BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

Reducing beef cattle pen fattening costs through on-farm feed formulation using poultry manure as crude protein: University of Zimbabwe farm.

A dissertation submitted in partial fulfillment of the requirements of the

Bachelor of Agricultural Science Honors Degree in Agricultural Economics and Management

By

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JUNE 2026

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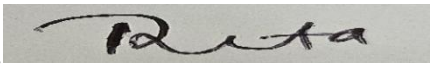
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The undersigned certify that they have supervised and recommended to Bindura University of Science Education for acceptance of the dissertation **entitled "Evaluation of the effects of on-farm feed formulation using poultry manure as the major component of the feed in beef cattle pen fattening to reduce production costs,"** submitted in partial fulfillment of a Bachelor of Science Honors Degree in Agricultural Economics and Management

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DECLARATION

I, Tinotenda Zvaita do hereby declare to the Senate of Bindura University of Science Education that this research project entitled "**Evaluation of the effects of on-farm feed formulation using poultry manure as the main source of crude protein in beef cattle pen fattening to reduce production costs"** is a result of my original research work. It has neither been submitted nor concurrently submitted to any other institute. All sources of information from other researchers have been duly acknowledged and cited.

Name: Tinotenda Zvaita

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DEDICATION

I dedicate this dissertation to my beloved parents (N and G Zvaita) for their endless support, encouragement, prayers and sacrifices throughout my academic journey. It is also dedicated to my family and friends whose motivations and beliefs inspired me to complete this study successfully.

ACKNOWLEDGEMENTS

Above all else, I praise and give glory to my almighty God for the strength, wisdom, persistence and grace that have seen me through to successfully completing this project. I wish to acknowledge my parents for their unwavering love, financial support and prayers through out my academic journey. I will also like to thank my project supervisor Dr. E. Zivenge for his guidance, patience and constant support through out this research process. I will also like to thank the management and staff at University of Zimbabwe Agro-Industrial Park (UZAIP) for giving me access to the facilities and technical help during the feeding trials. I wish to extend my sincere thanks to my fellow students and colleagues for the moral support, suggestions and help in various ways in collecting and analysing data during the course of this research.

ABSTRACT

Costs related to feeds form the biggest problem in beef cattle pen fattening in Zimbabwe, contributing about 70 percent of total production costs in the country. This study aimed at determining the effects of formulating feed on the farm using broiler manure as the main source of crude protein in the feed on the growth performance, feed conversion ratio, and profitability of beef cattle during the pen fattening period.

This study was conducted at the University of Zimbabwe Agro-Industrial Park (UZAIP), which is situated in Mazowe District in the Mashonaland Central Province of Zimbabwe. Twenty crossbred steers between 18 to 24 months old with starting weight of 200 to 250 kg were allocated into two groups for the different diets in a Completely Randomized Design (CRD). T1 received a commercial beef finishing meal while T2 received a broiler manure based formulated feed that included 35 percent inclusion of broiler manure along with other ingredients including maize silage, maize crushes, molasses, salt, and mabiko mineral supplement.

Results indicated that steers on the commercial beef finishing meal (T1) treatment performed better in terms of weight gain (105.2 kg), average daily gain, and feed intake in comparison to those steers fed with the broiler manure-based diet (T2), whose total weight gain was 81.0 kg. Feed conversion ratio was also found to be much higher in T1 (9.2) than in T2 (9.9) treatment, implying better nutrient utilisation efficiency in T1 treatment. Economically, however, the use of the broiler manure-based feed formulation in T2 decreased the cost of feeds from USD 380.00 per tonne to USD 167.80 per tonne, giving a gross margin of USD 139.00 versus USD 74.56, with a much better benefit-cost ratio of 1.35 versus 0.78 respectively.

It was therefore concluded that while the use of commercial beef finishing meal gives good biological performance, the broiler manure-based feed formulation is economically more profitable since it is associated with much lower production costs. Broiler manure-based on-farm feed formulations thus provide an economically viable feed resource option for beef cattle pen fattening systems**.**

Keywords: Broiler manure, beef cattle, pen fattening, feed conversion ratio, profitability, on-farm feed formulation, Zimbabwe.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADG	Average Daily Gain
ANOVA	Analysis of Variance
BCR	Benefit Cost Ratio
CRD	Completely Randomised Design
CV	Coefficient of Variation
FCR	Feed Conversion Ratio
LSD	Least Significant Difference
SED	Standard Error of Difference
TWG	Total Weight Gain
UZAIP	University of Zimbabwe Agro-Industrial Park

CHAPTER 1

INTRODUCTION

1.0 Background of the Study

Livestock has a significant part in Zimbabwe's agricultural economy in that it creates job opportunities, creates income for households, and also provides animal protein. Production of beef cattle has a significant impact on food security and the livelihood of the people through the production of meat, hides and livestock animals. The cattle population of Zimbabwe stands at between 4 million and 5 million head with the majority of the cattle being the indigenous breeds in communal farming areas and exotics in the commercial farming areas (Tavirimirwa et al., 2013).

Livestock and livestock products make a major contribution to the country's economy where cattle makes about 35%-38% of agricultural gross domestic product and 60% of households in rural areas have cattle (Runganga et al., 2021). About 25% of national total agricultural output is contributed by the livestock sector in Zimbabwe (Jenkins et al., 2018), with majority of the people in rural areas relying on agriculture for their livelihoods.

Though important in beef production, one of the problems facing intensive beef production operations like pen fattening is the rising costs of feed. "According to Piszcz et al. (2022), feed makes up 60-70 percent of the overall costs of production in beef operations. In pen fattening, cattle are confined and fed with a well-balanced diet with high energy levels for 60 to 120 days for better weight gain and carcass quality (Gororo, 2015). But the rising prices of feed ingredients like cottonseed cake, soya meal, and concentrated feeds have made it less profitable for the farmers and has made most smallholder farmers not to engage in feedlot operations (Arcanjo et al., 2022).

Due to the growing demand for cheaper livestock feeds, there has been an interest in alternative and available feed sources. Such alternatives include poultry manure that is abundant due to the growth of the poultry sector in Zimbabwe. The use of poultry litter as an animal feed ingredient is believed to have the following benefits of being a cheap feed ingredient (Tsadik et al., 2008).As the sector grows very fast, large quantities of poultry waste have emerged posing environmental management problems if the wastes are disposed

of inappropriately. Unmanaged poultry waste leads to environmental pollution including pollution of the soil and groundwater, bad odor, and the spread of disease (Rahman et al., 2022).

Studies show that the poultry manure is rich in nutrients including crude protein, minerals and non-protein nitrogen that can be used efficiently by ruminants after fermentation in the rumen by microorganisms (Chavda et al., 2014). Poultry manure has been found to contain 25 percent crude protein equivalent and 50 percent total digestible nutrients which make it a potential source of nutrient supplement for the ruminants (Feedipedia, 2012). Feeding of the poultry manure to ruminants is beneficial not only in reducing the feeding cost of ruminants but also helps in managing the pollution caused due to poultry waste. In addition, the manure helps to overcome the scarcity of protein and energy sources during the dry season.

A number of research studies have shown that cattle receiving feed that contains poultry manure are able to achieve similar growth rates when compared with cattle receiving conventional feeds while lowering the cost of feeding the animals (Chakoma et al., 2016). The addition of poultry manure to the diet of beef cattle, therefore, offers chances of making more efficient use of resources by transforming farm waste to produce efficient livestock. Nevertheless, despite the addition of poultry manure to beef cattle feeds, there is a need for evaluation of the implications for the safe and efficient use of broiler manure in order to ensure stable feed conversion, growth rates and profit margins (Khan et al., 2016).

The information asymmetry that exists between farmers and researchers in Zimbabwe is a challenge to the use of manure-based feed formulas for beef cattle pen fattening. Farmers still continue to depend on costly commercial feeds because of uncertainties regarding the nutritional content, safety and economic efficiency of manure-based diets.Thus, the objective of this study will be to investigate the impact of formulating on-farm feed using broiler manure as a major source of crude protein for pen-fattened beef cattle in order to reduce production costs at the University of Zimbabwe Agro-Industrial Park.

1.1 Statement of the Problem

Pen fattening of beef cattle in Zimbabwe is faced with several problems including increased production costs arising from the high cost of commercial feed, which represents about 70% of the total cost of producing beef. The continued use of expensive sources of protein like

cotton seed cake and soya meal makes the enterprise unprofitable and prevents small-scale farmers from venturing into beef feedlots. On the other hand, large amounts of broiler manure from poultry farms go to waste or are disposed inappropriately causing environmental pollution.

Although broiler manure contains high amounts of nutrients that can be utilised by ruminants, it remains an untapped potential in this regard. Nevertheless, although broiler manure has potential to be used as low-cost ingredients in formulating feeds, very few studies have been conducted to test the effect of broiler manure in Zimbabwe. Lack of scientific evidence in the locality makes farmers, livestock nutritionists, and extension workers doubtful of the efficacy and safety of this method. Consequently, the uptake of the feed formulation strategy using broiler manure is not popular yet. This research is geared towards studying the impacts of using poultry manure for feed formulation on the growth and profitability of beef cattle.

1.2 Justification of the Study

This assessment is important to stakeholders involved in the livestock industry such as farmers, feedlot managers, agricultural extension officers and policymakers since it assesses the possible uses of broiler manure as a cheap and readily available source of feed. In case the broiler manure feed formulations turn out to be effective, then the farmers would rely less on expensive commercial feeds hence reducing costs of production and increasing profits of the beef cattle fattening ventures.

It also supports sustainable agriculture through better utilisation and recycling of chicken waste into alternative feeds. Instead of broiler manure being wasted and acting as environmental pollutants, it can be put into good use by recycling it into productive resource within integrated livestock production systems. It leads to more efficient nutrient recycling, environmental protection and efficient resource utilisation.

Lastly, it also adds to the body of knowledge on alternative feeds for ruminant animals in resource-limited situations. Studies that investigate the utilisation of poultry manure in beef cattle diet under Zimbabwean conditions have not been widely documented. Hence, this research project will add scientific information about the effects of broiler manure feed formulations on beef cattle growth performance and profitability. The results of this study

can be used as a basis for future research and development of formulations that are likely to contribute to sustainable and profitable beef production systems in Zimbabwe and the entire Southern Africa region.

1.3 Main Objective

To evaluate the effects of on-farm feed formulation using poultry main source of crude protein in beef cattle pen fattening to reduce the cost of production.

1.4 Specific Objectives

To measure the impacts of feed formulation from broiler manure at farm level on growth performance of beef cattle during pen fattening.

To determine the feed conversion efficiency of beef cattle during pen fattening.

To evaluate the impacts of feed formulation from broiler manure at farm level on the profitability of beef cattle pen fattening through cost-benefit analysis.

1.5 Research Questions

- Does the incorporation of broiler manure into feeds have any significant effect on the performance of beef cattle?
- Is there any difference in the feed conversion ratio of beef cattle?
- Is the inclusion of broiler manure in the feeds a cost-saving measure for the beef cattle fattening business?

1.6 Hypotheses

H_0: The use of poultry manure as the main ingredient for on-farm feed formulation does not significantly affect production costs.

H_1: The use of poultry manure as the main ingredient for on-farm feed formulation significantly lowers production costs.

H_0: There is no significant difference in the feed conversion ratio between steers raised on a broiler manure-based diet and those on a standard commercial diet.

H_1: steers raised on a broiler manure based diet show a significant difference in feed conversion ratio compared to those on a standard commercial diet.

H_1: feeding a broiler manure- based formulation increases overall profitability per steer compared to a standard commercial ration.

H_0: feeding a broiler manure-based formulation significantly reduces overall profitability compared to a standard commercial ration.

1.7 Limitations of the Study

- Broiler manure nutrient content variability arising from variation in poultry feeds, litter types, and manure management techniques may affect the experimental outcome.
- Constraints in terms of space and resources at the University of Zimbabwe Agro-Industrial Park may limit the number of experimental animals, thus low statistical power.
- This experiment will be conducted on the pen fattening stage only for about 60 to 90 days and does not consider any other effect beyond this period such as carcass characteristics, fertility, or animal health status.

1.8 Delimitations of the Study

- The study considers broiler manure alone as feed additive while ignoring any other type of poultry manure.
- The study deals only with growth performance and economic profit without considering carcass traits, meat quality, and health of animals.
- The study includes certain inclusion rates of broiler manure obtained from preliminary trials but not all inclusion rates.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview of beef cattle pen fattening and feed costs

Production of beef cattle is a major agricultural venture across the world which contributes considerably towards food security, employment generation and income creation. The rising global population and urbanization have increased the need for meat protein, especially beef, hence increased demand for beef cattle production methods that would be efficient and sustainable (Food and Agriculture Organization [FAO], 2020). Beef production has been seen to play an important role in enhancing livelihoods and household incomes, especially in developing countries like Zimbabwe as studied by Banda & Tanganyika (2021). Cattle are reared using extensive, semi-intensive and intensive methods. Among these, pen fattening has been observed to be among the most efficient methods for finishing cattle in short period of time.

Pen fattening also referred to as feedlot is an intensive cattle production method whereby cattle are confined in pens where they are offered energy-rich feeds which will ensure they gain weight rapidly until they reach marketable weight prior to slaughtering (Streeter et al., 2012).Improvement of carcass characteristics, raising the level of dressing percentage, and ensuring economic profitability in the shortest possible period is one of the key aims of pen fattening. Pen fattening is common practice in Zimbabwe carried out mostly by commercial

farmers during the dry season because of the inadequacy of natural pasture and shortage of grazing areas (Pen et al., 2010).

In spite of these benefits associated with pen fattening, the cost of feed is one of the main problems in beef production systems that reduces profitability (Ahola & Hill (2012). Feed takes about 60–70% of total costs in intensive beef production due to high prices of traditional components of feedstuffs such as soybean meal, corn grain, and protein supplements (Piszcz et al., 2022). High costs of commercial feed have negatively impacted small farmers that are unable to invest enough money into feedlot operation. Thus, the development of cheaper sources of feed has attracted attention recently.

Among the alternative feed sources that have gained considerable interest is poultry manure. Poultry manure refers to poultry feces combined with feathers, spilled feed, and bedding materials like wood shavings or grass litter (Lima et al., 2016). Though viewed as waste before, poultry manure is a good source of crude proteins, minerals, and non-protein nitrogen that can be used as an important ingredient in feeding ruminants. Where poultry and beef industries exist together, poultry manure is increasingly being used as part of cattle feeds in efforts to cut down feeding costs and recycle agricultural wastes (Imam et al., 2007).

Feeding beef cattle using poultry manure has been increasing, particularly in the developing countries, because of rising feeding costs and environmental problems related to poultry waste disposal. Disposal of poultry manure causes environmental pollution by contaminating soils, air, and water resources (Prabakaran and Valavan, 2021). Feeding ruminants using poultry manure provides a two-way solution, in that apart from cutting down feed costs, environmental pollution caused by waste recycling will be minimized.The concept is aligned with sustainable agriculture practices, whereby local resources are efficiently utilised to boost productivity and conserve the environment.

In Zimbabwe, the production of poultry products has been growing steadily for decades, thereby contributing to an increase in the amount of poultry manure produced in broiler facilities (Mafigu et al., 2024). Conversely, beef production has been constrained by droughts, rise in feed prices and non-availability of common feed mixtures. Such challenges have made the provision of alternative sources of feeds, which are cheap and sustainable in beef pen fattening, possible. The use of poultry manure as a main ingredient in feeds formulation has become a viable method of

lowering production costs without heavily compromising animal performance (Washaya et al., 2018).

Poultry manure in beef production has remained controversial because of issues of nutrient variation, palatability, potential pathogen contamination and consumers' concerns about meat safety (Ndelekwute et al., 2019). Whereas some studies have documented good growth performance and economic benefits associated with the utilisation of poultry manure in ruminant diet, others have noted reduced feed intake and poor daily weight gain due to bad formulation and processing of the diets (Alemu et al., 2021). These discrepancies bring forth the need to carry out more studies on proper levels of inclusion, processing, and overall impacts of the poultry manure feeds on the performance of beef cattle locally..

2.1 Nutrient composition of poultry manure

Poultry manure has been acknowledged as an important unconventional source of feed in ruminant livestock due to its comparatively high nutritional value (Lanyasunya et al., 2006). Nutritional composition of poultry manure depends on various aspects such as breed, age of birds, diet, type of bedding used as well as manure management (Feedipedia, 2012). Normally, poultry manure consists of fairly large quantities of crude proteins, minerals and feed residues. Poultry manure contains a crude protein level of about 24.2% on a dry matter basis (Feedipedia, 2012). This places poultry manure on par with some conventional sources of protein supplement in livestock feeding.

Protein is an important component in beef cattle raising since it helps in muscle formation, tissue renewal, enzymes production and proper functioning of immune system (Tiago et al., 2021). Sufficient levels of protein are especially important in pen fattening where fast growth rates are expected. Lack of protein in cattle feeds leads to low feed consumption, slow growth rates, weight loss and increased disease susceptibility (McDonald et al., 2010). Hence, poultry manure could serve as an economically viable source of protein for beef cattle in cases when conventional protein supplements like soybean meal are costly or unavailable.

About 50 to 70 percent of the crude protein found in poultry manure is made up of non-protein nitrogen sources which include uric acid and ammonia (Imam et al., 2007). It is unique to ruminants that they can utilise the non-protein nitrogen source via microbial fermentation in the rumen (Niazifar et al., 2024). This feature makes poultry manure better for feeding cattle than

non-ruminants. In addition to proteins, other essential minerals found in poultry manure which support bone formation and metabolism include calcium, phosphorus, potassium and magnesium (Bolan et al., 2010).

Though poultry manure is rich in crude protein, it lacks energy when compared with cereal grains. Poultry manure alone cannot provide enough energy in beef cattle rations. The ideal ration should be formulated in a way that provides energy sources which are rich in energy such as maize grain, molasses and cereal by-products, thereby enabling optimal utilisation of nitrogen in the rumen microbes (Wilson et al., 2011). The lack of energy and protein balance will lead to poor nitrogen utilisation and growth performance.

The nutritional value of chicken litter is also dependent on the nature of litter material used in poultry farms. Materials such as wood shavings, saw dust, and grass litter add more fiber to the manure hence affecting its digestibility. Besides, there is a wide variation of the nutrient composition of chicken manure among the broilers and layers owing to variations in feed management techniques (Lima et al., 2016). Such variations require proper analysis of nutrients to develop rations for cattle.

2.2 Nutritional physiology of ruminants and utilisation of non-protein nitrogen

The capacity of ruminants to make use of poultry manure is dependent on the distinctive physiological structure of the rumen. The beef cow has a complicated structure of stomachs that include the rumen, reticulum, omasum and the abomasum. The rumen works as the fermentation compartment that houses billions of microorganisms like bacteria, protozoa and fungi whose functions are important in the process of digestion and synthesis of nutrients (Wilson et al., 2011). These microorganisms help the cattle to be able to digest fibrous feeds and non-protein nitrogen feeds which monogastric animals are not able to utilise.

Poultry manure is made up of uric acid which is a source of non-protein nitrogen. Uric acid is broken down by the rumen microorganisms through microbial enzymes action once the cattle have consumed the manure. The ammonia which results from this breakdown process is absorbed by the microorganisms in the rumen along with the carbohydrate energy to synthesise microbial proteins (McDonald et al., 2010). The microbial proteins are digested in the abomasum and the small intestine.

Microbial protein production efficiency is greatly dependent on the synchronicity of nitrogen and energy supply in the rumen (Zhang et al., 2020). The diets consisting of poultry manure, hence, need additional energy to maximise the utilisation of nitrogen and minimize loss of nitrogen via urinary excretion. Energy sources such as maize grains and molasses increase microbial activity and optimize feed use efficiency (Imam et al., 2007). Cattle on high concentrate finishing diets grow fast because of the availability of additional energy for tissue growth (Crawford et al., 2022).

The ability of ruminants to utilise non-protein nitrogen provides the basis of using poultry manure in the cattle diet (Zurak et al., 2023). Through this mechanism, cattle can transform agriculture waste products into nutritious animal protein and make the feed resource utilisation efficient and cost-effective. Excessive use of poultry manure without proper balancing may result in ammonia toxicity, poor palatability and decreased animal performance (Alemu et al., 2021). Proper feed management is necessary in the application of poultry manure in fattening of beef cattle. Similar results have been found by Truong and Preston (2021) by the use of soybean meal as a source of rumen escape protein for fattening cross-bred beef cattle.

2.3 Processing methods and safety considerations of poultry manure

Despite the great nutritional content that poultry manure possesses, the risks associated with pathogen and parasite presence, heavy metals and drugs make its widespread use impracticable. For instance, fresh poultry manure may have harmful microorganisms like Salmonella spp., Escherichia coli and Clostridium spp that create some health dangers for both animals and people (Belete and Ayza, 2015). It becomes crucial to implement certain processing procedures to make poultry manure safe for adding into cattle diet.

There exist a variety of processing techniques used to make poultry manure safer and more palatable. One of the most widely used and cost-effective techniques is deep stacking technique. Deep stacking implies piling the poultry manure for natural fermentation with the formation of the temperature of about 60°C that kills off pathogens and weed seeds (Talib and Ahmed, 2008). This technique also makes poultry manure more palatable since it removes the smell associated with fresh poultry manure.

The process of ensiling is another widely-used processing technique. Ensiling involves mixing poultry manure with feeds rich in moisture such as maize silage and storing under anaerobic

conditions. Through the process of fermentation, pH level drops down to 4.7 and lower, inhibiting pathogen reproduction (Bolan et al., 2010). Sun-drying and heating are also some of the common techniques used whereby the moisture content is greatly reduced along with the risk of microbial contamination.

Processing poultry manure prior to feeding to cattle as part of their diets makes the feed more acceptable to the animals. The use of poultry manure can be supplemented with maize meal, molasses, and silage along with salt to make well-balanced diets on farms. Molasses acts to increase palatability while reducing dustiness of feed while silage provides roughage which is very necessary for rumination.

Some research studies have revealed that beef obtained from cattle that were fed on properly processed poultry manure does not vary significantly in terms of texture or taste as compared to beef from cattle which were conventionally fed (Ndelekwute et al., 2019).

2.4 Effects of poultry manure on growth performance of beef cattle

2.4.1 Feed intake

Feed intake plays an important role in animal growth and performance in beef cattle fattening operations. Voluntary feed intake dictates nutrient availability and hence affects weight gain and efficiency of feed use. Early investigations indicated that poultry manure can lower feed intake because of its bad smell and taste. Later studies indicate that proper preparation and combination with palatable components increases acceptance by cattle (Alemu et al., 2021).

Molasses is added to diets based on poultry manure in order to make them palatable and increase feed intake. In the same way, mixing poultry manure with maize bran or silage increases palatability through better texture and smell, and hence feed intake. According to Tadesse et al., (2016), inclusion rates of 20-30% usually ensure good feed intake and animal performance, while higher rates above 40% decrease intake due to higher ash content and palatability.

Sufficient intake of feeds is key because the cows are supposed to take about 2-4% of their body weights daily in dry matter for proper growth (Kuhl, n.d.). Sufficient feed intake helps with nutrient utilisation and growth (Lippolis et al., 2017). It is for this reason that care should be taken when formulating feed for pen fattening cows using poultry manure.

2.4.2 Average daily gain

ADG stands out as a major parameter utilised in determining the growth performance of cattle raised in the feedlots. Many investigations have revealed that cattle fed with diets rich in poultry manure can attain good weight gain results when compared to those raised on standard protein supplements. Tassew et al., 2023 found out that Arsi cattle bulls reared on poultry manure diets could maintain acceptable growth performance if sufficient energy supplementation was included in their diets.

Results from research indicate that cattle raised on poultry manure diets tend to obtain ADG of about 0.9 to 1.3 kg/day based on the diet formulation and cattle breeds among others (Nguyen et al., 2024). Even though this level of ADG may be slightly less than what is obtained when raising cattle using diets based on soybean meal, the savings made in feed costs can offset this slight decrease in growth performance. Investigations by Quigley, 2019 have demonstrated that balanced commercial rations enhance feed utilisation and growth rates.

The quality of protein and nutrients contained in the manure can affect the growth rate. Poultry manures with protein less than 18% can cause inadequate feed consumption and sub-optimum daily gain (McDonald et al., 2010). Energy insufficiency causes reduced protein production in the microorganisms thus inefficient utilisation of non-protein nitrogen.

Most research findings on the performance of poultry manure in comparison with the regular protein supplements in animal feeding have found no difference in the body weight at the end of the feeding period for the diets that have been properly balanced. Obeidat et al., (2019), found out similar body weight of lambs fed poultry litter diet and soybean meal diet.

2.5 Effects of broiler manure-based feed of feed conversion ratio

Feed conversion ratio (FCR) is described as the level of feed intake in relation to the body weight gain and acts as an indication of feed usage efficiency. FCRs with low values denote efficient use of feed and lower costs of production (Davison et al., 2023). Efficient feed conversion is crucial in the profitable fattening systems of beef cattle since feed accounts for the biggest share of the cost of production.

It has been found that poultry manure feeds can attain good feed conversion ratios if appropriately balanced and formulated along with other energy sources (Alemu et al., 2021;

Ndelekwute et al., 2019). Excessive inclusion of such feeds in the ration can result in low digestibility and inefficient utilisation of nutrients hence low feed conversion ratios (Tadesse et al., 2016). It is, therefore, vital to balance protein, fiber, and energy sources in the diet of such feeds.

2.6 Economic implications of poultry manure utilisation in beef cattle fattening

The key reason why poultry manure should be included in the beef cattle feeds is lowering feed cost. Traditionally, protein sources such as soybean meal may be costly and not affordable for smallholders. Poultry manure serves as an economic source of protein feed since it is abundant waste of poultry enterprises (Imam et al., 2007).

Research in Southern Africa and elsewhere has shown that the replacement of traditional protein sources by poultry manure results in substantial decrease in the cost of feed formulation without negatively affecting the growth rate (Bolan et al., 2010). The cost of protein supplementation can be lowered from around US$185 per tonne to as low as US$5 – US$15 per tonne through the use of poultry litter (Washaya et al., 2018). This leads to significant savings in feed cost and makes the process more profitable especially in smallholder production systems.

Integration of poultry and beef enterprises facilitates the establishment of circular economy through the utilisation of waste produced by one farm as an important resource for the other. This integration leads to increased efficiency of resources utilisation, decreases pollution and makes farming more sustainable (Prabakaran and Valavan, 2021).

The cost benefit analysis reveals that even though cattle reared on diets made from poultry manure will grow at slower growth rates when compared to cattle reared on high-quality commercial diets, the low input costs usually lead to greater profit margins.

2.7 Current challenges associated with poultry manure utilisation

However, even as there are numerous advantages that come with the utilisation of poultry manure, there still exists quite a number of obstacles that hinder its uptake by farmers. First of all, there is the obstacle of negative public perception about the safety of giving animals the waste product as food. The people have the tendency to relate the practice of using poultry manure as feed with the poor quality of meat produced.

Moreover, there are challenges that arise from variation in the nutrient composition. Since there are variations in terms of what the chicken is fed on, what kind of bedding materials they use among others, the level of nutrients in the manure is variable hence making it hard to standardize the amount. In addition to that, improper processing techniques may lead to contamination by pathogens. Another obstacle is palatability especially when there is high inclusion rate. High poultry manure inclusion rate may lower feed intake because of smell and high ash content.

2.8 Theoretical framework

Utilisation of poultry manure in feeding of beef cattle is premised on the microbial protein synthesis theory. Cattle have microorganisms within their rumen which can convert non-protein nitrogen into microbial protein which is ultimately utilised by the animal (Wilson et al., 2011). Poultry manure acts as a source of non-protein nitrogen especially in terms of uric acid content which is used by the microbes as source of nitrogen.

Least-cost feed formulation is also a major premise for this research. The theory explains that feeders will try to reduce their costs by replacing costly feed components with less costly ones in order to achieve acceptable performance levels of animals (Imam et al., 2007). Therefore, use of poultry manure in the cattle feed is an inexpensive alternative to costly protein supplements.

Sustainable agriculture also forms part of the guiding principles of this research because it involves recycling of agricultural waste products. Use of poultry manure in cattle feeding helps in reducing pollution and sustainability of the farm in general.

2.9 Critical gaps in literature

Several aspects concerning the use of poultry manure in the beef cattle pen fattening system remain unclear. Firstly, even though there have been several studies carried out about the use of poultry manure in ruminant feeding systems globally, there have been no studies undertaken in Zimbabwe considering the differences in terms of feed availability, climate and management systems. Secondly, many studies have only concentrated on the nutrient content and digestibility of poultry manure without taking into account all the necessary growth performance parameters such as feed intake, daily weight gain and feed conversion ratio on-farm. Thirdly, there is inadequate data on the ideal amounts of poultry manure that can be included in on-farm feed formulations for beef cattle fattening in Zimbabwe since excess amounts will lead to low

palatability and poor growth performance while low amounts do not result in any economic benefit. Lastly, there is inadequate research done about the economic feasibility of poultry manure-based feed formulation in relation to commercial feeds under the same farming system. Therefore, this study aims to assess the effects of on-farm feed formulation using poultry manure as the major ingredient in beef cattle pen fattening systems..

CHAPTER 3

METHODOLOGY AND EXPERIMENTAL DESIGN

3.0 Overview

The methodology and experimental design employed in the investigation of the impacts of feed formulated from broiler manure on the growth performance, feed efficiency, and profitability of beef cattle under confined fattening conditions are covered in this chapter. This includes the description of the study area, experimental design, sampling technique, dietary treatment, animal management system, data collection, economic analysis, and statistical analysis techniques.

3.1 Study Area

The assessment was carried out at the University of Zimbabwe Agro-Industrial Park (UZAIP) situated in the Mazowe district of Mashonaland Central province of Zimbabwe. The area is categorized under natural region IIa with sub-tropical climatic conditions experiencing an annual rainfall ranging from 750 – 1000 mm between the months of November to March. The

temperatures of the region range from 18°C to 30°C and are conducive to both crop and livestock farming.

Natural region IIa is among the main agricultural areas of Zimbabwe because of its reliable rainfall and favorable climatic conditions. Main crops grown within the region include maize, wheat, soyabeans, tobacco, cotton, sorghum and groundnuts both through dry land and irrigation systems. Livestock farming undertaken within the region include beef, dairy, pig and poultry production.

The University of Zimbabwe Agro-Industrial Park was chosen as a study area because it includes both crops and livestock farming ventures. There are five poultry houses in this farm that have an estimated carrying capacity of about 22 000 broilers per each. This will provide enough broiler manure that can be used in the formulation of feeds. Also, the maize silage and maize crushes that were used in feed formulation came from crop farming activities.

3.2 Experimental Design and Animal Allocation

Experimental design was done in the completely randomized design which involved the use of two treatments. These treatments were allocated randomly to the experimental animals.

The total number of crossbred steers used in this experiment was 20. These steers were chosen because of their similarities in terms of body weight and age as well as breed type. There were ten steers in each treatment for ninety days..

The dietary treatments used in the experiment are shown in Table 3.1.

Table 3. 1Dietary treatments used in the pen fattening trial

Treatment symbol	**Treatment description**
T1	Commercial beef finishing meal
T2	Broiler manure-based feed formulation (35% broiler manure inclusion)

The commercial beef finishing feed meal was taken as the control since this is the standard feed that is normally fed to cattle under beef cattle pen fattening systems in Zimbabwe.

The animals were kept in pens outdoors in conditions that were fairly even. There was adequate space in the pens in order to prevent stress and injuries on the animals. The food and water troughs were kept separately from each other in the pens in order to promote movement..

3.3 Sampling Procedure

In total, 20 crossbred steers were chosen based on similarities in terms of body weight, type of breed, age, and health status. The cattle were aged between 18 to 24 months with a body weight of 200 to 250 kg. Before assigning the cattle to the treatments, the cattle were weighed using a calibrated weighing scale. Sampling was done randomly to assign the animals to the treatments in order to avoid any bias in the process of selection. The steers were tagged in the ear to identify them.

3.4 Experimental Diets and Feed Formulation

3.4.1 Feed ingredients

The feed materials used in the formulation of broiler manure feed were; broiler manure, maize silage, maize crushes, molasses, salt, and mabiko mineral supplement. The commercial beef finishing meal was bought from a registered feed material dealer and used as such. The broiler manure feed diet is as illustrated in table 3.2 below.

Table 3. 2Experimental diet for broiler manure-based feed formulation

Ingredient	**Inclusion rate (kg/tonne)**
Broiler manure	350
Maize silage	200
Maize crushes	370
Molasses	30
Salt	25
Mabiko mineral pack	25
Total	1000

Broiler litter was deep stacked for 21 days prior to application to ensure the elimination of pathogens like Salmonella spp. and Escherichia coli via heat fermentation. The litter was made up of poultry droppings, feathers, feed waste and bedding materials. The ingredients of the feed were accurately weighed using a digital scale prior to mixing. The broiler litter was manually crushed into small pieces before being mixed with the maize silage and maize crushes. The

molasses which had been diluted with water at the ration of 1:3 was added to the mixture along with salt and Mabiko mineral supplement..

3.5 Animal Management Practices

Prior to the start of the feeding experiment, all the steers were dipped against external parasites like ticks and dewormed against internal parasites like round worms and liver flukes. The steers were also vaccinated against botulism and given Vitamin A injections for better growth performance.

The cattle were kept in outside pens having feeding and watering facilities. Feeding troughs were located in one corner of the pen whereas watering troughs were in the opposite corner so as to avoid contaminations of feed and to encourage cattle movements. Two feeds per day at 0700 hours and 1400 hours were given to the steers. In the initial 10 days, experimental feeds were gradually introduced to adapt the rumen microbes to the new feed. Thereafter, feeds were fed daily at 3% of the live body weight of the animal. Clean drinking water was given ad libitum to the cattle during the experiment.

3.6 Data Collection

3.6.1 Growth performance of beef cattle

The individual weight of the broilers was done on a weekly basis using a digital weighing balance that has a capacity of 2000 kg and an accuracy of ±0.5 kg. The weighing was done before the broilers were fed.

The following parameters were determined during the experiment.:

Total Weight Gain (TWG, kg):

$$TWG = Final\ weight - initial\ weight$$

Average Daily Gain (ADG, kg/day)

$$ADG = \frac{Total\ weight\ gain}{number\ of\ days\ on\ trial}$$

Weekly weight gain (kg/week)

$$weight\ at\ end\ of\ week - weight\ at\ start\ of\ week$$

3.6.2 Feed intake of beef cattle

The feed intake of each animal was calculated daily using the difference between the amount of feed refused and the total feed fed. The feed refused was collected and weighed daily in the mornings before offering of feed to the animals. Feed intake was expressed in kg/animal/day.

3.7 Feed conversion ratio of beef cattle

Feed Conversion Ratio (FCR) was used to determine feed utilisation efficiency and was calculated as follows:

$$FCR = \frac{total\ feed\ intake}{total\ live\ weight\ gain}$$

Table 3. 3Data collection variables, measurement methods and frequency

Variable	**Measurement method**	**Frequency**
Live body weight	Electronic scale (kg)	Weekly
Average daily gain	Calculated from weight gain/day	Every 30 days
Weekly weight gain	Difference in weekly weights	Weekly
Feed intake	Feed offered – refusals	Daily
Feed conversion ratio	Total intake ÷ total gain	End of trial
Health observations	Daily visual assessment	Daily

3.8 Cost Benefit Analysis

Performance of the nutritional therapies in terms of economics was analysed using partial budgeting and gross margin approach. Prices for feed inputs were obtained from current market prices while prices for cattle were obtained from current buying prices in abattoirs. All monetary values have been expressed in US dollars (USD).

Table 3. 4Partial budget for feed formulation and production cost

Item	**Cost (USD)**

Commercial beef finishing meal (50kg)	19.00
Molasses	19.50
Maize crushes	88.80
Maize silage	24.00
Salt	5.00
Mabiko mineral pack	13.00
Broiler manure	17.50
Average cost of one steer	270.00
Veterinary costs	50.00
Labour (USD3/day)	270.00

The following formulas were used in the economic analysis:

Feed cost per kilogram live weight gain:

$$Feed\ cost\ per\ kg\ gain = \frac{total\ feed\ cost}{total\ live\ weight\ gain}$$

$$Gross\ revenue = total\ live\ weight\ gain * market\ price\ per\ kg$$

$$Gross\ margin = gross\ revenue - total\ variable\ costs$$

$$Benefit\ cost\ ratio = \frac{gross\ revenue}{total\ feed\ cost}$$

3.9 Experimental Model

The statistical model for the Completely Randomised Design was expressed as follows:

$$Yij = \mu + Ti + \varepsilon ij$$

Where:

Y= observed response variable of the ȷth animal under the ith treatment

μ= overall population mean

T_i= effect of the ith dietary treatment

ε_{ij}= random experimental error associated with each observation

3.10 Data Analysis

The data obtained from the research was subjected to statistical analysis using Microsoft Excel and Analysis of Variance (ANOVA) using SPSS software version 26. The analysis of variance was performed in order to establish whether there was any significant difference among the treatment means for growth performance, feed consumption, conversion ratio, and profitability. An independent samples t-test was used to separate treatment means wherever there was a significant difference ($P \leq 0.05$).

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Effects of Broiler Manure-Based Feed Formulation on Growth Performance of Beef Cattle

There was a significant impact of dietary treatments on the growth performance of the beef cattle in the pen fattening stage ($p \leq 0.05$). Weight gain for the steer given the commercial beef finishing meal was significantly higher than the steer given the broiler manure feed formulation. The treatment using the commercial feeds resulted in better average daily gain and live weight gain due to its high nutrient content and commercial nature. Nonetheless, the broiler manure feed formulation managed to have a satisfactory growth performance for the whole duration of the experiment. The data were statistically tested using SPSS Version 26 through analysis of variance (ANOVA), and independent-samples t-test was performed on treatment means.

Table 4.1Effects of Broiler Manure-Based Feed Formulation on Growth Performance of Beef Cattle

Treatment	Initial Weight (kg)	Final Weight (kg)	Total Weight Gain (kg)	Average Daily Gain (kg/day)
Commercial Feed	224.5[a]	329.7[a]	105.2[a]	1.17[a]
Broiler Manure-Based Feed	223.8[b]	304.8[b]	81.0[b]	0.90[b]

Parameter	Growth Performance
Grand Mean	93.1
P-value	<0.05
SED	5.12
LSD	10.2
CV%	11.6

Means followed by the same letter are not significantly different.

A Bar Graph Showing Average Daily Gain of Beef Cattle

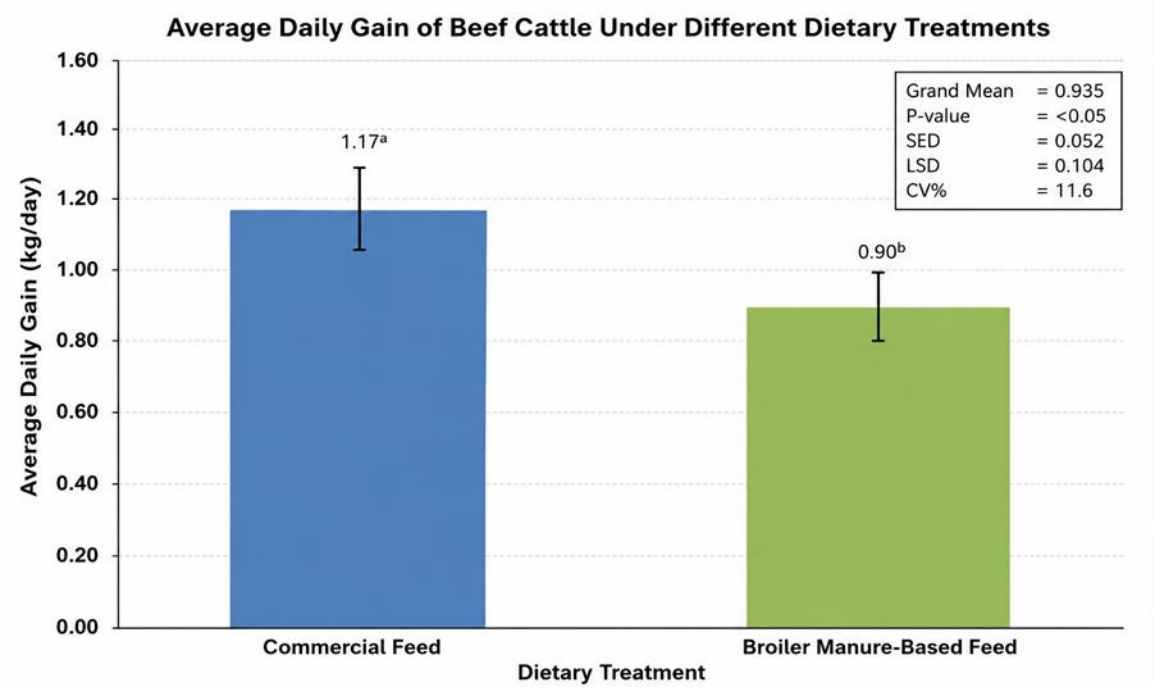


Fig 4.1 A bar graph showing average daily gain of beef cattle under different dietary treatments. Error bars represented standard deviation values. Means followed by the same letter were not significantly different

Discussion

The results from section 4.1 indicated that diet had a significant effect on the growth performance of beef cattle during the pen fattening stage. Steers offered the commercial beef finishing ration attained significantly high final live weights, weight gain, and average daily gains than those offered the broiler manure based ration. The better growth performance obtained in the commercial feed treatment could be due to the well-balanced nutrients composition in commercial beef finishing diets that provide more energy and protein content.

Commercial beef finishing diets are carefully balanced to ensure adequate intake of the required nutrients including digestible energy, crude proteins, vitamins, and minerals required for tissue growth. Quigley (2019) notes in his literature review that balanced commercial feeds increase feed utilisation and hence fast growth rate among beef cattle since the nutrients provided stimulate rumen microbes.

The poor growth performance exhibited in cattle receiving the broiler manure-based feed formulation may result from low digestibility of nutrients and low palatability of poultry manure inclusion. The poultry manure is rich in non-protein nitrogen, fiber, ash and non-digestible components that may reduce nutrient absorptive capability than traditional commercial feeds. Similar results have been found out by Bolan et al., (2010) that indicate poultry litter-based feed diet may stimulate moderate growth rate but produces lesser weight gains compared to commercial concentrates of high quality.

Although the growth was recorded lower, the broiler manure-based feed formulation managed to give satisfactory performance during the whole feeding experiment. This illustrates that poultry manure can act as a supplemental feed source able to stimulate acceptable growth under beef cattle pen fattening system. The results agree with previous research that shows proper processing of poultry manure may provide good nitrogen and minerals for ruminant feeding.

The significant difference among treatments shows that the quality of the feed plays an important role in affecting growth performance in beef cattle. The high nutrient content in the commercial

feed treatment probably stimulated muscle deposition and weight gain during the experiment period.

4.2 Effects of Broiler Manure-Based Feed Formulation on Weekly Weight Gain of Beef Cattle

There existed a statistically significant relationship between different dietary treatments and the rate of weight gain in beef cattle within the study duration ($p \leq 0.05$). The steers that were fed on the commercial beef finishing meal gained more weight per week than those that were fed on the broiler manure feed.

Table 4.2 Effects of Broiler Manure-Based Feed Formulation on Weekly Weight Gain of Beef Cattle

Treatment	Week 1	Week 3	Week 6	Week 9	Week 12
Commercial Feed	7.2	7.9	8.5	8.9	9.3
Broiler Manure-Based Feed	5.9	6.3	6.7	6.9	7.2
Grand mean	6.6	7.1	7.6	7.9	8.3
P-value	<0.05	<0.05	<0.05	<0.05	<0.05
SED	0.50	0.54	0.58	0.61	0.65
LSD	1.00	1.08	1.16	1.22	1.30
CV%	10.2	10.5	10.8	11.1	11.5

Means followed by the same letter are not significantly different.

A Line Graph Showing Weekly Weight Gain of Beef Cattle

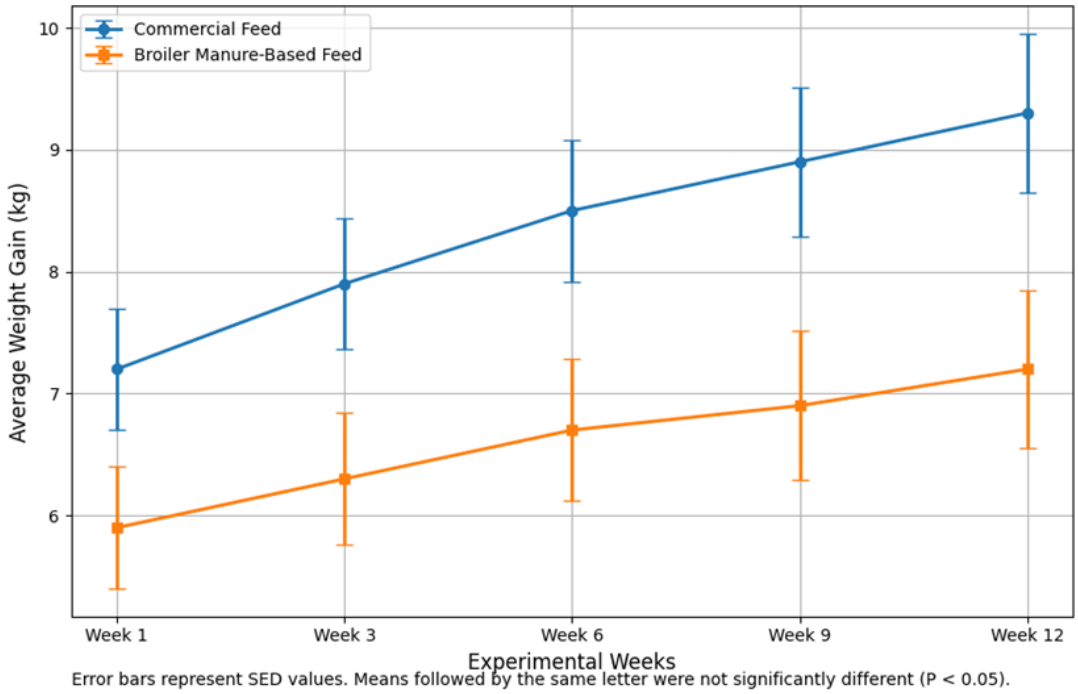


Fig 4.2 A line graph showing weekly weight gain of beef cattle under different dietary treatments. Error bars represented standard deviation values. Means followed by the same letter were not significantly different.

Discussion

As indicated in Section 4.2, there were significant differences in the weekly weight gains among different dietary treatments across the 90-day feeding period. The weekly weight gains of steers provided the commercial beef finishing diet were higher than those provided the broiler manure diet from week 1 up to week 12.

The increasing trend of weekly weight gains in both treatments demonstrates that animals performed well in terms of adaptation to the feeding system and continued gaining body weight during the trial period. But, the regular superiority of the commercial feed treatment indicates that the animals provided with commercially available balanced rations were able to gain their body tissue efficiently.

High weekly weight gains obtained from the use of the commercial feed treatment can be attributed to higher digestibility of nutrients, higher energy level and efficient rumen fermentation. High energy finishing diets have been found to improve microbial protein synthesis and thus nutrient utilisation in order to gain more live weight. According to Crawford

et al., (2022), cattle provided high concentrate finishing diets are able to gain their live weights faster due to high availability of energy for tissue deposition.

The lower weight gain per week achieved from the broiler manure feed treatment could be due to poor palatability and availability of fewer amounts of digestible nutrients in the feed.

Poultry manure may affect voluntary feed consumption and nutrient digestibility because of increased levels of fibres and minerals present in poultry manures. Environmental aspects like adaptation to manure odour and structure might have played some role in the feeding process and growth performance achieved.

Despite the broiler manure treatment having lower weight gains per week, there were progressive weight gains through the duration of the experiment. It means that the feed used had adequate nutritional value to ensure weight gains.

The significant difference among treatments through all the weeks illustrates the importance of the quality of feed formulation on the growth performance of cattle under pen fattening systems. It has been revealed that other sources of feed can achieve moderate growth performances of animals if well formulated.

4.3 Effects of Broiler Manure-Based Feed Formulation on Feed Intake of Beef Cattle

There were statistical effects among the different dietary treatments in feed consumption of beef cattle ($p \leq 0.05$). Beefs that were treated with the commercial beef finishing meal had higher feed consumption than the group of beef that was treated with broiler manure based diet. The lesser amount of feed intake by the latter group could be related to their unpalatable taste due to molasses addition.

Table 4.3 Effects of Broiler Manure-Based Feed Formulation on Feed Intake of Beef Cattle

Treatment	**Average Feed Intake (kg/day)**
Commercial Feed	10.8^{a}
Broiler Manure-Based Feed	8.9^{b}
Parameter	**Feed Intake**
Grand Mean	9.9
P-value	<0.05

SED	0.63
LSD	1.26
CV%	9.7

Means followed by the same letter are not significantly different.

A Bar Graph Showing Average Feed Intake of Beef Cattle

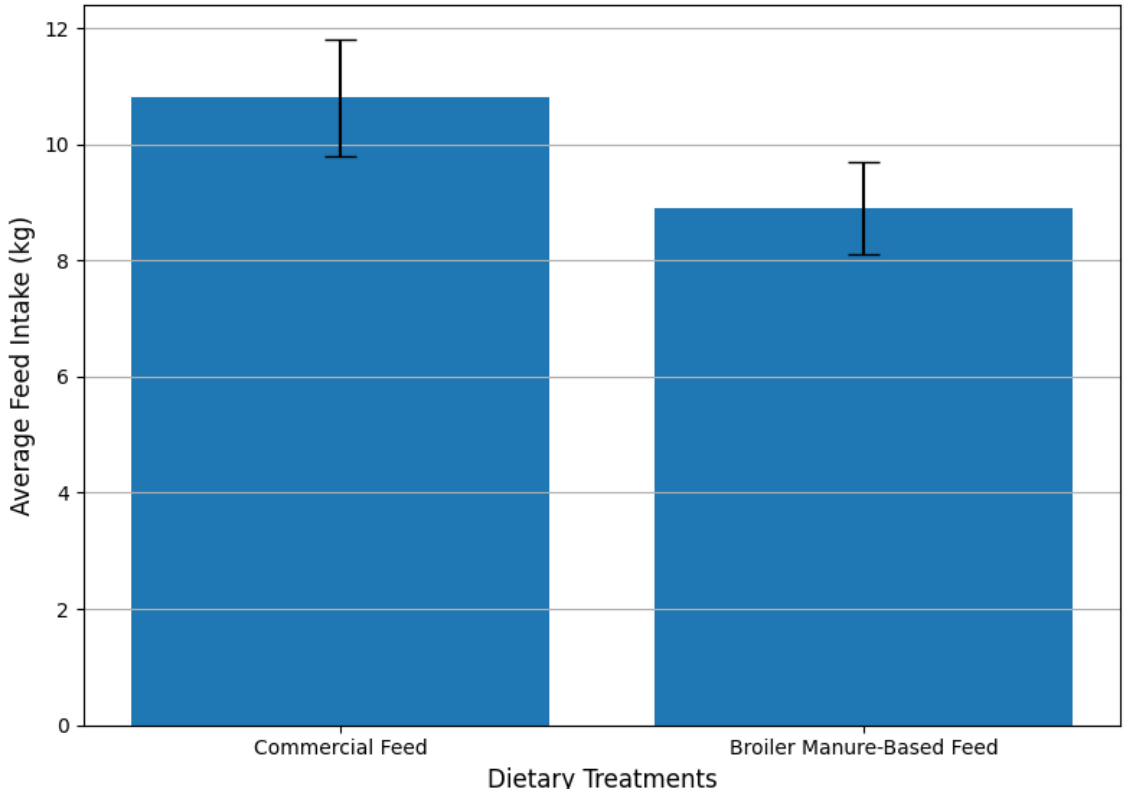


Fig 4.3 A bar graph showing average feed intake of beef cattle under different dietary treatments. Error bars represented standard deviation values. Means followed by the same letter were not significantly different.

The results obtained from Section 4.3 indicated that dietary treatment had a significant effect on feed intake by beef cattle. The steers that received the beef finishing commercial meal ration consumed significantly more feed than the steers receiving broiler manure feed formulation.

Increased feed intake by cattle in the case of consumption of the commercial feed formulation can be related to the better palatability, texture and feed acceptability by conventional commercial feed ingredients. The commercial beef rations are designed in such a way that feed intake is stimulated through a balanced composition of nutrients and good sensory properties.

Increased feed intake helps the animals to eat more nutrients required for fast growth and improved production.

Decreased feed intake by cattle in the case of feeding broiler manure feed formulation can be due to poor palatability of the feed formulation caused by the presence of poultry manure. The poultry manure contains peculiar smell and taste which can make feed unpalatable to the cattle despite the addition of molasses to increase palatability. Fontenot et al., (2018) reported similar results, whereby increased inclusion levels of poultry litter can decrease voluntary feed intake by ruminants due to sensory and mineral content constraints.

Low feed intake could have also played a role in the poor growth performance exhibited by the broiler manure-based feed treatment. Low nutrient intake results in low amounts of energy and protein that could be used for muscle building and development. According to Lippolis et al., (2017), voluntary feed intake is one of the major factors that influence the performance of animals since it affects nutrient intake.

However, despite the low intakes of feeds, cattle on broiler manure-based feed did well in their performances during the feeding period. This shows that poultry manure-based feed is capable of providing necessary nutrients to enable growth of cattle within such restricted production systems.

The large variations in feed intakes between treatments reveal how important palatability and formulation of feed is in influencing feed intake and cattle performance. Thus, better feed processing and formulation in poultry manure-based feeds will improve feed intake and performance of cattle.

4.4 Effects of Broiler Manure-Based Feed Formulation on Feed Conversion Ratio of Beef Cattle

There was a strong influence on feed conversion ratio (FVR) among the dietary treatments ($p \leq 0.05$). The commercial feed treatment had a smaller FVR compared to broiler manure based feed treatment showing better feed efficiency.

Table 4.3Effects of Broiler Manure-Based Feed Formulation on Feed Conversion Ratio of Beef Cattle

Treatment	Feed Conversion Ratio
Commercial Feed	9.2[b]
Broiler Manure-Based Feed	9.9[a]
Grand mean	9.6
P-value	<0.05
SED	0.44
LSD	0.88
CV%	8.5

Means followed by the same letter are not significantly different.

A Bar Graph Showing Feed Conversion Ratio of Beef Cattle

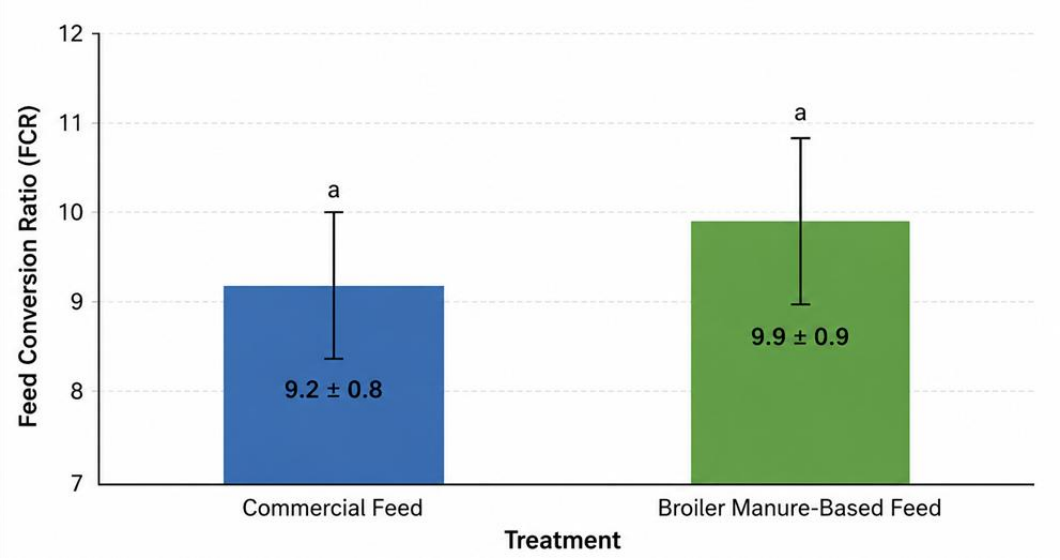


Fig 4.4 A bar graph showing feed conversion ratio of beef cattle under different dietary treatments. Error bars represented standard deviation values. Means followed by the same letter were not significantly different.

Results presented in Section 4.4 indicated that dietary treatment significantly influenced the feed conversion ratio (FCR) of beef cattle. The commercial feed treatment had a lower feed conversion ratio compared to broiler manure-based feed formulations, reflecting improved feed conversion efficiency.

Feed conversion ratio is an indicator of efficiency of converting feed into gain in body weight. The lower the feed conversion ratio, the more efficient the feed utilisation efficiency since less feed is needed to achieve a unit of gain in body weight. The increased feed conversion efficiency seen in the commercial feed treatment can be explained by high nutrient digestibility, adequate balance of amino acids, and enhanced energy utilisation.

Commercial beef finishing rations are developed to enhance rumen fermentation processes for the provision of nutrients. Efficient nutrient digestion ensures effective use of feeds in muscle and tissue development. According to Truong and Preston (2021), nutritionally balanced rations increase feed conversion efficiency by improving microbial action and minimizing wastage of nutrients through digestion.

The increased feed conversion ratio in the broiler manure-based feed treatment implies poor feed utilisation efficiency. The reason for this is that poultry manure has relatively more indigestible fibre and ash which decreases the digestion of nutrients thus requiring more feed to be consumed in order to gain weight. Poor feed intake and less availability of nutrients might have also contributed to poor feed conversion efficiency.

Despite the poor feed conversion efficiency of the broiler manure-based feed treatment, it can be noted that there are acceptable performances of the animals despite incorporating the use of poultry manure into their diet. With only a slight variation in the two treatments, it seems that poultry manure-based feeds are still economically viable especially in instances when feed prices are high.

The significant differences in feed conversion ratio between the two treatments highlight the significance of feed quality and balanced nutrition in increasing efficiency of cattle production. Efficient feed utilisation plays a very crucial role in beef production since feed accounts for a large portion of production cost.

4.5 Effects of Broiler Manure-Based Feed Formulation on Profitability of Beef Cattle Pen Fattening

There was statistical effect on profitability of beef cattle pen fattening between the various dietary treatments ($p \leq 0.05$). Even though the commercial feed treatment exhibited high live weight gain, there was a marked reduction in feed cost and improvement in profitability with broiler manure feeding diet. There was an increase in the gross margin and benefit-cost ratio due to low cost of production with the use of poultry manure. Economic assessment was done based on the live mass of the steers at the end of the experiment. Market value was estimated from the market price per unit live weight of the animal multiplied by the total live weight gain of the animals. Slaughter of animals was not done during the experiment.

Table 4.5 Effects of Broiler Manure-Based Feed Formulation on Profitability of Beef Cattle Pen Fattening

Treatment	Feed Cost (USD/tonne)	Feed Cost/kg Gain (USD)	Live Weight Gain (kg)	Market Price/kg Live Mass (USD)	Gross Revenue (USD)	Gross Margin (USD)	Benefit-Cost Ratio
Commercial Feed	380.00[a]	3.61[a]	105.2[a]	2.80	294.56[b]	74.56[b]	0.78[b]
Broiler Manure-Based Feed	167.80[b]	2.07[b]	81.0[b]	2.80	226.80[a]	139.00[a]	1.35[a]

Parameter	Profitability
Grand Mean	1.07
P-value	<0.05
SED	0.21
LSD	0.42
CV%	10.9

Means followed by the same letter are not significantly different.

A Bar Graph Showing Gross Margin of Beef Cattle Pen Fattening

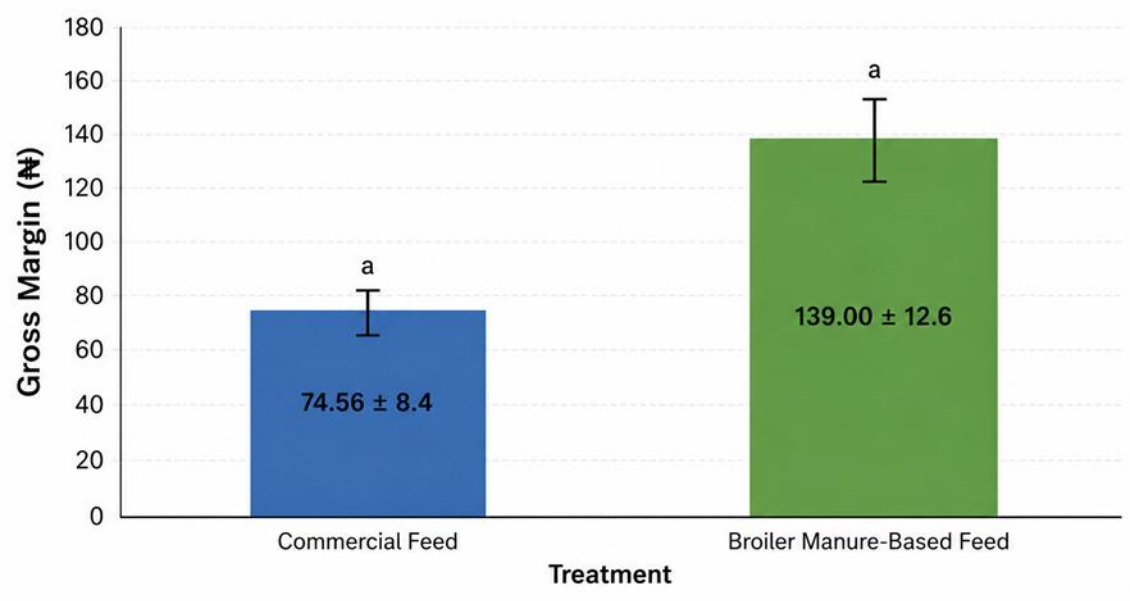


Fig 4.5 A bar graph showing gross margin of beef cattle under different dietary treatments. Error bars represented standard deviation values. Means followed by the same letter were not significantly different.

Results shown in Section 4.5 indicated that the feeding regimes had a significant influence on the profitability measures of pen fattening of beef cattle. Although commercial feed treatment resulted in better live weight gain and gross income, the broiler manure diet had a better gross margin and benefit-cost ratio due to low cost of feeds.

Commercial feed treatment performed better regarding animal growth due to the balanced nutrition composition. However, the high cost of feed made commercial feed treatment less profitable despite high live weight gain. Cost of feed is among the major input costs incurred in beef cattle production, and thus high feed costs lower the profit for producers.

Broiler manure diet resulted in significant lowering of the cost of feed since poultry manure is relatively cheap and readily available source of feeds. The reduction in feed cost per kilogram of gain under broiler manure diet improved the profitability of the system despite lower growth of animals. Similar results were reported by Akinfala and Komolafe (2011).

High gross margin and benefit cost ratio from the broiler manure based feeds treatment in beef cattle demonstrate the economic prospects of using alternative feed sources in beef cattle

production. The reduction in production cost leads to increased profitability in relation to low costs of buying commercial concentrates. This is more so to small-scale farmers who operate under constrained financial capacity.

The results show that apart from biological performance, livestock profitability also relies on the production cost. Commercial feeds offer maximum growth, however, alternative feeds can result in higher net returns by lowering feed costs.

It is therefore important to have a balanced approach when selecting feeding programs for beef cattle pen fattening schemes considering both animal performance and economic benefits. Poultry manure based feeds may be an effective and economical way of feeding beef cattle.

4.6 Summary of Results

There were marked differences in growth performance, feed utilisation and economic performance of the experimental parameters among various dietary treatments. In terms of weight gain, average daily gain, intake and feed efficiency, commercial beef finishing meal performed better than broiler manure feed formulation. Nevertheless, despite lower growth performance, broiler manure feed formulation showed lower costs of feed and better performance measures such as gross margin and benefit-cost ratio. From the results it is evident that manure-based feed formulations from poultry could be used as cheap source of feeds for beef cattle pen fattening..

4.7 Overall Effects of Broiler Manure-Based Feed Formulation on Beef Cattle Production

Overall results from the experiment indicated that formulating feed from broiler manure could be a good alternative feed source for pen fattening of cattle. While commercial beef finishing meal was responsible for producing the best growth rate, feed consumption and feed efficiency among other parameters, the use of broiler manure formulated feed helped to cut down costs of production.

From the results of the above analysis, feed from poultry manure has the ability to provide adequate performance by cattle while also improving economic performance due to cost saving measures on feed expenses. This is important as feed scarcity and cost remain some of the main challenges faced by livestock productivity in many developing countries.

Commercial feed was biologically superior while broiler manure feed formulation was economically beneficial showing the need for farmers to take into consideration both productivity and profitability when considering which feeding technique to adopt.

Unconventional feed sources have been proven to be useful in sustainable livestock production systems as well. Poultry manure is easily available and cheap. When adequately processed, it can provide necessary nutrients for feeding ruminants.

4.8 Chapter Summary

In conclusion, it is observed from the results that the impact of broiler manure feed formulation has been examined in terms of growth performance, feed utilisation, and profitability of beef cattle in the pen fattening system. The commercial beef finishing feed has greatly enhanced the growth performance of beef cattle due to the high nutrient value of the feeds and their balanced formulation. Nonetheless, it has been observed that broiler manure feed formulation has greatly decreased the cost of feed inputs and enhanced the economic performances like gross margin and benefit cost ratio of the beef cattle even though it has recorded low biological performance. It is observed from the above discussion that broiler manure feed formulation has great economic potential.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The major objective of this study was to establish whether the cost of feeds could be reduced while ensuring the economic viability of using farm-based broiler manure feeds as an alternative to expensive commercial beef finishing feeds for fattening beef cattle pens without compromising the wellbeing of the cattle. From the results obtained from the 90 days feeding trial conducted at University of Zimbabwe Agro-Industrial Park,

Steers that were fed commercial beef finishing feed attained a significantly higher final average body weight of 329.7 kg as compared to 304.8 kg for the ones on the broiler manure based feed. While commercial beef finishers contain readily digestible true protein, the manure based diet consists of non-protein nitrogen that is gradually broken down in the rumen. The steers on the manure based feed grew steadily throughout the whole period of feeding but showed a relatively high FCR; hence the steers had to consume a lot of dry matter to gain meat.

The on-farm feed formulation achieved the intended purpose of minimising the production costs. The profit margins were more for the manure of the broiler chicken feed formulation. Although the steers that ate the beef finishing meal attained high growth rates, the very costly nature made the profit margin less. This shows that, in practical agriculture, biological efficiency does not mean financial efficiency. Through the cost reduction approach and use of waste material, we get a lot of net profits.

5.2 Recommendations:

Based on the findings and conclusions of this study, the following recommendations are made:

- The small-scale farmers and the beef producers should ensure that the right processes are followed in feeding cattle with the broiler manure to cut down costs.
- The farmers should never feed the animals with fresh broiler manure since the manure could contain some pathogens such as Salmonella and E.coli that would harm the livestock. Some of the processes include deep stacking, drying under the sun and ensiling.

- The farmers should include molasses in the broiler manure formulations since it will help to improve its palatability. It is also recommended for use since the broiler manure formulations need the energy and the roughage.
- The poultry and beef producers should ensure that their production processes are integrated by feeding the broiler manure to the cattle.
- Extension services should ensure that there is the promotion of on-farm feed formulation models especially within the fattening areas to enhance the food security and the rural development. The small-scale farmers should be taught how to use the available resources to make money.
- Extension Services need to conduct on-farm demonstration trials to demonstrate the advantages of broiler manure-based feed formulation to the farmers.
- The Ministry of Lands, Agriculture, Fisheries, Water, and Rural Development needs to develop policies that encourage the use of alternative and underutilised feed sources such as poultry manure to cut down on cost feed costs and make the livestock sector competitive.
- The feed market in Zimbabwe is very volatile and hence policies should encourage the integration of poultry production systems with beef pen fattening systems to create circular bio-economy.
- Research needs to be conducted to assess the buildup of potential heavy metals and veterinary drugs including copper and antibiotics present in the poultry manure in the muscular tissues of cattle.
- Future research studies need to focus on carcass traits and meat quality parameters such as tenderness and marbling.

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APPENDICES

Appendix A: Broiler Manure-Based Feed Formulation Diet Composition

Table A1: Ingredient composition of the broiler manure-based experimental diet (t2) used in the pen fattening trial.

Table A1: Ingredient composition per tonne of broiler manure-based feed

Ingredient	Inclusion rate (kg/tonne)
Broiler manure	350
Maize silage	200
Maize crushes	370
Molasses	30
Salt	25
Mabiko mineral pack	25
Total	1000

Appendix B: Weekly Live Weight Records

Table B1: weekly individual live weight recording sheet used during the 90-day pen fattening trial at UZAIP

Steer ID	**Treatment**	**Week 1**	**Week 3**	**Week 6**	**Week 9**	**Week 12**
C1	Commercial Feed	7.3	7.5	8.3	8.7	9
C2	Commercial Feed	7	7.6	8.3	8.9	9.2
C3	Commercial Feed	7.1	7.6	8.3	9.2	9.4
C4	Commercial Feed	7.2	7.6	8.6	8.6	9.2

C5	Commercial Feed	7.5	7.9	8.5	9	9.5
C6	Commercial Feed	7.3	7.7	8.1	8.7	9.2
C7	Commercial Feed	6.9	8.2	8.7	8.7	9.4
C8	Commercial Feed	7.1	8.1	8.4	8.7	9.1
C9	Commercial Feed	7.2	7.7	8.5	9.1	9.2
C10	Commercial Feed	7	8.2	8.5	8.6	9
B1	Broiler Manure-Based Feed	5.6	6.4	6.9	6.9	7
B2	Broiler Manure-Based Feed	5.8	6.6	6.7	7.2	7.4
B3	Broiler Manure-Based Feed	5.5	6.4	6.8	7	7.1
B4	Broiler Manure-Based Feed	5.9	6.1	6.7	6.9	7.5
B5	Broiler Manure-Based Feed	6.1	6.2	6.7	6.8	7.5
B6	Broiler Manure-Based Feed	6.1	6.2	6.8	7	7.1
B7	Broiler Manure-Based Feed	6	6.3	6.9	7	7
B8	Broiler Manure-Based Feed	5.7	6	7	7.1	7.4
B9	Broiler Manure-Based Feed	5.7	6	6.9	7.2	7
B10	Broiler Manure-Based Feed	5.8	6	6.9	7.1	7.1

Appendix C: Daily Feed Intake Recording Sheet

Steer ID	**Treatment**	**Average Feed Intake (kg/day)**
C1	Commercial Feed	10.8
C2	Commercial Feed	10.9
C3	Commercial Feed	10.5
C4	Commercial Feed	11.2
C5	Commercial Feed	10.7
C6	Commercial Feed	10.5
C7	Commercial Feed	10.8
C8	Commercial Feed	11.1
C9	Commercial Feed	10.4
C10	Commercial Feed	10.6
B1	Broiler Manure-Based Feed	9.5
B2	Broiler Manure-Based Feed	9.1
B3	Broiler Manure-Based Feed	8.8
B4	Broiler Manure-Based Feed	8.9
B5	Broiler Manure-Based Feed	8.4
B6	Broiler Manure-Based	8.6

	Feed	
B7	Broiler Manure-Based Feed	8.7
B8	Broiler Manure-Based Feed	9
B9	Broiler Manure-Based Feed	8.6
B10	Broiler Manure-Based Feed	8.6

The following formulas were used to calculate growth performance parameters during the 90-day pen fattening trial.

$$Total\ Weight\ Gain\ (kg)\ =\ final\ weight\ gain\ -\ initial\ weight$$

$$Average\ Daily\ Gain\ =\ total\ weight\ gain\ /\ number\ of\ days\ on\ trial$$

$$Weekly\ Weight\ Gain\ (kg/week)\ =\ weight\ at\ end\ of\ week\ -\ weight\ at\ start\ of\ week$$

$$Feed\ Intake\ (kg)\ =\ feed\ offered\ -\ feed\ refusals$$

$$Feed\ Conversion\ Ratio\ =\ total\ feed\ intake\ /\ total\ live\ weight\ gain\ (kg)$$

Appendix D: Economic Analysis Parameters

Table D1: Economic performance indicators used in the cost benefit analysis of the two dietary treatments.

Parameter	T1 Commercial	T2 Broiler Manure
Feed cost USD/tonne	380.00	167.80
Feed cost per kg gain (USD)	3.61	2.07
Live weight gain (kg)	105.2	81.0
Market price/kg live mass (USD)	2.80	2.80

Gross revenue (USD)	294.56	226.80
Gross margin (USD)	74.56	139.00
Benefit Cost Ratio	0.78	1.35

NOTE: $Feed\ cost\ per\ kg\ gain\ =\ total\ feed\ cost\ /\ total\ live\ weight\ gain$

$$Gross\ Revenue\ =\ total\ live\ weight\ gain\ (kg)\ *\ market\ price\ per\ kg\ live\ mass\ (USD)$$

$$Total\ Variable\ Costs\ =\ total\ feed\ cost\ +\ veterinary\ costs\ +\ labour\ costs$$

$$Gross\ Margin\ =\ gross\ revenue\ -\ total\ variable\ costs$$

$$Benefit\ Cost\ Ratio\ =\ gross\ revenue\ /\ total\ feed\ cost$$

Appendix E: Statistical Analysis Summary

Table E1: Summary of ANOVA results for the effects of dietary treatment on growth performance, feed conversion ratio and profitability parameters of beef cattle during the 90-day pen fattening trial.

Parameter	Grand mean	P-value	SED	LSD	CV%
TWG (kg)	93.1	<0.05	7.8	15.6	12.4
ADG (kg/day)	1.03	<0.05	0.09	0.17	11.8
Feed intake (kgDM)	6.80	<0.05	0.32	0.63	9.2
FCR	9.6	<0.05	0.44	0.88	8.5
BCR	1.07	<0.05	0.21	0.42	10.9

Note: *TWG= Total Weight Gain; ADG = Average Daily Gain; FCR = Feed Conversion Ratio; BCR = Benefit Cost Ratio; SED= Standard Error Difference; LSD= Least Significant Difference; CV% = Coefficient of Variation.*