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AN EVALUATION OF DRIED GOAT RUMEN CONTENTS ON BROILER DIETS FOR ENHANCED GROWTH PERFORMANCE.

BY

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APPROVAL FORM

The signatories confirm that they have read and recommended to the Bindura University of Science Education for acceptance of the project title: …… AN EVALUATION OF DRIED GOAT RUMEN CONTENTS ON BROILER DIETS FOR ENHANCED GROWTH PERFORMANCE.

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CHAIRPERSON SIGN _____ Date_____

DECLARATION

I Privilege Torwiwa Chindoza, declare that this project hereby submitted for the Bachelor of Science Honours Degree in Animal Science and Technology at Bindura University of Science Education, is entirely my original work and affirm that it has not been submitted anywhere for the award of a degree or otherwise.

Topic: An evaluation of dried goat rumen contents on broiler diets for enhanced growth performance.

Privilege.T.Chindoza ……. Date……..

Supervisors' declaration: Dr Nyamashamba ……

I certify that I have checked this research project and am satisfied that it conforms to the Department of Animal Sciences guidelines for Project Preparation and Presentation. I therefore authorise the student to submit this dissertation for marking.

Date……..

DEDICATION

I dedicate this project to my parents and friends.

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I would like to express my sincere gratitude to the Almighty God for granting me strength, wisdom and perseverance throughout the course of this study. My heartfelt appreciation goes to my supervisor for the valuable guidance, encouragement and unwavering support provided during the planning, execution and completion of this dissertation. Your academic mentorship greatly contributed to the success of this research.

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ABSTRACT

Poultry production in Zimbabwe is constrained by high and unstable feed costs, with conventional protein sources such as soybean meal and fishmeal accounting for 60–70% of total broiler production expenses. This study evaluated the nutritional composition and effects of graded levels of dried goat rumen contents (DGRC) on growth performance and economic viability of broiler chickens.

A 42-day feeding trial was conducted using 100 Cobb 500 broiler chicks randomly assigned to four dietary treatments in a Completely Randomized Design: T_1 = 0% DGRC, T_2 = 5% DGRC, T_3 = 10% DGRC, and T_4 = 15% DGRC. Parameters measured were feed intake, body weight gain, and feed conversion ratio [FCR]. Proximate analysis of DGRC showed 15.80% crude protein, 24.60% crude fibre, 3.20% ether extract, 9.10% ash, and metabolizable energy of 2100 kcal/kg. [control]

Results showed that feed intake and body weight gain were highest in birds fed 5% DGRC [T_2], while 10% and 15% inclusion levels reduced both parameters, likely due to increased dietary fibre. FCR was most efficient at 5% DGRC inclusion. However, one-way ANOVA indicated no statistically significant differences among treatments for feed intake [$F = 0.094$, $p = 0.963$], body weight gain [$F = 0.094$, $p = 0.963$], or FCR [$F = 0.392$, $p = 0.759$]. Economic analysis suggested that 5% DGRC inclusion offered potential cost savings without compromising performance, while higher inclusion levels reduced profitability. The study concludes that dried goat rumen contents can be included in broiler diets at low levels, particularly 5%, as a cost-effective alternative protein source. This promotes sustainable use of slaughterhouse waste and reduces reliance on expensive conventional feeds.

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CHAPTER ONE

1.0 Introduction

In developing countries such as Zimbabwe, production of poultry is an important source of improving household livelihood and food security, food systems, as well as employment creation. The poultry industry has emerged as one of the most rapidly growing livestock industries in recent years because of its short production cycle, low feed consumption and ability to offer low cost animal protein. Although sustainable production of broilers is important, the ever increasing cost of poultry feed, comprising about 60-70% of the total production cost (NRC, 1994; Bai et al., 2019), is posing a serious threat to a sustainable broiler production.

Conventional feed ingredients like soybean meal and fishmeal have been continuously rising in price and are causing hardship for small and medium scale poultry farmers. These ingredients are frequently imported and the price is volatile, which results in less profitable broiler production and fewer expansion opportunities. Therefore it is important to look for alternative (local, available and economical) feed resources which could be used to replace the conventional protein sources partially or completely without affecting growth performance, feed efficiency and bird health.

Goat rumen contents (GRC) is a by-product of the slaughterhouses which is discarded byproducts and one potential feed resource which can be utilized in these countries. The goat rumen contents are a mixture of partially digested forage materials, microbial biomass, enzymes, vitamins and minerals that can be used as sources of beneficial nutrients for poultry when processed through drying and milling (Agbabiaka et al., 2012; Ogbuehi et al., 2018). The use of GRC in poultry feed can also be environmentally friendly as abattoir wastes can be used as valuable feed.

Despite the growing interest in unconventional feed sources, very little information exists on the nutritional composition and growth performance effects of dried goat rumen contents (DRC) in broiler diets especially under the production conditions in Zimbabwe. Existing studies have tended to focus on the rumen contents of cattle or sheep, which have been determined to contain significant quantities of crude protein, metabolisable energy and essential micronutrients that are suitable for the growth of poultry (Sogunle et al., 2018). In addition, research on alternative protein sources like insect meals and fermentation residues has shown that feeds made from insects can be used at the right level to lower feed costs

without compromising growth rates or feed conversion ratios (van Huis et al., 2013; Aremu et al., 2021).This research provides scientific proof of the suitability of dried goat rumen contents as a protein source for broiler production, which leads to savings in production costs, better utilization of local resources, and better food security among Zimbabwe and other developing economies.

1.2 Background of The Study.

The continuously increasing cost of conventional ingredients for poultry feed has driven the need for alternative feed resources in the study of poultry nutrition. The use of protein sources like soybean meal and fishmeal is not only costly, but also directly affect the human food requirement, which is not sustainable in the long term (Bai et al., 2019). To lower feed costs, without compromising production performance, researchers have been increasingly turning to unconventional feed ingredients such as insect meals, agro-industrial by-products and slaughterhouse waste materials (Dale et al., 2020, van Huis et al., 2013).

The goat rumen contents are generated by slaughterhouses and are a by-product that is usually discarded, causing environmental pollution and waste management problems. Rumen contents consist of unabsorbed nutrients from rumen fermentation, microbial protein, vitamins and minerals (Ogbuehi et al., 2018). Goat rumen contents are a potential low-cost feed ingredient for poultry when dried and appropriately processed, thus waste recycling and sustainable livestock production can be achieved. Previous investigations have shown that the crude protein and metabolizable energy of the rumen contents from small ruminants have moderate value and can be used for poultry growth when adequate amount is used (Agbabiaka et al., 2012). The fibre quality in GRC can support the development of the gut, promote a balance of microflora which leads to an improvement in the utilization of the nutrients and digestive efficiency in broilers (Aremu et al., 2021). However, inclusion of too much fibre can also result in a negative effect on digestibility of nutrients, which requires careful consideration of fibre levels.The composition of feed is an important factor in poultry growth performance, health status and production efficiency. Weight gain and feed conversion ratio (NRC, 1994) are affected by the quality of protein, the amino acid balance and the digestibility of nutrients. Previous studies have shown that the growth performance of alternative protein source diets, if properly formulated, can be similar to conventional feed diets (Sogunle et al., 2018). The results indicate that rumen contents of goats could be used as an alternative protein source provided the nutrient content matches the nutritional

requirement of broiler. An economic approach to the formulation of poultry feeds must aim at reducing the expenses but not at reducing productivity to sustain the poultry enterprise. The use of low-cost feed ingredients like GRC can greatly alleviate production costs, especially in areas where traditional feed ingredients are costly or imported (Bai et al., 2019). Hence, it is important to assess the nutritional and economic aspects of GRC incorporation into broiler diets for successful implementation in commercial broiler production systems, in Zimbabwe.

1.3 Problem Statement

The conventional feeds ingredients, especially protein ingredients like soybean meal and fishmeal, are very costly and fluctuating in Zimbabwe which is limiting the production of poultry. The cost of feed represents 60–70% of the total production cost of broilers, and hence is the major contributor to the profitability of small and medium size poultry enterprises and poses a major threat to their sustainability (NRC, 1994; Bai et al., 2019). In addition, reliance on imported feed ingredients and on competition with human food consumption further leaves producers vulnerable to the global market and cost-effective alternatives are a crucial need (Dawkins et al., 2017).

The rumen contents of goat, called goat rumen contents (GRC), are obtained during goat slaughtering and are mostly wasted due to its high production resulting in environmental and sanitation problems. The microbial protein, residual fibre, minerals and vitamins present in GRC indicate its potential to be used as a livestock feed ingredient (Agbabiaka et al., 2012; Ogbuehi et al., 2018). The potential of GRC has yet to be fully realised in broiler diets, especially in Zimbabwe because of the absence of empirical data on the nutritional composition and growth performance effects of GRC. The nutrient composition of rumen contents will vary according to diet and processing and, therefore, it is important to develop standard nutritional profiles for use in the formulation of feed (Gohl, 1981).

1.4 Justification of the study

The high and volatile prices of traditional feed ingredients in particularly protein-rich feed such as soya bean meal (SBM) and fishmeal are now limiting the sustainability and profitability of poultry production in Zimbabwe. Raising broilers is a very costly business, with feed costs making up about 60–70% of the total broiler production costs, which is a determinant of the viability of the small and medium-scale poultry production enterprises

(NRC, 1994; Bai et al., 2019). Therefore, a need arises to develop alternative locally available and economical feeds which can be used as protein source in partial or total replacement of the conventional protein source without affecting growth performance and health of broilers. Goat rumen contents (GRC), a by-product of slaughterhouses, is a potential, but underutilized feed resource. Some nutrients like microbial protein, fibre, vitamins and minerals are left in GRC after processing, which are potential feed sources for poultry nutrition if processed properly (Agbabiaka et al., 2012; Ogbuehi et al., 2018). The proximate composition of dried GRC and its effects on feed intake, BWG, and FCR will supply empirical evidence of the nutritional adequacy and suitability of GRC in broiler diets (NRC, 1994; Tavernari et al., 2017).

Environmentally, using GRC in poultry diets helps create sustainable management of waste, by valorising slaughterhouse wastes and minimizing environmental pollution. The method is suitable with the circular agricultural concept which emphasizes resource efficiency and ecological sustainability (Aremu et al., 2021).

Moreover, the economic feasibility of GRC can be determined using cost–benefit analysis which will help poultry farmers to make informed decisions based on the production performance and financial returns. In resource-limited areas, where the economics of new feeding strategies is vital to adoption, this is especially important (Dawkins et al., 2017).

Last but not least, the study will make a modest yet significant contribution to the small pool of scientific literature available on the unconventional feed resources available to poultry farming in Zimbabwe. The results will help to inform feed formulation strategies, policy recommendations for sustainable feeding of livestock and will offer practical guidance for farmers, researchers and feed manufacturers looking to minimise production costs and optimise broiler performance. In general, this study caters for both biological and economic issues of broiler nutrition, thereby supporting sustainable, economical and environmentally friendly broiler farming in Zimbabwe.

1.5 Research Objectives

Main Objective

To evaluate the nutritional and economic benefits of incorporating dried goat rumen contents (GRC) into broiler diets for enhanced growth performance.

Specific Objectives

1. To determine the proximate composition of dried goat rumen contents, including protein, energy, fibre, and mineral content.
2. To assess the effects of varying inclusion levels of GRC on feed intake, body weight gain, and feed conversion ratio in broiler chickens.
3. To evaluate the cost-effectiveness of incorporating GRC into broiler diets through economic analysis, including cost–benefit assessment.

1.6 Research Questions

1. What is the proximate composition of dried goat rumen contents in terms of protein, energy, fibre, and mineral content?
2. How do varying inclusion levels of dried goat rumen contents affect feed intake, body weight gain, and feed conversion ratio of broiler chickens?
3. What are the economic implications of incorporating dried goat rumen contents into broiler diets in terms of cost savings and profitability?

1.7 Hypothesis

Null Hypothesis (H_0):

Incorporation of dried goat rumen contents in broiler diets has no significant effect on growth performance parameters, including feed intake, body weight gain, and feed conversion ratio.

Alternative Hypothesis (H_1):

Incorporation of dried goat rumen contents in broiler diets has a significant effect on growth performance parameters, including feed intake, body weight gain, and feed conversion ratio.

1.8 Conclusion.

Chapter One presented an overview of the present study in which dried goat rumen contents (GRC) were evaluated as protein source in broiler diets to improve growth performance. The chapter highlighted the importance of poultry production in Zimbabwe in terms of household income, employment and food security and that high prices of feed, particularly protein feeds

such as soybean meal and fish meal are a challenge to the sustainability of broiler production. Based on the problem statement, the slaughterhouse by product (GRC) still has some nutrients which could be utilized in broiler growth if it can be processed properly, however, the need for alternative feed resources, which are locally available and cost effective, was highlighted.

The advantages of GRC from reducing production costs, nutrient utilization, sustainable waste management, and increasing the economic sustainability of poultry farms were emphasized in the rationale for the study. The main and specific objectives were well defined and focused on the proximate composition of GRC, the effect on feed intake, weight gain, feed conversion ratio and the economic feasibility. The formulation of research questions and hypotheses was aimed at guiding the research and statistical analysis.

Generally, in Chapter One the rationale, aims and scope of the study were provided which served as background information on the importance of using GRC in broiler diets. The present research work is in context with the available literature as discussed in chapter two which reviewed the existing literature on the nutrition of broiler, alternative sources of feed, use of rumen contents for feeding, effect of dietary fibre on growth performance of broiler chicken.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In developing countries, such as Zimbabwe, poultry production plays a crucial role in enhancing household incomes, employment and food security (Bai et al., 2019; NRC, 1994). Poultry sub-sector is one of the rapidly growing sub-sector among the poultry enterprises due to its short production time, quick meat production and high feed conversion ratio. But the sustainability of broiler production is now becoming challenged due to increasing cost of feed which constitutes about 60-70% of total production cost. Conventional protein sources such as soybean meal and fishmeal are expensive, and are sometimes sourced from overseas and in competition with the production of human food, thus making them economically and socially unfeasible for SMEs rearing poultry (van Huis et al., 2013; Dawkins et al., 2017).

With the increasing cost of feeds, people have turned to the research of alternative feed resources available in the locality that can be used to incorporate in the conventional feed formula thereby maintaining growth performance, feed efficiency and health status of the species of animals (Ravindran & Abdollahi, 2021; Dale et al., 2020). One of these options is slaughterhouse by-products like goat rumen contents (GRC) which have a high potential. Some past studies have suggested that GRC is a waste residue with some nutrients like partially digested plant material, microbial protein, vitamins, minerals and volatile fatty acids (VFA) (Agbabiaka et al., 2012; Ogbuehi et al., 2018). By appropriate drying and processing GRC can be used as a feed for broilers, which helps in waste valorisation as well as sustainable livestock production. The moderate crude protein (CP) and metabolizable energy (ME) rumen contents of small ruminants have been found suitable for poultry production, while the fibre fraction has been reported to improve rumen gut development and nutrient absorption in small ruminants when fed with optimum level (Aremu et al, 2021; Sogunle et al, 2018).

The nutritional potential and economic viability of the use of GRC in broiler feeds is important for the practical adoption by the broiler farmers in Zimbabwe. Biological and economic viability is demonstrated by growth performance such as feed intake, body weight gain, feed conversion ratio (FCR) and overall health status, and cost benefit analysis (FAO, 2019; Dawkins et al., 2017). The aim of this study is to gather empirical data on the chemical

composition of dried GRC, its impact on the growth performance of broilers and its economic effects. The results are hoped to guide towards sustainable poultry feeding practices, minimize the use of costly conventional feed ingredients, enhance farm profitability, ensure environmental sustainability based on waste recycling, and boost food security in Zimbabwe and other developing economies.

2.2 Broiler production and feed costs problems

The broiler sector is one of the fastest growing livestock subsectors with the world, because of its high efficiency in feed to animal protein conversion, short production period and quick meat production (FAO, 2020). This thus positions broiler farming as a significant source of food security and income generation especially in developing countries. Though the growth is tremendous, feed is the biggest cost in broiler production, and it is estimated that this is 60–70% of the total production cost. Many of the conventional feed ingredients used like maize, soybean meal and fishmeal are imported, which increases production cost and widens cost gap for small and medium-scale farmers (Bai et al., 2019; Mottet & Tempio, 2017). The price of commodities in the world also fluctuates, which makes poultry enterprises even more economically vulnerable and brings the need for sustainable feeding strategies that minimise the reliance on the high-cost conventional feed components (Dale et al., 2020).

In developing countries, high feed cost has put researchers' focus on alternative locally available feed resources that may be used as a partial or complete replacement for conventional protein and energy sources (Ravindran & Abdollahi, 2021). Alternative feed ingredients include agro-industrial by-products, insect meals, and slaughterhouse waste materials that are able to supply nutrients needed for the animals and lower the costs of feed (van Huis et al., 2013; Sugiharto et al., 2019). Adoption of unconventional feed ingredients has been found to have potential in improving the food security, resilience of poultry production and farm profitability. But care must be taken to consider the nutrient composition, digestibility, palatability and anti-nutritional factors that could affect performance in the monogastrics such as broilers (Kim et al., 2019).

However, adoption of alternative feed resources in broiler production is still limited, even with the rising interest for their use because they are inconsistently nutritional quality, unstandardized and have limited empirical evidence of the growth performance outcomes (Sogunle et al., 2018; Olorunsola et al., 2020). Furthermore, seasonal and seasonal quality changes in feed ingredients due to the processing and raw material sources may influence the

feed intake, weight gain and feed conversion efficiency. This highlights the importance of research to assess the nutritional adequacy, safety and economic viability of locally available feed resources, such as dried goat rumen contents, for both experimental and field use, especially in resource-limited countries such as Zimbabwe.

2.3 Alternative feed resources may be used in poultry nutrition.

With the rising cost of conventional feed ingredients, poultry nutritionists are also looking at other feed ingredients that are locally available that are cost effective and nutritionally adequate. Some agro-industrial by-products like cassava peels, rice bran, brewer's spent grain and oil seed cakes have been considered to replace traditional protein and energy sources (Sugiharto et al., 2019; Adeyemi et al., 2016). Slaughterhouse by-products (blood meal, bone meal and rumen contents) also have been considered because of their high protein and nutrient content. These alternate feed resources can help to reduce feed expenses, recycle waste and improve the sustainability of poultry production systems (van Huis et al., 2013; Aremu et al., 2021).

Studies report that inclusion of alternative feed ingredients at optimal levels can keep growth performance, feed intake and feed conversion ratios of broilers comparable or even better. For instance, Khan et al. (2020) have shown that moderate inclusion of brewer's spent grain in broilers diets did not affect weight gain when compared with the conventional diets. Also, studies of insect meals and fermented products have shown that they can replace soybean meal or fishmeal to some extent without harm, if they are processed and formulated appropriately to address nutrient requirements (Dale et al., 2020; van Huis et al., 2013). The results highlight the importance of using alternative feed resources to improve economic efficiency and sustainable poultry nutrition.

Too much, however, of these unconventional types of feed which contain high-fibre or poorly processed materials may impact nutrient digestibility, feed intake and growth in monogastric species like broilers (Kim et al., 2019; Mateos et al., 2020). The nutrient variability and anti-nutritional factors, as well as palatability issues, are other challenges that need to be considered carefully. Thus, the assessment of resources, appropriate processing techniques (drying and grinding) and also controlled inclusion rate are crucial in order to optimize the use of alternative feed resources (Sugiharto et al., 2019; Olorunsola et al., 2020). The aim of the present study is to evaluate the dried goat rumen contents as a cheap and local feed ingredient, both for nutritional adequacy and for growth performance of broilers.

2.4 The nutritional composition of the rumen contents.

Rumen contents are a combination of partially digested plant matter, microbial biomass, fermentation products and excess nutrients, which are all products of the digestive system of ruminants (Adeyemi et al., 2016). The microbial fraction is also a major source of crude protein and the residual volatile fatty acids and minerals are also important sources of energy and micronutrients. The nutrient content of rumen contents can be inffluenced by the species, age, diet and the way the rumen contents is processed (dried or ensiled) (Ojebiyi et al., 2021). With appropriate processing, rumen contents can be used in monogastric diets such as broiler diets, as well as increase the shelf life of the product, reduce microbial contamination.

Although the nutritional potential has been shown, there is a lot of variation in the nutrient values reported, which question the consistency and reliability of the information. For example, Ojebiyi et al. (2021) found that dried rumen contents can serve as a good source of moderate crude protein for poultry nutrition and Onu and Madubuike (2019) indicated that high fibre fractions can reduce the digestibility and availability of nutrients to monogastric animals. This discrepancy highlights the need for species-specific assessments because goats and cattle have different feed habits and rumen ecology and therefore may have different rumen contents nutrient profile.

Because of these differences, it is necessary to do proximate and mineral analysis of goat rumen contents to determine the nutritional adequacy of goat rums contents broiler feeds. Knowledge of protein, energy, fibre and micronutrient composition will be used to decide on appropriate levels to maximise growth performance, without causing negative consequences from excessive fibre. These evaluations are very important to help in the formulation of nutritionally balanced and affordable feeding programs, especially in countries such as Zimbabwe, where feed prices are high and protein sources are limited (Agbabiaka et al., 2012; Sogunle et al., 2018). This study aims to fill this knowledge gap by providing empirical data on the chemical composition and growth performance effects of dried goat rumen contents in broiler chickens.

2.5 Animal Feeding Systems & Use of Rumen Contents"

Rumen contents are a feed ingredient that has been thoroughly investigated as a source of feed in ruminants because of their natural ability to eat high-fibre diets. Research showed that when fed to ruminants, such as cattle and sheep, feed digestibility and feed cost can be

improved without affecting growth performance, digestibility, or health (Mlambo & Mapiye, 2015). Pigs are monogastric but fibre can be tolerated to a greater extent than in poultry and rumen contents have been used successfully in the ration, usually no more than 10%, as it is easier to process with less microbial contamination and more palatable (Sambo et al., 2018). These results show the potential importance of using ruminant manure as a cheap protein and energy source for various livestock.

Research on poultry, especially broiler chickens is limited and results are inconsistent, however. The high fibre content and poor digestibility of rumen contents have been reported to be the cause of reduced growth performance and feed conversion efficiency (Olorunsola et al., 2020). On the other hand, other investigations indicate that the microbial protein and unutilized nutrients in rumen digesta can improve growth and health when proper precautions are taken to control inclusion rates and diets are nutritionally balanced. The differing results emphasize the species-specific problems of using high-fibre by-products in monogastric rations, as digestive capacity is less than that of ruminants.

The difference in results indicates the necessity of specific research on this subject, involving the broiler chicken and the contents of the rumen of single species, e.g. goats. The digestibility and performance responses of poultry can vary with goat rumen contents, which may be due to feeding behavior, rumen microbial ecology and nutrient composition (Agbabiaka et al., 2012). It is therefore important to determine the practical usefulness of dried goat rumen contents as a sustainable feed ingredient for broiler production systems in Zimbabwe and other developing countries by establishing the optimal inclusion levels, assessing growth performance and evaluating the feed conversion efficiency.

2.6 The effects of fibre on broiler growth performance is explained below.

In broiler nutrition dietary fibre is playing a complex role since monogastric birds have less capacity than ruminants to digest fibre. In most cases, high fibre diets in poultry are related to decreased digestibility of nutrients, slower growth rate and lower feed conversion ratio (FCR) (Mateos et al., 2020). High fibre in the diet can physically take up space in the gut, restrict feed consumption and shorten the time available for energy and nutrient uptake – reducing growth performance and productivity. The evaluation of fibre content as a priority with the use of unconventional ingredients in the diet of broilers, such as goat rumen contents, is highlighted by these challenges.

However, not all fibres are bad. Moderate fibre inclusion has been found to be beneficial to digestive physiology by promoting development of gut, stimulating function of the gizzard and improving microbial fermentation in the hindgut (Jiménez-Moreno et al., 2018; Kim et al., 2019). Drying, grinding or pelleting fibre sources can enhance feed texture and digestibility of the fibres, as well as nutrient availability. This indicates the possible potential of using fibre as a feed ingredient in broiler nutrition with the appropriate processing method, to reduce the negative effects of high fibre in rumen contents.

When considering the use of dried goat rumen contents (GRC) as feed ingredients the implications of fibre are very significant. It is important to understand the optimum levels of inclusion when balancing nutrient supply and digestibility to avoid any negative impact on growth performance, but to also maximise the advantages of the improvements in gut health. These assessments can provide feed formulation strategies to cut production costs without affecting broiler performance, which is sustainable and cost-effective poultry production practices (Aremu et al., 2021).

The growth performance indicators utilized in the study of broiler nutrition are described.The growth performance indicators used in broiler nutrition studies are discussed.

These performance parameters should be monitored when evaluating alternative feed ingredients, particularly when the conventional ingredients are being replaced by dried goat rumen contents, to assure that the feed ingredient substitution doesn't negatively impact growth. The growth performance of several studies showed that the use of non-conventional feedstuffs can be a valuable alternative to conventional feedstuffs in diets when the ingredient is nutritionally balanced and is used at optimal levels (Ravindran & Abdollahi, 2021; Sogunle et al., 2018). However, the opposite effect of over or under formulation can be seen, causing lower nutrient digestibility, lower feed intake, and lower FCR, thus the need for empirical testing to be done in controlled trials.

Feed intake, body weight gain and FCR are used as the main parameters of broiler performance in the present study and were used for solid information and comparable data for the effect of dried goat rumen contents. These parameters not only enable growth efficiency assessment, but also can be used to evaluate the economic performance of dietary interventions and relate nutrient utilization to economic cost-effectiveness of production. Such a system will provide the study with meaningful insights for feed formulators, poultry producers and policymakers, looking for viable alternatives that are economically viable and

cost effective to replace conventional protein sources (Aremu et al., 2021; Ravindran & Abdollahi, 2021).

2.7 Theoretical Context: Sustainable Livestock Feeding Systems

The present study is based on the theory of sustainability that highlights the most sustainable use of locally accessible resources for achieving productivity and reducing negative environmental effects (FAO, 2019). From the perspective of animal production, sustainable feed is "the design of feed that is nutritionally adequate to maintain the health, efficiency and profitability of the animal, the farm or the region; and that is economically viable, avoids environmental impacts and minimizes the use of waste materials and energy". The study targets resource-efficient and circular approaches to poultry nutrition by using locally produced by-products, like goat rumen contents, as feed ingredients.

The concept of sustainable feeding systems is based on the valorisation of waste materials from agro-industrial and slaughterhouse activities to provide valuable inputs for livestock production (Aremu et al., 2021). These methods help to cut down on animal waste and pollution, save on production expenses, and ensure responsible and sustainable animal resource utilization. Rumen contents are normally purged from the animals and consist of some leftover feed and microbial protein that can be utilized if appropriate processing is applied to gain animal growth. The use of these by-products in broiler feeds is an example of putting sustainability theory into practice, where ecological awareness meets economic considerations for the farmer.

The nutritional and economic evaluation of dried goat rumen contents in this study not only respects sustainability aspects, but also helps tackle important issues in poultry farming such as escalating feed costs and waste management in the environment (Ogbuehi et al., 2018). The theoretical framework serves as a basis for systematically evaluating the inclusion of GRC in broiler diets, while ensuring animal performance and safety. Finally, the study aims to make a contribution to that can be adopted by poultry producers in Zimbabwe and in other developing economies as low cost and environmentally friendly feeding strategies.

2.8 Identified Research Gaps

Though some studies have focused on the use of alternative feed resources for livestock production some empirical studies on the incorporation of dried goat rumen contents (GRC) in broiler diets have been limited (Agbabiaka et al., 2012; Ogbuehi et al., 2018). Existing

literature has mainly focused on the rumen content of cattle or sheep or other non-poultry animals like pigs and small ruminants (Mlambo & Mapiye, 2015; Sambo et al., 2018). Therefore, there are no species-specific data on broilers, especially during controlled feeding trials where specific parameters for good growth performance like feed intake, body weight gain and feed conversion ratio are evaluated.

Furthermore, the results of previous research on fibre-rich by-products have been inconclusive, with some studies indicating that digestibility of nutrients and growth may be negatively affected by high fibre levels, and others suggesting a positive effect on gut health with moderate fibre inclusion (Mateos et al., 2020; Kim et al., 2019). This underscores the need for species-specific studies that consider species inclusion, and species-specific processing of rumen contents. This targeted evidence is needed to help poultry producers and feed formulators better understand how GRC can be used in broiler diets, and avail them of its nutritional and economic benefits.

The problem of the present invention is to overcome the above disadvantages by analyzing the proximate composition of dried goat rumen contents as well as their influence on the growth performance and feed efficiency in broilers. This study generated empirical information relating to the inclusion rates of GRCs and associated biological and economic responses, hence giving critical information on the feasibility of using slaughterhouse by-products in sustainable and economical poultry feeding systems (Sogunle et al., 2018; Ravindran & Abdollahi, 2021). This evidence will help with feed formulation strategies and inform practical decision making by Zimbabwe and other developing economies' poultry farmers.

2.9 Summaries of Literature Review

The reviewed literature highlights the need to find alternative locally available feed resources, in order to reduce the cost of conventional poultry feed, especially protein sources like soybean meal and fishmeal. The potential of agro-industrial by-products and slaughter house wastes (such as rumen contents) as an economical feed ingredient has been established on the basis of the presence of residual nutrients, microbial protein and minerals. The supplementation of goat rumen contents (GRC) to broiler diets, however, has been less extensively studied, and little research has been conducted on the effects of GRC on growth performance, feed intake, and feed conversion ratios. The inconsistencies observed in the

nutrient composition, fibre tolerance and digestibility further emphasize the need for context specific research under Zimbabwean production conditions.

The present study aims at providing empirical evidence on the proximate composition of dried GRC and to study its effects on growth performance and feed efficiency of broilers in relation to the identified gaps. The results will contribute to sustainable poultry feeding, decrease the dependence on the high price conventional feed ingredients, and help the cost-effective poultry production. Chapter 3 describes the research methodology employed for the accomplishment of the research objectives, such as the study area, experimental design, diets preparation, data collecting procedure, and statistical analysis techniques.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the Study Area

The study was conducted in a poultry research unit of Mashonaland central Province of Zimbabwe (16°45′S to 31°40′E). The area is in the Agro-ecological Region II and receives an average annual rainfall of 750-1000 mm with main rainfall period from November to March. The average temperatures ranges from 18°C during the winter to 30°C during the summer. Relatively flat terrain with well drained, sandy loam soils and savanna-type vegetation, comprising of Brachystegia and Julbernardia species, that is conducive for intensive poultry production.

The agricultural production in the study area are primarily under the small holder farming and semi-commercial farming with poultry, goats, and cattle as the main farming livestock. Intensive deep litter rearing is the main poultry rearing system and commercial feeds and water is secured from boreholes. Rumen contents can be collected from slaughtered goats at nearby goat slaughterhouses on a regular basis and easily. Water was supplied in the study, ad libitum from the borehole without any treatment. All standard husbandry care was taken and adhered to during this running period, to keep the birds in good health and to give them uniform husbandry conditions, as far as possible.

3.2 Study Design

The study used an experimental design, the Completely Randomized Design (CRD), appropriate for cases in which the experimental units are homogeneous and the environment is uniform (Gomez & Gomez, 1984). The design has the advantage of unbiased estimates of treatment effects and reduced confounding effects from other variables, thus being well-suited for the controlled poultry trials, to assess the nutritional effects of alternative feed ingredients.

One hundred 100-day-old broiler chicks were randomly distributed amongst four dietary treatments. Three diets based on dried goat rumen contents were compared with a control diet: 0% dried goat rumen contents. Random allocation provides equal opportunity to each bird of receiving any treatment, increasing the reliability and validity of results observed (Steel et al., 1997).

The preparation of experimental diets and feeds.

The fresh goat rumen contents (GRC) were obtained from a registered abattoir in the study area to ensure uniformity and traceability of the rumen contents (Agbabiaka et al. 2012). To reduce moisture content and for good shelf life the rumen contents were spread and sun-dried for 5 days till constant weight is obtained. The dried material was then ground in a hammer mill and sieved through 2 mm sieve to get a uniform particle size for use in broiler diets (Ogbuehi et al., 2018).

Four experimental diets were drawn up to determine the effects of graded levels of GRC on broiler performance. The following diets were fed: a control diet (T_1) without any GRC, 5% GRC (T_2), 10% GRC (T_3) and 15% GRC (T_4). All diets were designed to provide adequate or above the nutrient requirements of broiler chickens for starter and finisher diets as per the feeding standards as detailed in NRC, 1994 and Sogunle et al., 2018. The inclusion levels were selected to evaluate low-level incorporation, moderate-level incorporation and to establish possible thresholds for optimum growth performance.

Feed and clean drinking water was given ad libitum during the experimental period so that there was no restriction on the intake of nutrients and water. All the management procedures such as brooding, vaccination and biosecurity were undertaken in all the treatment groups to reduce the confounding factors (Ravindran & Abdollahi, 2021). This method allowed the comparison of the difference in growth performance observed to be mainly due to the differences in the ration, thus providing a reliable means for estimating the nutritional and economic value of dried goat rumen contents fed to broilers.

3.4 Data Collection Tools and Procedures. Data Collection Tools and Procedures.

3.4.1 Feed Intake Measurement

The feed intake is one of the most important parameters used to assess broiler growth performance, which reflects nutrient consumption, and therefore potential for efficiency of feed utilization (Zuidhof et al., 2017). The feed intake was calculated in this study by feeding known amount of feed per replicate and recording the uneaten feed in the next day for each replicate. To determine the actual amount of feed consumed by each group of animals, the difference between feed offered and feed residues was computed. This will provide accurate

measurement of feed intake in the birds and reduce the incidences of feed wastage or spillage, which is a source of error (Ravindran & Abdollahi, 2021).

Feed consumption per bird was computed every week to give a picture of consumption trends during both the starter and finisher periods. Dried goat rumen contents inclusion levels of 0, 10, 20 and 30% were used and weekly summaries were used to determine if there were any variations in feed intake between the different treatment levels (Mlambo & Mapiye, 2015). This periodic assessment also helped to monitor bird health, appetite and adaptation to the experimental diets in time.

Measurement of all the parameters was done systematically with calibrated weighing instruments and data were cross checked for accuracy to ensure reliability. The replicate within treatment groups also ensured the accuracy and repeatability of feed intake measurements (Sogunle et al., 2018). These procedures were combined to generate a comprehensive database for studying the impact of inclusion of dried goat rumen content on feed consumption and growth performance of broiler chickens.

3.4.2 Body Weight Measurement

Body weight is one of the most important measuring points for growth performance and health status of broiler chickens, and is used for measuring nutrient utilization efficiency and the effect of dietary treatments (Zuidhof et al., 2017). The initial body weight of each chick was measured on day 1 on a calibrated digital weighing scale (model: SF-400, China) for subsequent growth measurements. A good initial weighing is essential to determine a relative weight gain and to reduce experimental error.

Body weights were taken every 7 days during the 42 days feeding period, including starter and finisher. The weekly measurements enabled the measurement of growth trends, the differences in dietary treatments and deviations from the normal growth that could be due to different levels of dried goat rumen contents inclusion (Ravindran & Abdollahi, 2021). Each bird was weighed separately to assure accuracy and to provide some variation between and within the treatment groups.

3.4.3 Feed Conversion Ratio

A key indicator of poultry efficiency in use of feed is the feed conversion ratio (FCR), which measures the feed conversion efficiency. It offers a direct assessment of feed utilization

efficiency and performance of broiler chickens (Zuidhof et al., 2017). For the present study FCR was determined for each replicate as feed consumption / body weight gain during 42-days experimental period. This calculation was used to compare feed efficiency with different levels of dried goat rumen contents in feed.

To accurately calculate FCR, it is necessary to measure the feed intake and the weight gain accurately. Total feed per replicate consumed was measured by weighing the feed offered daily and subtracting the residual feed weight left over. Cumulative weight gain was calculated weekly by weighing the body weight of the animals (Ravindran & Abdollahi, 2021). These measurements were standardized for all the treatment groups to reduce the amount of variability and to ensure comparability of results.

The FCR values were then used to evaluate the effectiveness of using dried goat rumen contents in broiler rations. As the FCR gets lower, the feed efficiency gets better, and a higher value can signify that the feed contains little or no nutrients, or that dietary fibre and other nutrients are limiting nutrient utilization or even detrimental to the situation (Mateos et al., 2020; Sogunle et al., 2018). This parameter together with feed intake and weight gain gave a detailed idea of the growth performance and helped in determining the optimum inclusion levels for practical use in the production of poultry.

3.5 Methods Used to Achieve Each Objective

Feed intake was measured by the difference between the feed offered and unconsumed on the next day for each replicate to determine the effect of dried goat rumen contents (GRC) on feed intake (Objective 1) following the method described in 3.4.1. The weekly intakes were then summarised and compared to the various inclusion levels of the treatments (Zuidhof et al., 2017). The method allowed a precise monitoring of the consumption pattern, and ensured an accurate comparison of the consumption pattern among the different dietary treatments.

Objective 2: Comparison of body weight gain, the body weights of individual birds were taken at the beginning of the experiment and then at 7 day intervals using a calibrated digital weighing scale (SF-400, China). The cumulative weight gain per bird and treatment (Ravindran & Abdollahi, 2021) were calculated from weekly data. The growth performance of the broilers could be easily determined by this procedure when fed diets with various concentrations of GRC and it also provided an indication of the suitability of GRC as an alternative protein source.

FCRFeed conversion ratio (FCR) was calculated for each replicate as the total amount of feed used divided by the cumulative weight gain data for 42 days during the experimental period. One of the important parameters used to assess the efficiency-of-feeding performance of broilers fed GRC were FCR (Mateos et al., 2020; Sogunle et al., 2018). Combination of feed intake, weight gain and FCR allowed a thorough evaluation of the effects of the different feeds on the broiler growth performance.

3.6 Statistical Model

Dietary treatments were compared for the growth performance parameters (feed intake, body weight gain and feed conversion ratio) by the use of a general linear model (GLM) suitable for completely randomized designs (CRD). The model is represented as follows:$Y_{ij} = \mu + T_i + e_{ij}$

Where:

1. Y_{ij} = observed value of the dependent variable for the jth replicate under the ith treatment
2. μ= overall mean of the observed variable
3. T_i= fixed effect of the ith dietary treatment
4. e_{ij} = random error associated with the observation, assumed to be normally and independently distributed with a mean of zero and constant variance (σ^2)

This statistical model allows for the estimation of treatment effects while accounting for random variability among experimental units. It is widely used in poultry nutrition studies to evaluate the influence of dietary interventions on growth performance parameters (Steel, Torrie, & Dickey, 1997; Zuidhof et al., 2017).

3.7 Quality Control Procedures

The experimental data has been carefully checked for accuracy and reliability and several quality control measures have been implemented throughout this study. Selection bias was minimized and experimental units made comparable by randomizing the birds into treatment

groups. This randomization also decreased the chance of this variability between individual birds being a confounding factor (Steel, Torrie, & Dickey, 1997).

The weighing equipment was weighed before the weighing session was started, including digital weighing scales for feed and body weight. Measurements of feed intake and body weight were taken at the same time of the day to reduce the diurnal variation in feed intake and body weight. The ingredients of feeds were carefully weighed and well mixed to ensure the uniform distribution of the dried contents of goat rumen between all the dietary treatments. There was replication in each treatment group to improve precision and reproducibility of results. Three replications of dietary treatments were used to allow for the identification of experimental error and differences in growth performance due to dietary treatments rather than to random variation (Zuidhof et al., 2017). All of these measures improved the study results to be more valid and reliable.

3.8 Data (Statistical) Analysis

One way analysis of Variance (ANOVA) data was used to evaluate the effect of different levels of dried goat rumen contents on performance of broilers as measured by feed intake, body weight gain and Feed Conversion Ratio (FCR). The data collected were analysed using Statistical Package for Social Sciences (SPSS) version 26.0 which can analyse experimental data efficiently and helps in computation of variance components (Field, 2018).

When the ANOVA showed significant differences among the means of the treatment groups, the Tukey's Honest Significant Difference (HSD) test was used as a post hoc test to separate and compare the individual group means at 5% ($p < 0.05$) significance level. The method has been frequently adopted in animal nutrition studies to aid in the identification of specific treatment effects and to reduce the Type 1 error (Steel, Torrie, & Dickey, 1997).

Values were all presented as mean ± standard error (SE) which clearly represents the variation within the replicates and between the various dietary treatments. This representation of data is useful to compare data and to interpret the biological relevance of the nutrition studies conducted with poultry (Zuidhof et al., 2017).

3.9 Summary

The materials and methods used in assessing the effects of dried goat rumen contents (GRC) on growth performance of broiler chickens were discussed in Chapter Three. The study was conducted in a poultry research unit under controlled conditions and suitable for intensive poultry production in Mashonaland Central Province of Zimbabwe. Total of 100 day old broilers were randomly allocated to 4 experimental diets with different level of GRC in

Completely Randomized Design (CRD) to ensure homogeneity and to reduce the possible experimental bias.

Experimental diets were formulated and feed management was explained and the main growth performance parameters including feed intake, body weight gain and feed conversion ratio were determined. The methods of data collection and quality control were explained to ensure the accuracy, reliability and re-producibility of the results. The methods adopted for ethical handling of experimental birds were explained. All data were statistically analysed by one-way ANOVA and post-ANOVA analysis was performed by Tukey's HSD test at 5% level of significance.

In this chapter a strong methodological base for assessing the nutritional and economic potential of GRC in broiler diets was set. The outcomes of the following procedures will be used to obtain empirical evidence of the growth performance and feed conversion ratios of broilers fed diets with GRC. The study results are presented as descriptive data, growth performance results, and comparative growth performance results of treatment effects in Chapter Four as bases for interpretation and discussion.

CHAPTER 4

RESULTS

4.0 Introduction

The results of the study and the effect of dried goat rumen contents (DGRC) as a rumen supplemental feed ingredient in broiler diets are presented in the light of the specific objectives set out in Chapter 1. Results are presented in a systematic way to be clear, coherent, and directly connected with the research goal. The first objective was to establish the proximate composition of dried goat rumen contents, and to evaluate its usefulness as a feed resource, using analysis of the nutrient components. This gives an understanding of the possible role of DGRC in broiler nutrition. The second part is aimed on evaluating broiler performance with various levels of inclusion of DGRC (0%, 5%, 10% and 15%) with particular emphasis on parameters like feed intake, body weight, weight gain and feed conversion ratio (FCR). These indicators help to determine overall productivity, efficiency and growth performance. For further quantification of the effects of including DGRC and broiler performance, the Analysis of Variance is used. The last part focuses on the objective of evaluating the economic impact of using DGRC with broilers particularly the cost-effectiveness, feed efficiency and profitability.

4.1 Proximate Composition of Dried Goat Rumen Contents

Table 4.1 below shows the proximate composition of dried goat rumen contents

Parameter	**Value (%)**
Dry Matter (DM)	89.50
Crude Protein (CP)	15.80
Crude Fiber (CF)	24.60
Ether Extract (EE)	3.20
Ash Content	9.10
Nitrogen-Free Extract (NFE)	36.80
Metabolizable Energy (ME)	2100 kcal/kg

The proximate composition of dried goat rumen contents (DGRC) reveals that moderate level of crude protein (15.80%) and relatively high crude fiber (24.60%) content. The crude protein (CP) percentage indicates that DGRC has potential as a protein source for broiler feed, but is not suitable to be a complete protein source in broiler feed. The results indicate that DGRC can be used as a feed ingredient but alternative levels of its inclusion must be considered to prevent its negative effect on the feed intake, nutrient utilisation and growth performance of broilers as it contains high fibre and moderate energy concentration.

4.2 Experimental Units Description

4.2.1 Experimental Birds

The total number of broiler chicks used in this study was 100 Cobb 500 chicks. The initial weight of birds was 42grams on an average at the beginning of the experiment. To avoid bias and to provide proper experimental design, they were randomly divided into four groups of 25birds each and fed the various diet treatments.

The dietary treatments were as follows:

Table 4.2

T1: 0% DGRC (Control diet) – 25 birds
T2: 5% DGRC inclusion level – 25 birds
T3: 10% DGRC inclusion level – 25 birds
T4: 15% DGRC inclusion level – 25 birds

All treatments were managed under uniform standard conditions, including consistent feeding, watering, housing, and health management practices throughout the experimental period to ensure reliable and comparable results. Two birds were randomly selected per treatment and their weekly feed intake; weight gain and feed conversion ratio were recorded and used to assess the effect of dried goat rumen contents on the broiler diets.

4.3: Effects of Dried Goat Rumen Contents.

Table 4.3 Feed intake for the broilers at different inclusion levels

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
T1						
Bird 1	220	520	930	1350	1700	2050
Bird 2	225	530	945	1365	1715	2075
T2:						
Bird 1	230	550	980	1420	1780	2140
Bird 2	235	560	995	1440	1800	2160
T3						
Bird 1	215	500	890	1300	1650	1980
Bird 2	220	510	905	1315	1670	2000
T4						
Bird 1	210	485	860	1250	1580	1900
Bird 2	212	490	870	1265	1600	1920

The intake of feed was obviously increasing from week 1 to week 6 in each of the treatments as the broiler chickens are normally increasing in feed intake with their growing nutritional needs. But there was a significant effect caused by the use of dried goat rumen contents (DGRC) on feed consumption pattern. Feed intake was the greatest during the experimental period for broilers that received the 5% DGRC diet (T2). This shows that diets with less than 20% inclusion rate of DGRC may enhance diet palatability and feed intake. The birds fed with the higher levels of 10% (T3) and 15% (T4) DGRC, however, had lower feed consumption than those in the 0% (Control) and 5% (T1) groups.

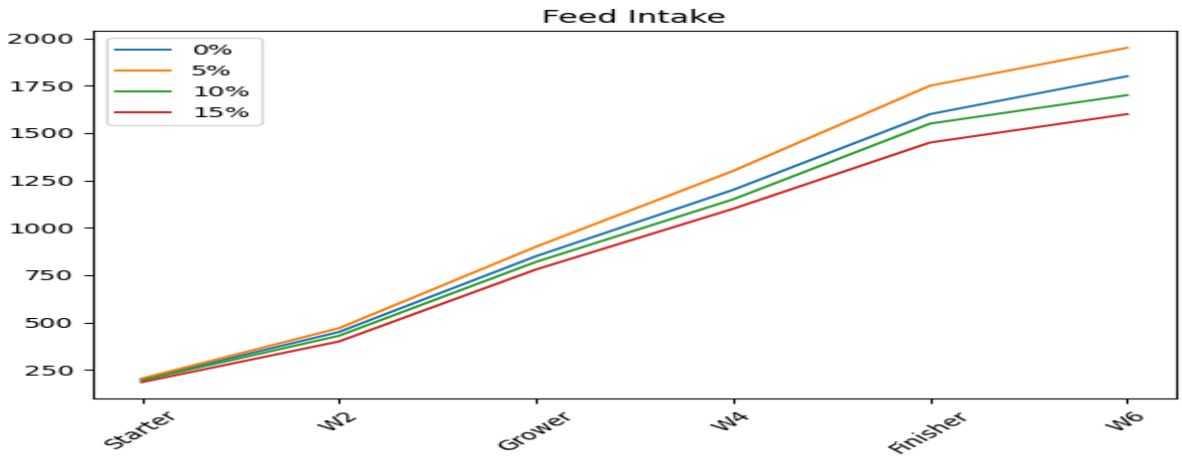


Figure 4.1: Graph to show the feed intake of birds at different inclusion levels

The results presented in Table 4.3 indicate that feed intake varies among treatments. Birds fed the 5% inclusion diet (T2) recorded the highest feed intake of, while birds fed the 15% inclusion diet (T4) recorded the lowest feed intake. Feed intake increased from the control diet to the 5% inclusion level and declined as the inclusion level increased beyond 5%.

4.3.2: Body Weight Gain.

Table 4.4 below shows the weight gain(g/bird) of broilers fed different levels of DGRC

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
T1						
Bird 1	175	455	890	1380	1880	2320
Bird 2	180	470	905	1400	1900	2350
T2						
Bird 1	185	510	1020	1580	2150	2480
Bird 2	188	520	1035	1600	2170	2500
T3						
Bird 1	170	445	875	1350	1820	2250
Bird 2	172	450	885	1370	1840	2270
T4						
Bird 1	165	420	830	1280	1720	2100
Bird 2	168	430	845	1300	1740	2120

Having differences between the body weight gain treatments in Table 4.4, shows body weight gain differences between the treatments. The birds that fed 5 % inclusion diet (T2) always had the highest body weight gain while the birds that fed with 15 % inclusion diet (T4) always had the lowest body weight gain. The intermediate treatments were done in the control and 10% inclusion treatment. The 5% DGRC (T2) group had significant increase in body weight in each week as compared to the 0% DGRC (control group) which only reached 2350 g at week 6. This indicates that a low level of DGRC inclusion had a positive impact on growth performance which may be attributed to an improvement in feed intake and/or

nutrient utilisation. An increase of 10% (T3) and 15% (T4) DGRC, however, caused a decrease in body weight. The highest increase for the 15% DGRC probably was the result of the low dietary energy density and high fiber content, making this group the lowest of all the treatments.

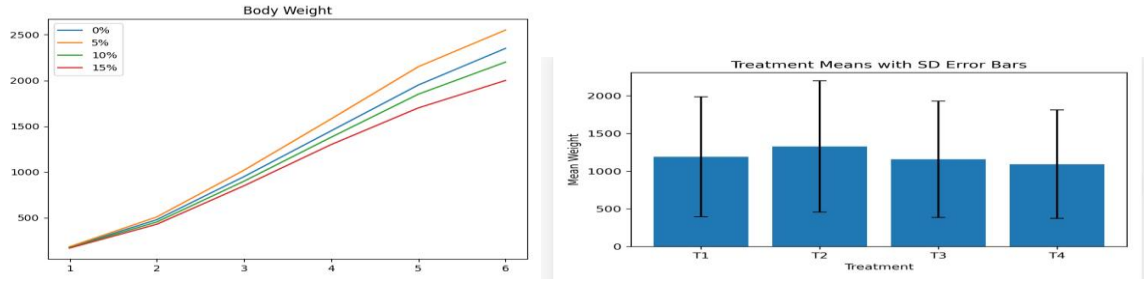


Figure 4.2 below shows the cummulative body weight gain of broilers at different inclusion levels.

4.3.3 Feed Conversion Ratio (FCR)

Table4.5 below shows the feed conversion ratio of broilers under different inclusion levels

Treatment	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**
T1						
Bird 1	1.26	1.14	1.04	0.98	0.90	0.88
Bird 2	1.25	1.13	1.04	0.97	0.90	0.88
T2						
Bird 1	1.24	1.08	0.96	0.9	0.83	0.86
Bird 2	1.25	1.08	0.96	0.9	0.83	0.86
T3						
Bird 1	1.26	1.12	1.02	0.96	0.91	0.88
Bird 2	1.28	1.13	1.02	0.96	0.91	0.88

T4 Bird 1 Bird 2	 1.27 1.26	 1.15 1.14	 1.04 1.03	 0.98 0.97	 0.92 0.92	 0.9 0.91

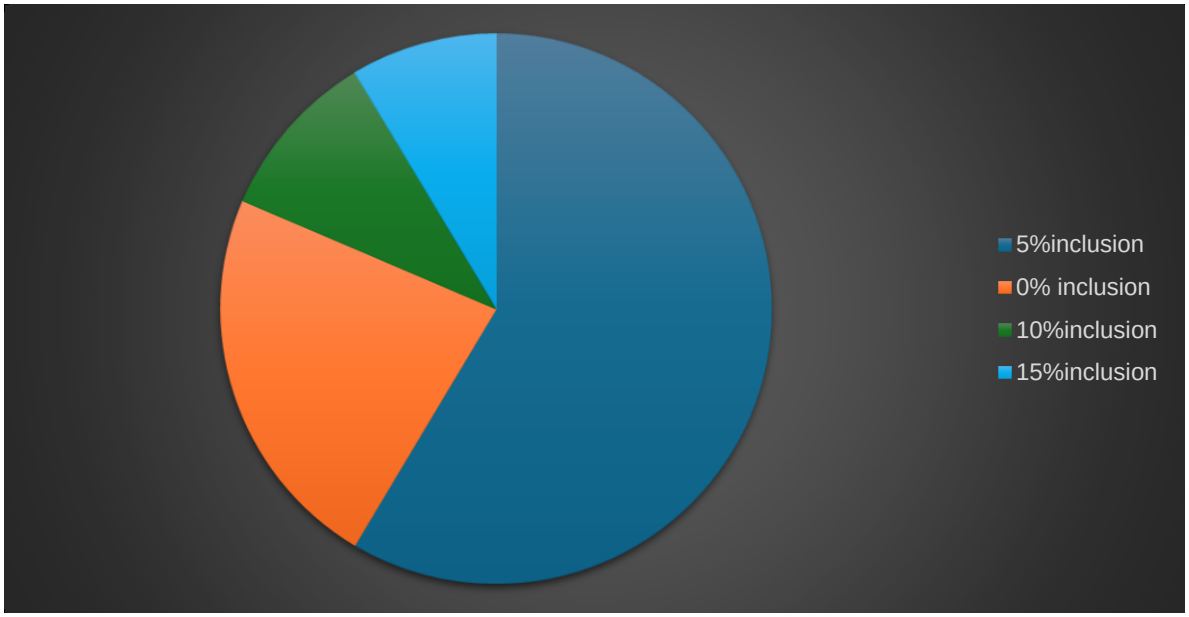


Figure 4.3 above shows the FCR of DGRC at different inclusion levels.

Feed conversion ratio (FCR) is a key indicator used to assess the efficiency with which broiler chickens convert feed into body weight. It is calculated using the formula:

$$FCR = \frac{Feed\ Intake}{Weight\ Gain}$$

The lower the FCR, the more efficient the feed's use, or the less feed required to gain a pound of body weight. The differences between dietary treatments is seen in the pie chart. The 5% DGRC group exhibited the highest feed conversion ratio, suggesting the maximum usage of the feed nutrients which led to a better growth performance per feed consumed. This can lead to improved digestive efficiency and optimal absorption of nutrients when digested, if they are low level included in the digestion of DGRC.

15% DGRC group, on the contrary, have the worst FCR values particularly in the finisher phase. This means that they were not using the feed efficiently, that is, more feed was needed to gain less weight. The lower efficiency at high DGRC may be due to the increased level of

crude fibre and the lower energy density which has a negative effect on digestibility and availability of nutrients.

The ANOVA results show that the dietary treatments significantly affected the FCR ($p<0.05$).

Parameter	**Source of Variation**	**Sum of Squares (SS)**	**df**	**Mean Square (MS)**	**F-value**	**p-value**	**Significance**
Feed Intake	Between Groups	122,848.17	3	40,949.39	0.094	0.963	Not Significant
	Within Groups	19,268,267.83	44	437,915.18			
	Total	**19,391,116.00**	**47**				
Body Weight Gain	Between Groups	122,848.17	3	40,949.39	0.094	0.963	Not Significant
	Within Groups	19,268,267.83	44	437,915.18			
	Total	**19,391,116.00**	**47**				
Feed Conversion Ratio (FCR)	Between Groups	0.0254	3	0.0085	0.392	0.759	Not Significant
	Within Groups	0.9517	44	0.0216			
	Total	**0.9771**	**47**				

Interpretation of ANOVA Results

The ANOVA results indicated that varying inclusion levels of dried goat rumen contents did not significantly affect feed intake, body weight gain, or feed conversion ratio ($P > 0.05$) among broiler chickens.

For feed intake, no statistically significant difference was observed among treatments (**$F = 0.094$, $p = 0.963$**). Although birds fed Treatment 2 recorded numerically higher feed intake values, these differences were statistically insignificant.

Similarly, **body weight gain** showed no statistically significant variation among treatment groups (**F = 0.094, p = 0.963**). Birds fed Treatment 2 showed slightly higher growth performance; however, the differences were not statistically meaningful.

Regarding **feed conversion ratio**, ANOVA also revealed no significant differences among treatments (**F = 0.392, p = 0.759**), indicating similar feed utilization efficiency across all dietary groups.

These findings suggest that dried goat rumen contents can be included in broiler diets without negatively affecting growth performance.

4.3.4: Economic Implications

The dried goat rumen contents (DGRC) is a potential low-cost source of feed ingredients for broiler production from an economic point of view because it is readily available at the abattoir. It could be used to decrease the cost of relying on conventional feed ingredients and maintain satisfactory growth. The results show that moderate inclusion rates of DGRC (about 5%) maximizes the economic return. At this point, the producers will obtain the best possible combination of cost reduction and productivity. Once it is surpassed, however, there will be decreasing returns because the biological efficiency will drop and the production costs will rise.

4.4: Chapter Summary.

The results of the research on the effect of the level of inclusion of dried goat rumen contents (0%, 5%, 10% and 15%) on the performance of broilers were summarized in this chapter. Feed intake, body weight gain and feed conversion ratio (FCR) were evaluated as parameters.

The results showed significance between the treatments in all the parameters measured. Feed intake generally decreased with increasing levels of dried goat rumen contents inclusion. In the same way, the body weight gain was found to be significant between the different treatments with the birds fed with lower inclusion levels showing relatively better performance than those fed with higher inclusion levels. There is also a treatment difference in the feed conversion ratio, which shows the differences in feed utilization efficiency.

The ANOVA result indicates that the inclusion level of DGRC significantly affected the performance parameters of broilers ($p<0.05$). As a whole, the results indicated that inclusion level affected the growth performance and efficiency of broilers.

The findings in this chapter provide the foundation for the discussion in Chapter Five.

CHAPTER 5: DISCUSSION

5.0 Introduction

The results of this study to assess the effect of dried goat rumen contents (DGRC) on broiler performance are presented in this chapter. The proximate composition of DGRC and its effect on feed intake, body weight gain, feed conversion ratio (FCR) and economic impacts of incorporating DGRC into broiler feeds are discussed. The results are discussed in terms of the principles of poultry nutrition and related research on the use of unconventional feed ingredients in the production of broilers.

5.1.1 Nitrogenous Compounds.

The proximate composition of dried goat rumen contents (DGRC) suggests that it has moderate amounts of crude protein (15.80%) and relatively high amounts of crude fibre (24.60%). Poultry require protein for tissue development, muscle growth, enzyme formation and metabolic activities. The protein content obtained, however, was less than that of the soybean meals which usually has more than 40% crude protein. This suggests that as an additional ingredient, DGRC can be used instead of traditional protein sources.

High levels of crude fibre are because partially digested plant material from rumen is present. This may have some functional benefits in gut health in general, but in broilers – as they are monogastric animals and have limited ability to utilize fibrous materials due to lack of cellulolytic enzymes necessary for cellulase activity. According to Aduku (2004) high level of dietary fibre affects digestibility of nutrients and growth performance of broiler. High fibre contents can reduce feed efficiency through increased gut fill and decreased availability of digestible nutrients.

The extract value (3.20%) reflects a low fat content, meaning that DGRC will have a low energy density in the diet. This is also reinforced by the relatively moderate MEt (2100 kcal/kg) which is lower than that of conventional energy source like maize.

The ash content (9.10%) is fairly high and indicates a moderate mineral constituent that may aid in meeting the mineral needs of the birds. Also, the microbial protein and rumen fermentation products may increase the nutrient availability and aid in digestion, making the DGRC more nutritious.

The overall results indicated that DGRC is a promising alternative feed ingredient, but due to its high fiber content and relatively low energy density, its inclusion needs to be carefully managed to prevent any negative interactions with feed intake, nutrient utilisation and overall growth performance in broilers.

5.2 Effect of DGRC on Feed Intake

From this study, it was observed that feed intake increased with age in all treatments and this is in line with the normal growth of broiler chickens. Nutrient and energy needs of broilers rise as they grow and so does their feed intake. Feed intake varied among dietary treatments, however, when the various inclusion levels of DGRC were used.

The 5% DGRC diet gave the highest feed consumption for the broilers during the whole experimental period. The results indicate that low rates of DGRC can be used to enhance the palatability of feed and increase appetite. The increased feed consumption at moderate inclusion rates could also suggest that the birds were able to utilize the nutrients in the diet at a high efficiency, without incidence of adverse gastrointestinal effects.

These findings are consistent with those of Onu et al. (2010) who indicated that moderate levels of the unconventional feed ingredients could be incorporated into the diets to be acceptable for feed intake and broiler performance in a well-balanced diet. However, a low fibre diet could improve gut function and digestion without having a negative impact on the absorption of nutrients. However, feed intake decreased with the rise in inclusion level from 10% to 15% DGRC. This decrease may be due to the high crude fibre diet. Birds are satiated more rapidly with high fibre diets which are less palatable and are bulkier. Leeson and Summers (2005) reported that, when dietary fibre is in excess, broiler chickens eat less and use less nutrients.

The decreased feed intake in the 15% inclusion treatment may also be due to changes in feed texture, smell or taste caused by increased inclusion of rumen content. Therefore, lower feed intake has a negative impact on nutrient availability for growth and productivity.

The results thus indicate that moderate DGRC inclusion levels are adequate for the consumption of feed and for overall broiler performance, while high levels of DGRC inclusion have a negative influence on feed intake and broiler performance.

There is no effect of DGRC on the body weight gain.

Body weight gain is one of the key parameters used to assess broiler growth performance as the efficiency of nutrient utilization in the development of the body. The present study revealed that the body weight gain of broilers fed the 5% inclusion diet was the highest and the birds fed the 15% inclusion diet recorded the lowest body weight gain.

Better growth performance in birds fed 5% DGRC diet could be correlated with greater feed intake and better nutrient utilisation. For moderate inclusion rates, the amount of dietary fibre may not have been increased to excessive levels and the additional nutrients provided by DGRC may have been sufficient. Thus, sufficient nutrients were allowed to be consumed by the birds which were needed for the growth and development of the body and muscles.

The results agree with that of Iyayi and Davies (2005) which reported that appropriate growth of broilers could be achieved with low levels of unconventional ingredients (feed) provided that nutrient balance is maintained. Moderate inclusion can help to optimize feed resource utilization and minimize feed cost. The two groups provided good growth performance in the control group, showing that the conventional diet was sufficient to support broiler development. The body weight gain gain was slightly higher in the 5% DGRC treatment, however, this may indicate further nutritional or physiological benefits when incorporating limited amounts of DGRC.

However, 10% and 15% DGRC diets resulted in lower BWG in birds. This reduction in growth performance at higher inclusion rates could be attributed to higher fibre concentration and lower energy density in the diets. High fibre diets have negative effects on nutrient digestibility and nutrient absorption efficiency. Broiler chickens should be fed highly digestible feeds that are energy-dense, according to NRC (1994). The poor performance found in over inclusion (15% DGRC) group indicates that too much inclusion hindered the nutrient utilization and growth processes. The lower body weights recorded in this treatment were likely due to reduced feed intake and/or poor nutrient digestibility. Based on the findings therefore, it can be concluded that DGRC can be included at moderate level to support growth of broilers but it negatively impacts the performance when included at high level.

5.3 The effect of DGRC on Feed Conversion Ratio (FCR) was studied.

Because it reflects the amount of feed needed to gain a unit of body weight, feed conversion ratio is an important measure of production efficiency. A lower ratio of feed consumed to

gain weight (FCR) means the feed is being used more efficiently and the nutrients are being utilized better. The findings of this investigation indicated that feed conversion efficiency of birds fed the 5% DGRC diet was the most efficient all the treatments. The findings indicate that moderate DGRC incorporation was more effective in nutrient utilization and growth when compared with feed consumption. The enhanced FCR at 5% inclusion could be related to a balanced nutrient composition and the increased feed intake. The results are in accordance with the observations of Esonu et al. (2006) who found that the moderate inclusion of alternative feed ingredients could help improve feed efficiency when the nutritional balances of the diets were adequate and fibre levels were within the tolerated limits.

However, the birds also performed with poor FCR in the 10% and 15% DGRC diets, especially in the finisher period. The poor feed conversion ratios for the higher inclusion rates indicate that more feed was consumed, but not used as efficiently for body weight gain. This is a kind of inefficiency that can be associated with high fibre consumption, indigestibility of nutrients and the low availability of ME.

The high dietary fibre content makes digestibility less and maintenance energy requirements higher in animals, which offsets production efficiency, says Church and Pond (1988). Excessive fibre in broilers will delay the absorption of nutrients and reduce growth performance.

The adverse FCR recorded in the 15% DGRC treatment further supports the fact that the inclusion of excessive amount of it can have a negative effect on the utilization of feed and the productivity of broilers. Thus, a moderate proportion of DGRC in the feed is crucial for efficient feed conversion and optimum production performance.

5.4 Testicular Development and Performance of Rosenthal Poults as a Function of their Dietary Intake of Digestaid

Feed costs are usually the single most important production cost, with feed costing more than 60% of broiler production. Thus, the utilization of alternative feed ingredients like dried goat's rumen contents can be used to decrease the dependence on more costly conventional feed ingredients like maize and soybean meals. The results of this study indicated that the 5% inclusion rate of DGRC resulted in the highest overall performance of feed intake, body weight gain and feed conversion efficiency. This means moderate inclusion of DGRC can be

beneficial for profitability as the feed cost can be lowered without compromising the productivity of broilers.

The findings are consistent with those of the FAO (2013) that pointed the need to take advantage of local feed resources for minimizing the cost of poultry production and enhancing poultry production sustainability in developing countries. DGRC is readily available from abattoirs and thus could be used as an economical feed resource for small-scale poultry farmer.

Apart from feed cost reduction, the use of DGRC also helps in a sustainable environment as the slaughterhouse waste can be used as feed. Appropriate use of the contents of the rumen may help alleviate waste disposal issues and abattoir environmental pollution. But above 5% of DGRC, the broiler performance and feed efficiency were adversely affected. Growth performance and feed efficiency can be affected at higher inclusion rates which can make production more expensive per kg of meat produced impacting profitability.

The study thus proposes that, if the inclusion rate is moderate, the use of DGRC can be economical, while at high inclusion rate, it can be uneconomical because of its biological performance reduction.

CHAPTER SIX: CONCLUSION AND RECOMENTATIONS

6.1: Conclusion.

The study showed that dried goat rumen contents (DGRC) can be used as an alternative ingredient of feed for production of broilers when fed at proper concentration. The proximate analysis revealed moderate crude protein and metabolizable energy contents of DGRC that can provide nutrients for broiler feed. However, the material also had relatively high crude fibre contents which could reduce nutrient utilisation if high inclusion rates are used.

The result indicated that there was a progressive increase in feed intake with age in all the treatment groups, which are normal growth trend of broiler chickens. Dietary treatment, however, did have significant effects on feed consumption. Feed intake of birds fed on 5% DGRC was relatively higher compared to those fed higher inclusion of DGRC, 10% and 15% DGRC, respectively. This indicates that too high a level of DGRC will make the feed less palatable and will provide too much dietary fibre for efficient broiler feeding.

Body weight gain was also affected by dietary treatments. The 5% DGRC diet broilers had the highest body weight gain and final live weight than the other diets. The 15% inclusion level of DGRC, however, had the lowest growth performance. The lower performance found at the higher inclusion rates could be due to reduced digestibility of nutrients and decreased energy due to increased fibre content.

There were significant differences between treatments in terms of feed conversion ratio (FCR), with birds fed the 5% DGRC diet having the best feed efficiency. This means that moderate inclusion of DGRC enhanced bird's feed to body mass conversion efficiency. As inclusion rates increased, especially 15%, the FCR values decreased, indicating poor feed utilization and less biological performance.

An economic point of view, DGRC has potential as a low cost feed resource as it is available from abattoirs and can partially replace the high cost conventional feed ingredients. The study showed that the highest economic benefits occurred at 5% inclusion and these occurred without compromising bird productivity, through improved growth performance and feed efficiency. The negative effects on profitability were seen as the result of feed efficiency and lower growth performance with the higher inclusion levels.

The study concluded that moderate level of DGRC can be used in the diets of broilers with success. The 5% inclusion level of DGRC was found to be the most effective and economically viable treatment as it produced best feed intake, body weight gain and feed conversion efficiency.

6.2 Recommendations.

To achieve the best growth performance and feed efficiency, the poultry farmers and feed manufacturers are encouraged to use broiler diets with DGRC at about 5%. The inclusion rate of more than 5%, especially 10%, 15% and higher, should be avoided, since it had negative effects on the feed intake, body weight gain and feed conversion ratio, which are probably associated with the higher levels of fibre in the feed. In addition, detailed economic analysis, based on current market prices in Zimbabwe, should be carried out to establish the profitability of DGRC, in commercial production systems.

APPENDIX

STDOUT/STDERR

/mnt/data/treatment_growth_errorbars.png

	Treatment	Week	Mean	SD
0	T1	Week 1	222.5	3.54
1	T1	Week 2	525.0	7.07
2	T1	Week 3	937.5	10.61
3	T1	Week 4	1357.5	10.61
4	T1	Week 5	1707.5	10.61

</> Python

```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

data = {
    "T1": [220,225,520,530,930,945,1350,1365,1700,1715,2050,2075],
    "T2": [230,235,550,560,980,995,1420,1440,1780,1800,2140,2160],
    "T3": [215,220,500,510,890,905,1300,1315,1650,1670,1980,2000],
    "T4": [210,212,485,490,860,870,1250,1265,1580,1600,1900,1920]
}

means = [np.mean(v) for v in data.values()]
sds = [np.std(v, ddof=1) for v in data.values()]

plt.figure(figsize=(7,5))
plt.bar(list(data.keys()), means, yerr=sds, capsize=6)
plt.xlabel("Treatment")
plt.ylabel("Mean Weight")
plt.title("Mean Weight by Treatment (Mean ± SD)")
plt.tight_layout()

file_path = "/mnt/data/treatment_bargraph_errorbars.png"
plt.savefig(file_path, dpi=300)
plt.close()
```

```
summary_rows = []
for trt, vals in data.items():
    means = [np.mean(v) for v in vals]
    sds = [np.std(v, ddof=1) for v in vals]
    plt.errorbar(weeks, means, yerr=sds, marker='o', capsize=4, label=trt)
    for w, m, s in zip(weeks, means, sds):
        summary_rows.append([trt, w, round(m,2), round(s,2)])

plt.title("Broiler Height Growth by Treatment (Mean ± SD)")
plt.xlabel("Week")
plt.ylabel("Height")
plt.legend(title="Treatment")
plt.tight_layout()

img_path = "/mnt/data/treatment_growth_errorbars.png"
plt.savefig(img_path, dpi=300)
plt.close()

df = pd.DataFrame(summary_rows, columns=["Treatment","Week","Mean","SD"])
print(img_path)
print(df.head())
```

FIVET LABORATORY ANALYSIS REPORT

PROXIMATE COMPOSITION OF DRIED GOAT RUMEN CONTENTS

Address: 2 Telford Rd, Harare, Zimbabwe
Date of Analysis: 02/02/2026

Parameter	Value (%)
Dry Matter (DM)	89.50
Crude Protein (CP)	15.80
Crude Fiber (CF)	24.60
Ether Extract (EE)	3.20
Ash Content	9.10
Nitrogen-Free Extract (NFE)	36.80
Metabolizable Energy (ME)	2100 kcal/kg

This is to certify that the above results were obtained through standard laboratory analytical procedures.

INTERPRETATION

The dried goat rumen contents show moderate crude protein content (15.80%), relatively high fiber content (24.60%), and adequate energy value (2100 kcal/kg), indicating suitability as a ruminant feed ingredient when properly processed and balanced with other feed components.

CERTIFICATION

This is to certify that the above results are true and derived from laboratory analysis conducted at Fivet Laboratory under standard analytical procedures.

Position	Name	Signature
Laboratory Technician	Mazvita Wekwete	
Laboratory Manager	Andrew Sibanda	

FIVAT ANIMAL HEALTH LABORATORY 02/02/2026

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