gastrointestinal tract, small intestine, large intestine and caeca was taken. The length of small intestine, large intestine and caeca was each expressed as % of the gastrointestinal tract length.

3.5.5 Benefit cost

Benefit cost was evaluated at the end of the feeding trial/finisher phase using the formula of Kondo *et al*. (2015).

(π) = TVP – TC

Where;

(π) = Profit/Net revenue

TVP = Total value product

TC = Total cost of production

3.6 Statistical Analysis

The data generated in the study were entered in Microsoft Excel Spreadsheet. The response variables were subjected to one-way ANOVA with four dietary treatments as the main effects using the SPSS (2011) version 20. Means separation of the significantly ($p<0.05$) different indices was carried out using Least Significance Difference (LSD).

CHAPTER FOUR

4.0 RESULTS

4.1 Nutrient Composition of Aloe species: *Aloe barbadensis, Aloe arborescens* and *Aloe ferox* whole leaf powder

The result of nutrient composition of *A. barbadensis*, *A. arborescens* and *A. ferox* whole leaf powder is shown in Table 4.1. Percent dry matter of T1, T2, and T3 did not vary significantly ($p>0.05$) while, percent ash, crude fibre, crude fat, phosphorus and calcium differed ($p<0.05$). The % ash of 20.69 and 21.21 in *A. barbadensis* and *A. arborescens* did not differ ($p>0.05$) but higher ($p<0.05$) than 13.47% ash in *A. ferox*. However, crude fibre of 9.56% in *A. ferox* was significantly ($p<0.05$) higher than 7.19% and 7.98% crude fibre in *A. barbadensis* and *A. arborescens*, respectively, which did not vary significantly ($p>0.05$). The crude fat in *A. barbadensis* (2.21%) was significantly ($p<0.05$) higher than 0.31% and 0.51% crude fat in *A. arborescens* and *A. ferox*, respectively, which were not significantly ($p>0.05$) different. The P content of 2.19% and 2.19% in *A. barbadensis* and *A. arborescens*, respectively did not differ significantly ($p>0.05$) but were significantly ($p<0.05$) higher than 1.76% P in *A. ferox*. The Ca content in *A. barbadensis* (0.31%) was higher ($p<0.05$) than 0.24% Ca in *A. arborescens* which was also significantly ($p<0.05$) higher than 0.19% Ca in *A. ferox*.

4.2 Nutrients in the Basal Commercial Diets

The nutrients in the commercial diets used in the three different growth phases determined in the laboratory and which were stated on the feed tag are presented in Table 4.2. The laboratory determination of dry matter showed that starter crumbs had the highest dry matter content of 87.61%, while finisher pellets had 87.46%, the lowest. On the feed tags of starter, grower and finisher diets, a constant DM of 88.00% dry matter was stated. Starter crumbs gave higher crude protein (17.04%) than grower pellets (13.57%) and finisher pellets (14.93%) in laboratory analysis. However, on the feed tag, the CP ranged from 18.19% to 23. 87% (starter crumbs 23.87% CP, grower pellets 18.19% CP, finisher pellets 20.46% CP). The laboratory determined CF ranged from 2.04% to 3.48% compared to the CF range of 3.98% to 7.96% on the feed tag. In the laboratory, dietary crude fat content varied from 2.10% to 3.22%, whereas it varied from 0.80% to 3.41% on the feed tag. Dietary P in the laboratory varied from

Table 4.1: Nutrient Composition of Aloe vera (*Aloe barbadensis*)**, Candelabra aloe** (*Aloe arborescens*) **and Bitter aloe** (*Aloe ferox*) **whole leaf**

Nutrients (%DM)	**Dietary Treatments**			**SEM**	**P-value**
	T1	**T2**	**T3**		
Dry matter	94.60	95.31	94.20	0.34 [ns]	0.47
Crude fibre	7.19 [b]	7.98 [b]	9.56 [a]	0.41*	0.03
Crude fat	2.21 [a]	0.31[b]	0.51 [b]	0.35*	0.01
Crude protein	ND	ND	ND	ND	-
Ash	20.69 [a]	21.21 [a]	13.47 [b]	1.28*	0.00
Nitrogen free extract	NC	NC	NC	NC	-
Calcium	0.31[a]	0.24[b]	0.19[c]	0.02*	0.00
Phosphorus	2.19[a]	2.19[a]	1.76[b]	0.07*	0.00

[a, b, c]Means having different superscripts in same row are significantly different (P<0.05), [ns]Not significantly different (p>0.05), P-value = Probability value, ND = Not determined, NC = Not calculated
T1 = Aloe vera
T2 = Candelabra aloe
T3 = Bitter aloe

Table 4.2: Nutrients in the Basal Commercial Diets (% DM)

Nutrients	Starter crumbs		Grower pellets		Finisher pellets	
	Laboratory analysis	Feed tag	Laboratory analysis	Feed tag	Laboratory analysis	Feed tag
Dry matter	87.61	88.00	87.56	88.00	87.46	88.00
Crude protein	17.04	23.87	13.57	18.19	14.93	20.46
Crude fibre	3.48	5.96	2.04	3.98	2.86	7.96
Crude fat	3.22	2.85	2.13	0.80	2.10	3.41
Phosphorus	0.56	0.69	0.48	0.69	0.58	0.80
Calcium	0.30	1.14	0.59	0.91	0.22	1.26
Lysine	0.89	1.48	1.20	1.25	1.09	1.03
Nitrogen free extract	71.29	-	79.30	-	76.98	-
Ash	4.97	-	2.96	-	3.13	-
Salt	0.06	-	0.07	-	0.07	-
Methionine	0.57	-	0.52	-	0.54	-

% DM = Percent dry matter

0.48% to 0.80%, while it was 0.69% to 0.80% on the feed tag. Dietary Ca determined in the laboratory ranged from 0.22% to 0.59% compared to 0.91% to 1.26% on the feed tag. Laboratory determined lysine ranged from 0.89% to 1.20%, whereas it ranged from 1.03% to 1.48% on the feed tag. The laboratory determined NFE varied from 71.29% to 79.30%. The ash determined in the laboratory ranged from 2.96% to 4.97%. Laboratory determined salt ranged from 0.06% to 0.07% and methionine ranged from 0.52% to 0.57%.

4.3 Effect of Aloe species Dietary Supplement on Performance of Starter Broiler Chickens

The effect of aloe species as feed supplement on growth performance at starter phase is presented in Table 4.3. The result showed that aloe species supplement had no significant ($p>0.05$) variation on the final live weight, feed intake, body weight gain, FCR and mortality rate.

4.4 Effect of Aloe species Dietary Supplement on Growth Response of Grower Broiler Chickens

The effect of aloe species as feed supplement on growth performance of broiler chickens in the grower phase is presented in Table 4.4. The result showed that aloe species supplement had no significant ($p>0.05$) effect on final live weight, feed intake, body weight gain, FCR, and there was no mortality.

4.5 Effect of Aloe species Dietary Supplement on Growth Response of Finisher Broiler Chickens

Effect of aloe species as a supplement on growth response of meat type chickens is given in Table 4.5. From the result the experimental diets had no significant ($p>0.05$) effect on final live weight, feed intake, body weight gain, FCR, mortality rate and benefit cost. The effect of the aloe species on the growth pattern is shown in Figure 1.

Table 4.3: Effect of Aloe species on the Performance of Starter Broiler Chicks (Day old - 2 wk)

Indices	Diet				SEM	P value
	C	T1	T2	T3		
Initial live body weight (g/bird)	43.00	43.00	43.00	43.00	0.00^{ns}	-
Final live body weight (g/bird)	296.67	283.33	303.33	290.00	3.55 ^{ns}	0.23
Feed intake (g/bird/day)	27.10	25.57	26.31	25.61	0.26 ^{ns}	0.09
Body weight gain (g/bird/day)	18.12	17.64	19.26	17.64	0.30 ^{ns}	0.18
FCR	1.49	1.46	1.41	1.41	0.02 ^{ns}	0.39
Mortality rate (%)	4.44	2.22	6.25	2.08	1.48 ^{ns}	0.77

^{ns}Not significant (p>0.05), P value = Probability value
C = Control diet with no aloe species supplement
T1 = Aloe vera supplement at 500 mg/litre
T2 = Candelabra aloe supplement at 500 mg/litre
T3 = Bitter aloe supplement at 500 mg/litre

Table 4.4: Effect of Aloe species on the Growth Response of Grower Chickens (3 - 4 weeks)

Indices	Dietary Treatments				SEM	P value
	C	**T1**	**T2**	**T3**		
Initial live weight (g/bird)	296.67	283.33	303.33	290.00	3.55^{ns}	0.23
Final live body weight (g/bird)	1290.00	1296.67	1306.66	1256.67	9.26^{ns}	0.31
Feed intake (g/bird/day)	105.24	107.28	106.28	102.76	0.90^{ns}	0.36
Body weight gain (g/bird/day)	70.94	72.37	72.16	69.04	0.63^{ns}	0.23
FCR	1.47	1.47	1.48	1.47	0.00^{ns}	0.91
Mortality rate (%)	0	0	0	0	0.00^{ns}	-

^{ns}Not significant (p>0.05), P value = Probability value
C = Control diet with no aloe species supplement
T1 = Aloe vera supplement at 500 mg/litre
T2 = Candelabra aloe supplement at 500 mg/litre
T3 = Bitter aloe supplement at 500 mg/litre

Table 4.5: Effect of Aloe species on the Performance of Finisher Chickens (5 - 7 weeks)

Indices	Dietary Groups				SEM	P-value
	C	T1	T2	T3		
Initial live weight (g/bird)	1290.00	1296.67	1306.66	1256.67	9.62^{ns}	0.31
Final live body weight (g/bird)	3456.67	3493.33	3473.33	3350.00	25.30^{ns}	0.18
Feed intake (g/bird/day)	171.13	177.63	176.52	178.91	1.85^{ns}	0.52
Body weight gain (g/bird/day)	98.75	99.93	98.82	95.43	0.99^{ns}	0.46
FCR	1.73	1.78	1.82	1.66	0.05^{ns}	0.74
Mortality (%)	8.88	8.36	6.25	3.92	1.63^{ns}	0.76
Benefit cost (M/bird)	29.78	24.50	25.26	25.07	1.01^{ns}	0.24

^{ns} Not significantly different (p>0.05), P-value = Probability value
C = Control diet with no aloe species supplement
T1 = Aloe vera supplement at 500 mg/litre
T2 = Candelabra aloe supplement at 500 mg/litre
T3 = Bitter aloe supplement at 500 mg/litre

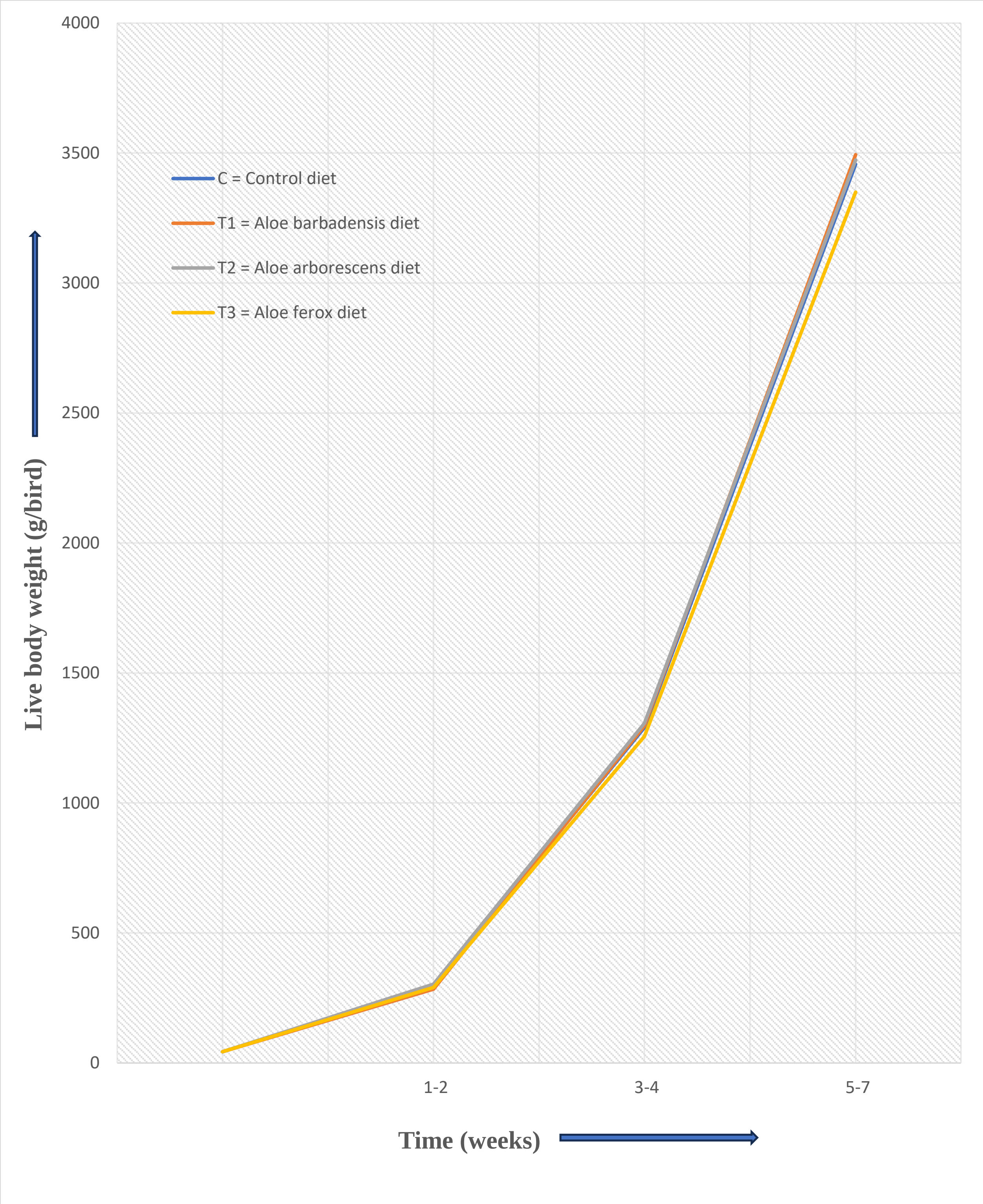

Figure 1: Mean weekly live body weight of broiler chickens fed *A. barbadensis, A. arborescens* and *A. ferox* supplements

4.6 Effect of Aloe species as Natural Dietary Supplement on Carcass Yield of Finisher Chickens

The effect of aloe species as dietary supplement on the carcass yield of finisher broiler chickens is in Table 4.6. The result showed that aloe species had no significant ($p>0.05$) impact on dressed weight, dressing percentage, back and neck, thigh, drumstick and wing but had significant ($p<0.05$) effect on breast. The %DW of breast in T1 (40.83) was significantly ($p<0.05$) higher than the %DW of breast in T3 (35.31) and C (35.04) but did not vary significantly ($p>0.05$) from % DW of breast in T2 (38.44).

4.7 Effect of Aloe species as Natural Dietary Supplement on Visceral Organs of Finisher Chickens

Effect of aloe species supplement on the visceral organs of broiler chickens is in Table 4.7. The result revealed that the treatments had no significant effect ($p>0.05$) on all organs except liver which differed significantly ($p<0.05$). The result showed that the chickens in T3 had a significantly ($p<0.05$) higher %FLW liver (1.84) than the chickens in C (1.67), T1 (1.55) and T2 (1.65) which did not vary significantly ($p>0.05$).

4.8 Effect of Aloe species as Natural Dietary Supplement on Offal of Finisher Broiler Chickens

The result of aloe species dietary supplement on broiler chickens offals is given in Table 4.8. Feather is expressed in percentage fasted live weight while head, shank and visceral fat are expressed in percentage dressed weight. The results revealed that feather, head, shank and visceral fat were not affected by the aloe species and resulted in no significant ($p>0.05$) difference.

Table 4.6: Aloe Species Effect as Feed Supplement on Carcass Yield of Finisher Broiler Chickens

Indices	Diet Groups				SEM	P-value
	C	T1	T2	T3		
Fasted live weight (kg)	3.43	3.48	3.43	3.34	0.03^{ns}	0.49
Dressed weight (kg)	2.73	2.73	2.69	2.66	0.03^{ns}	0.78
Dressing (%)	79.86	78.35	78.63	78.11	0.70^{ns}	0.86
Breast (% DW)	35.04^{c}	40.83^{a}	38.44^{ab}	35.31^{bc}	0.85*	0.01
Back and neck (% DW)	26.78	21.89	23.37	27.31	1.02^{ns}	0.16
Thigh (% DW)	14.56	14.82	14.39	14.17	0.29^{ns}	0.91
Drumstick (% DW)	11.34	11.97	11.02	10.75	0.26^{ns}	0.42
Wing (% DW)	9.74	9.54	9.34	9.58	0.17^{ns}	0.90

$^{a, b, c}$Means with different superscripts in same row differ significantly (P<0.05), ^{ns}Not significantly different (p>0.05), P-value = Probability value, DW = Dressed weight
C = Control diet with no aloe species supplement
T1 = Aloe vera supplement at 500 mg/litre
T2 = Candelabra aloe supplement at 500 mg/litre
T3 = Bitter aloe supplement at 500 mg/litre

Table 4.7: Effect Aloe species Diet Groups on Visceral Organs of Finisher Broiler Chickens

Indices	Dietary Treatments				SEM	P-value
	C	T1	T2	T3		
Fasted live weight (kg)	3.43	3.48	3.43	3.34	0.03 [ns]	0.49
Heart (% FLW)	0.49	0.47	0.48	0.56	0.02 [ns]	0.22
Liver (% FLW)	1.67[b]	1.55[b]	1.65[b]	1.84[a]	0.04*	0.02
Gall bladder (% FLW)	0.09	0.09	0.08	0.08	0.00 [ns]	0.87
Lung (% FLW)	0.47	0.42	0.40	0.46	0.01 [ns]	0.34
Empty gizzard (% FLW)	1.29	1.52	1.36	1.32	0.06 [ns]	0.62
Proventriculus (% FLW)	0.36	0.33	0.36	0.35	0.01 [ns]	0.89
Crop (% FLW)	0.32	0.33	0.25	0.35	0.02 [ns]	0.30
GIT weight (% FLW)	5.71	6.10	5.04	6.08	0.17 [ns]	0.06
LI weight (% FLW)	0.10	0.10	0.36	0.10	0.07 [ns]	0.46
SI weight (% FLW)	2.16	2.14	2.00	2.26	0.04 [ns]	0.09
Caeca weight (% FLW)	0.49	0.48	0.41	0.43	0.02[ns]	0.52
GIT length (cm)	228.67	237.17	235.67	240.50	2.29 [ns]	0.35
LI length (% GIT length)	5.04	4.21	4.53	4.50	0.15 [ns]	0.30
SI length (% GIT length)	84.53	83.71	79.48	83.47	1.00 [ns]	0.32
Caeca length (% GIT length)	5.84	5.85	6.03	5.63	0.08 [ns]	0.48

[a, b]Means having different superscripts in same row differed ($P<0.05$), [ns]Not significantly different ($p>0.05$), P-value = Probability value, FLW = Fasted live weight, GIT = Gastrointestinal tract, LI = Large intestine, SI = Small intestine

C = Control diet with no aloe species supplement

T1 = Aloe vera supplement at 500 mg/litre

T2 = Candelabra aloe supplement at 500 mg/litre

T3 = Bitter aloe supplement at 500 mg/litre

Table 4.8: Effect of Aloe species Dietary Supplement on Offal of Finisher Broiler Chickens

Indices	Dietary Treatments				SEM	P-value
	C	T1	T2	T3		
Feather (% FLW)	6.51	7.56	7.40	7.74	0.29 ns	0.52
Head (% DW)	2.09	2.19	2.23	2.51	0.11 ns	0.62
Shank (% DW)	3.80	3.78	4.03	5.16	0.26 ns	0.18
Visceral fat (% DW)	0.68	0.78	0.58	0.61	0.05 ns	0.63

nsNot significantly different (p>0.05), P-value = Probability value, FLW = Fasted live weight, DW = Dressed weight
C = Control diet with no aloe species supplement
T1 = Aloe vera supplement at 500 mg/litre
T2 = Candelabra aloe supplement at 500 mg/litre
T3 = Bitter aloe supplement at 500 mg/litre

CHAPTER FIVE

5.0 DISCUSSION

5.1 Nutrient Composition of Aloe species whole leaf powder

The dry matter of *A. barbadensis, A. arborescens and A. ferox* in powdery form in this study is higher than 44. 06% for aloe vera gel extract reported by Onyeji *et al*. (2022). The difference in dry matter content is attributable to their powdery and gel forms. The ash content in the present study is similar to 19.50% in aloe vera reported by Haque *et al*. (2014), while ash content in T3 is comparable to the ash content of 12.5% observed by Talukdar *et al.* (2023). However, Adesuyi *et al*. (2012) on the composition profile of *Aloe barbadensis* reported 2.36% ash content. The crude fibre level in T1 and T2 are within the range of 7. 84% (Adesuyi *et al*., 2012) and 8.20 to 8.50% (Temitope and Ayodele, 2014). The crude fibre level of 9.56% in T3 is comparable to 10.00% (Onyeji *et al*., 2022). The crude fat of *Aloe barbadensis* obtained in the current study is lower than 2.4% for aloe vera leaf (Talukdar *et al.*, 2023) and 2.91% (Ahmed and Hussain, 2013). Adesuyi *et al*. (2012) reported 0.27% crude fat which was lower than the crude fat range of T2 (0.31%) and T3 (0.51%). The crude fat obtained in the current study in all aloe species was lower than crude fat of 14.86% reported by Waris *et al*. (2018). In broiler production, phosphorus is highly required for bone formation (Umeoka, 2024). The percent range of phosphorus level in the aloe species was 1.76 to 2.19% higher than 0.665% (Adesuyi *et al*., 2012) 0.19 % in aloe vera (Haque *et al*., 2014). Calcium in the aloe species varied from 0.19 to 0.31% and higher than 0.03% Ca reported by Temitope and Ayodele (2014). The observed differences might be due to differences in research locations, soil composition, age and varieties of the leaves evaluated in the different studies.

5.2 Nutrients in the Basal Commercial Diets

The laboratory analysis showed lower crude protein in all phases (starter, grower and finisher) while feed tag showed adequate crude protein values in starter and finisher phases and less crude protein value in grower phase. Also crude fibre is adequate in starter, grower and finisher phases. According to BIS (2007), the recommended crude protein (minimum) for broilers was 23.00% (starter), 22.00% (grower) and 20.00% (finisher) and crude fibre (maximum) was 5.00% in the three phases. Nevertheless, Ahmadi *et al*. (2008) suggested 20%, 17.9% and 16% crude protein as minimum for these phases, respectively, and 5.50% crude fibre at 22-42 days of age (de Miranda Caniatto *et al.*, 2014). The crude fat values obtained in both laboratory analysis were lower than the recommended levels of 3%, 3.5% and 4.0% for the three phases respectively (BIS, 2007), except in starter phase where 3.22% was obtained in the laboratory. Phosphorus was adequate in both laboratory analysis and feed tag, similar the minimum requirement of phosphorus in broilers put at 0.45% from starter to finisher phase (BIS, 2007). In contrast, PoultryHub (2024) stated that phosphorus requirements for broiler phases on average are 0.50%, 0.45% and 0.42% respectively. The laboratory analysis in all phases showed lower calcium percentage while feed tag showed satisfactory calcium percentage from starter to finisher phases. PoultryHub (2024) suggested 1.0%, 0.90% and 0.85% calcium on average in the three phases, respectively. However, BIS (2007) recommended the minimum of 1.0% calcium in all phases. Lysine was adequate in laboratory analysis and feed tag excluding starter phase in laboratory analysis which was lower in comparison with the average of 1.44%, 1.25% and 1.05% lysine in starter, grower and finisher periods, respectively (PoultryHub, 2024). Toledo *et al*. (2011) and Bernal *et al*. (2014) suggested 1.30% and 1.24% lysine in starter and grower periods, respectively. Also BIS (2007) recommended 1.30%, 1.20% and 1.00% lysine as minimum. The nitrogen free extract in this study is higher than dietary nitrogen free extract in the three phases of starter (60.57%), grower (66.89%) and finisher (66.17%) reported by Monesa and Oluremi (2024). The ash content in laboratory analysis is higher in the phases in comparison to the recommended maximum ash of 2.50% in in three phases according to BIS (2007). The dietary salt determined in the laboratory is inadequate compared to the maximum salt of 0.5% recommended by BIS (2007) for the entire broiler chicken production phases. The laboratory determination methionine is adequate compared to 0.50% in starter as well as grower phase and 0.45% in finisher phase (BIS, 2007). However, Kaewtapee *et al*. (2021) recommended 1.13% (starter) and 0.99% (grower) methionine. Also Ahmadi *et al*. (2008) suggested minimum of 0.42%, 0.35% and 0.25% methionine for the performance of broilers. The appropriate levels of amino acids can resulted in to better growth performances and carcass composition of broilers (Indarsih and Pym, 2011).

5.3 Effect of Aloe species Dietary Supplements on Performance of Starter, Grower and Finisher Broiler Chickens

The result of the study showed that 500 g/litre aloe species supplements had no significant effects on the final body weight, feed intake, body weight gain, FCR and mortality rate in broiler chickens during the three physiological growth phases. The result supports the findings of Quaye *et al*. (2023) who observed no significant differences in growth performance when broiler chickens were given 0.5 and 1% aloe vera gel extract as supplement. Similarly, Islam *et al*. (2017) found that total feed intake of meat type chickens was not affected, however, the chickens on 15 ml/L aloe vera gel in water recorded higher feed consumption. Meimandipour *et al*. (2017) found that, addition of herbal extracts free and nanoencapsulated (aloe vera 0.02%) in the diet had no significant influence on body weight gain and FCR and feed consumption in the time periods of 1-14 and 14-28 days. Darabighane *et al*. (2017) reported that adding aloe vera gel at 10 g/kg to the feed of broiler chickens enhanced their feed intake but did not affect feed conversion ratio. However, some authors reported that aloe vera can be used as an efficient substitute for common growth promoters, improving a variety of physiological parameters in broilers. This is supported by Ojimaduka *et al*. (2020) who showed better body weight in broilers treated with aloe vera, showing its involvement in boosting growth. Additionally, aloe vera supplementation has been shown in studies to significantly boost growth performance measures like BWG and feed conversion ratios (Khaliq *et al*., 2017). In addition, Meimandipour *et al*. (2017) indicated that feeding birds with 0.05% non-encapsulated extracts of dill and aloe vera significantly improved BWG, and feed conversion ratio relative to control group in 28-42 days. Moreover, Allam Abd El–Dayem *et al*. (2021) and Gowri *et al*. (2023) found that aloe vera group supplemented at 2% and 5 mg/L in drinking water respectively, resulted in higher BWG, feed consumption and better FCR. Onyeji *et al*. (2022) found that final body weight was improved with 30% of aloe vera gel extract. The aloe vera supplement had improved body weight gain (Akhtar *et al*., 2012; Zayed *et al*., 2020) and FCR than in control group (Khan *et al*., 2023). Also, Ahmad *et al*. (2020) indicated that the overall performance of broiler chickens was significantly higher in control group relative to groups treated with amaprolium and aloe vera at 5 g/L water. Furthermore, inclusion of 1.5% *A. barbadensis* powder in basal diet also resulted in high BWG and feed intake together with better FCR (Bhargande *et al*., 2022). According to Islam *et al*. (2017) broilers fed on 15 ml/L aloe vera aqueous extract in water showed significantly higher live gain than those provided clean water. Aloe vera in combination with antibiotic growth promoters (virginimycin) resulted in better growth response in broilers (Jalal *et al*., 2019). The disparity in some of the indices in earlier studies on aloe vera and this current study is possibly because of the different aloe species used and the level of inclusion in water. Also the methods of aloe species processing to obtain aloe powder dissolved in water and how it was administered to the chickens can also explain the differences in results obtained.

The *A. barbadensis*, *A. arborescens* and *A. ferox* supplements had no significant effects on the economics of production/benefit cost at the starter, grower and finisher phases. However, Allam Abd El–Dayem *et al*. (2021) reported the potential of aloe vera gel as a natural low cost substitute to enhance broiler performance. Also, Islam *et al*. (2017) stated that aloe vera extract gave higher gross return per broiler than other treatment groups.

In the current study, there was mortality cutting across all the aloe species groups and the control in starter and finisher phases. This could be due to the prevailing cold environmental conditions in starter phase which coincided with winter, while the mortality in the finisher phase was due to water belly. In starter phase, candelabra aloe supplement group had comparatively higher mortality rate of 6.25%, while the lowest mortality rate of 2.08% was observed in bitter aloe group. In finisher phase, control group gave higher mortality rate of 8.88% and least mortality of 3.92% was in the bitter aloe group. Chickens treated with aloe vera had lower mortality than candelabra aloe but higher than bitter aloe in starter phase. However, the mortality was higher in chickens treated by aloe vera than in candelabra and bitter aloe but lower than control group in finisher phase. Mortality rate has been found to reduce in aloe vera supplemented groups compared to control (Quaye *et al*., 2023; Gowri *et al*., 2023). Sharma *et al*. (2018) observed mortality in control group not in aloe vera supplemented group in drinking water at 5 ml/L.

5.4 Effect of Aloe species Dietary Supplements on Carcass Yield of Finisher Chickens

The result indicated that the aloe species had no significant impact on dressed weight, dressing %, back and neck, thigh, drumstick and wing but had significant effect on breast. The % DW of breast in T1 (40.83) was higher than for aloe species supplement categories which ranged from 35.31 to 40.83 was comparatively higher than 35.04 % DW in the control group. With the exception of the breast % DW, this observation is consistent with the finding of Quaye *et al*. (2023), that augmentation of *A. barbadensis* did not alter the carcass traits of broiler chicken. Again, Meimandipour *et al*. (2017) said that herbal extracts of dill and aloe vera had no effect on carcass traits. The addition of aloe vera gel in basal diet of chickens has also been observed not to influence dressing percentage (Darabighane *et al*., 2017). Singh *et al*. (2013) added that there were no significant differences observed in dressing %. *A. barbadensis* gel administration has been linked to increased dressing weight (Mohamed *et al*. 2017). It has been discovered that *A. barbadensis* enhanced intestinal villi height, which is important for nutritional absorption (Singh *et al*., 2013; Arif *et al*., 2022). The increased villus height indicates improved gut architecture, which can contribute to higher digestive efficiency and general health in broiler chickens (Arif *et al*., 2022). This morphological improvement is critical because it has a direct correlation with the length and efficiency of the gastrointestinal system, which influences the birds' total growth performance.

5.5 Effect of Aloe species as Natural Dietary Supplements on Visceral Organs of Finisher Broiler Chickens

The result revealed that aloe species used as natural dietary supplements in meat type chickens produced no significance on all visceral organs except liver. The chickens in T3 (*Aloe ferox* or bitter aloe) had a significantly higher %FLW liver of 1.84 than the chickens in the control, (1.67), T1 (1.55) and T2 (1.65) which did not vary significantly. The result of the study is partly in line with Quaye *et al*. (2023) that augmentation of aloe vera did not alter weight of internal organs. This shows that, while aloe vera can improve general growth and health, its effects on individual organ weights may differ depending on the dosage and form of the product utilized. Khaliq *et al*. (2017) found that broilers fed aloe vera had better intestinal health, which is attributable to gut micro biota modulation and less intestinal lesions. The polysaccharides in aloe vera are thought to be critical in these effects, because they improve nutrient absorption and reduce inflammation in the gastrointestinal system (Darabighane *et al*., 2011). Mohamed *et al*. (2017) associated aloe vera gel administration to increased intestine weights. Furthermore, aloe vera supplementation can affect the length of the gastrointestinal tract.

5.6 Effect of Aloe species as Natural Dietary Supplements on Offal of Finisher Broiler Chickens

The % fasted live weight of feather, and % dressed weight of head, shank and visceral fat were not affected significantly by the above species dietary supplements. This research output is similar to an earlier report of Islam *et al*. (2017) that addition of aloe vera gel in drinking water of broiler produced no effect on visceral fat. Also, Mohamed *et al*. (2017) said that *A. barbadensis* congeal administration did not cause belly fat deposition. Aloe vera works primarily by regulating metabolic pathways associated with fat storage and energy expenditure (Javaid and Waheed, 2020). Javaid and Waheed (2020) said aloe vera extract can increase the mRNA expression levels of genes linked with brown adipose tissue activation, which is required for thermogenesis and fat burning. This activation reduces white fat deposition, which is commonly associated with visceral fat and overall body weight (Misawa *et al*., 2012). They also found that utilizing dried aloe vera congeal powder significantly lowered body fat mass in diet-induced obesity models. These findings suggest that *A. barbadensis* not only assists in weight management, but also particularly targets fat deposits. In addition to its impacts on fat mass, aloe vera has been demonstrated to affect general poultry growth and development. Doley *et al*. (2014) found that nutritional augmentation with aloe vera significantly elevated muscle tissues mass in broiler chicks, implying that aloe vera can improve growth performance. This effect may also apply to offals, as the bird's overall health and metabolic efficiency can influence the weight of non-muscle tissues such as feathers.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

From this study, in which *Aloe barbadensis, Aloe arborescens* and *Aloe ferox* were used as natural dietary supplements in broiler chicken production, it is concluded that:

a) The nutrient composition of *A. barbadensis, A. arborescens* and *A. ferox* showed significant variations in crude fibre, crude fat, ash, calcium and phosphorus.
b) The aloe species (*A. barbadensis, A. arborescens* and *A. ferox*) when used as natural dietary supplement at 500 mg/L did not improve growth response: feed consumption, body weight, body weight gain and FCR of broiler chickens in the three physiological phases of their growth.
c) *Aloe barbadensis*, *Aloe arborescens* and *Aloe ferox* gave higher breast % DW of 40.83%, 38.44% and 35.31%, respectively in comparison to 35.04% in the control, whereas the *Aloe ferox* dietary supplement group gave a significantly higher liver weight of 1.88 % FLW.
d) The *Aloe barbadensis*, *Aloe arborescens* and *Aloe ferox* groups when used as natural dietary supplement at 500 mg/L did not improve the economics of production (benefit cost) in the three physiological phases.

6.2 Recommendations

Composite leaf power of *Aloe barbadensis, Aloe arborescens* and *Aloe ferox* cannot be used as dietary supplement in broiler chicken production at a rate of 500 mg/L. More investigations are necessary to ascertain the level of dietary supplement of *Aloe barbadensis, Aloe arborescens* and *Aloe ferox* that will give optimum performance and economic benefit.

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