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Profitability Analysis of Finishing Rations: The Case of Dorper Sheep Using the Internal Rate of Return

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ABSTRACT
This study evaluated the profitability of locally formulated finishing rations to enhance sheep growth performance. Kenya, a net importer of meat and meat products, is projected to face increased demand due to rising incomes and urbanization. Sheep play a crucial role in food production, rural employment, and the national economy by converting roughage into meat, wool, and skin. The growing domestic and export demand for mutton necessitates the development of more efficient production systems. However, current production systems are constrained by low slaughter weights and extended timeframes to market readiness, with small ruminants requiring over two years to reach market weight. This study therefore, focuses on evaluating the profitability of Dorper sheep fattening under an intensive feeding system using locally available, cost-effective feed resources. Thus, a Completely Randomized Design (CRD) was employed, assigning 10 groups of three sheep to different diets, including a control group. Data were analyzed using analysis of covariance (ANCOVA), with diet as the primary independent variable. The results indicated that Ration 8 significantly outperformed other diets, achieving the highest weekly average weight gain. Profitability analysis revealed an internal rate of return (IRR) of 22 per cent, suggesting that the investment would break even within 2.5 years. Ration 8 demonstrated both growth and economic benefits, providing a viable solution for improving sheep production. This study advocates for the promotion and commercialization of Ration 8 to enhance meat production, reduce imports, support rural livelihoods, and contribute to climate change mitigation. Future research should focus on investigating the nutrient composition, digestibility, and genetic interactions of Ration 8, along with long-term studies on its effects on meat quality, reproduction, and flock health.

Key words: Finishing, growth performances, internal rate of return, profitability, ration.

INTRODUCTION

The profitability of small ruminant fattening hinges on several key factors: the duration of the fattening period, the feed consumed until slaughter, the carcass dressing percentage and composition, and the revenue generated from meat sales. Breed differences also play a significant role in these dynamics, especially under intensive rearing conditions using concentrate-based diets, which have been shown to yield the highest daily gains and optimal feed conversion efficiency (Chacko et al., 2024). However, while high-energy diets promote rapid growth, they also result in increased body fat retention (Hozza, 2011).

Atsbha et al. (2020) posit that fattening duration is influenced by factors such as feed quality, intake, conversion efficiency, and the animal's growth potential. Although sheep typically exhibit slow growth rates (Erlangga & Uke, 2012), mutton remains highly popular among Kenyan consumers. Slow growth can be mitigated through strategic feed supplementation and rationing. Research indicates that intensive management of sheep enhances growth performance and profitability (Sultana, 2011). Thus, exploring feeding strategies that optimise growth rates under intensive systems is crucial for improving the economic outcomes of sheep farming.

Growth performance in small ruminants largely depends on the availability of high-quality feeds and effective feeding regimes (Moorby & Fraser, 2021). Poor growth rates have been identified as a major limitation, but these can be improved through balanced diets that provide sufficient energy and protein. The response to such nutritional interventions varies among breeds (McGrath et al., 2018). Studies show that diets with higher energy and protein levels significantly boost daily weight gains in sheep (Cui et al., 2019). Despite the proven benefits of intensive management, the practice of confining sheep for optimal growth and weight gain is uncommon in Kenya. Most small ruminants are reared by smallholder farmers for subsistence and local market sales, resulting in economic returns far below their potential.

This study focuses on evaluating the profitability of Dorper sheep fattening under an intensive feeding system using locally available, cost-effective feed resources. By analysing the growth performance, internal rate of return, and overall profitability of formulated finishing rations, the study aims to provide insights into commercialising the sheep value chain. The discussion will address the critical components of feed formulation, growth performance, and economic outcomes, offering practical recommendations for maximising profitability in small ruminant farming.

LITERATURE REVIEW

Profitability analysis in sheep farming is critical in providing a deeper understanding of the long-term economic prospectivity of farming (Merida et al., 2024). It has been argued that profitability analysis in farming provides farmers with a clear understanding of the financial viability of their operations, helping them evaluate returns relative to costs (Mulei et al., 2024). However, feed and nutritional expenses are among the largest components of production costs, and optimising these can significantly enhance profit margins in sheep farming (Chisoro et al., 2023). Thus, it is imperative to promote strategic feeding, such as feedlotting using finishing ration, that is tailored to animal needs and that can reduce waste and improve growth rates, leading to better financial outcomes (Boudalia et al., 2024). Merida et al. (2024) posit that profitability analysis aids in decision-making regarding flock management, such as breeding strategies, health interventions, and market opportunities.

In order to adjust for the influence of covariates and refine estimates of the relationship between the independent and response variables, an analysis of covariance (ANCOVA) was conducted (Schneider et al., 2015). After determining the best performing ration, ANCOVA was followed by a profitability analysis using the internal rate of return (IRR). IRR was preferred because the approach serves as a crucial metric in assessing the profitability of sheep fattening operations, particularly for Dorper sheep, due to its ability to encapsulate the economic efficiency of an investment within a single percentage value (Liu & Luk, 2022). This value not only provides clarity but also enables comparisons across various investment options, accounting for the time value of money - a fundamental concept in

capital budgeting. Arjunan (2022) posits that IRR is the only rate that fully utilises the net cash flow (NCF) and makes the closing balance zero, and investors are comfortable to compare the IRR with the cost of capital in percentage terms.

For Dorper sheep fattening investment, where cash flows may involve significant upfront investment in animal acquisition, feed, and infrastructure, followed by staggered returns from sales, the IRR becomes an indispensable tool. By calculating the discount rate that equates the net present value (NPV) of cash inflows to outflows, the IRR reflects the operation's break-even cost of capital (Huang et al., 2022). As a thumb rule, a higher IRR indicates a more profitable investment, as it surpasses the minimum acceptable rate of return, such as the cost of borrowing or opportunity cost of capital (Huang et al., 2022).

In addition, empirical data on sheep fattening often exhibit variable cost and revenue structures influenced by feed conversion efficiency, mortality rates, and market prices. For Dorper sheep, known for their adaptability, rapid growth rates, and high meat quality (Wanjala et al., 2023), IRR analysis effectively accounts for these parameters. Thus, the significance of IRR in Dorper sheep fattening stems from its capacity to simplify complex cash flow dynamics into a clear and practical metric. By combining time-based cash flow forecasts with economic benchmarks, IRR provides farmers and agri-entrepreneurs with a reliable decision-making tool that balances operational viability with profitability goals.

METHODOLOGY

The methodology section includes a detailed description of the study area, experimental design, diet composition, and experimental animals. Housing conditions, acclimatisation, disease control, and feeding protocols are outlined. Response variables, including growth and feed efficiency, were monitored. Data collection involved tracking weight gain and feed intake. Finally, a profitability analysis was conducted, considering feed costs, growth rates, and total weight gain. This section is crucial as it ensures transparency, reproducibility, and reliability of research, allowing others to understand, evaluate, and replicate the experimental design and procedures accurately.

Study Area

The research was conducted at the Kenya Agricultural and Livestock Research Organisation (KALRO) Buchuma station through a controlled feeding trial involving local weaner Dorper lambs.

Experimental Design

A Completely Randomised Design (CRD) with a 4×4 factorial arrangements were employed, comprising three replicates per treatment. The CRD ensured unbiased treatment allocation, evaluated interactions between factors, increased statistical power, and provided robust, replicable data on dietary effects in Dorper sheep feeding experiments. The experimental animals were weighed and randomly assigned into 10 groups to ensure uniformity, minimise bias, and enhance comparability among treatments and controls, enabling accurate evaluation of dietary effects on growth performance and health parameters. Dorper sheep aged 3–4 months (weaners) were selected to ensure uniform physiological development, optimise nutrient utilisation during the growth phase, and facilitate reliable assessment of dietary effects on performance and carcass traits during critical growth stages.

Diet Composition

The treatments comprised energy levels of 9.5, 11.5, and 13.5 megajoules of Metabolisable energy per kilogram of dry matter (MJ ME/Kg DM) and crude protein levels of 8, 12, 14, 16, and 18 per cent dry matter (DM). Positive (commercial range cubes) and negative (Rhodes grass hay alone) controls were included. These treatments aimed to evaluate the effects of dietary energy density and protein intake on growth performance, feed efficiency, and carcass quality, optimising energy supply and determining protein requirements for maximising productivity and economic efficiency in sheep finishing systems. The finishing rations were formulated using conventional feed ingredients, including maize grain, maize germ, wheat bran, molasses liquid, Rhodes grass hay, Lucerne hay, cottonseed, cottonseed cake, sunflower seed cake, digestible crude protein, limestone, mineral premix, Diamond V, salt, and

aflatoxin binder. Conventional feed ingredients were preferred to ensure balanced nutrition, optimal productivity, metabolic health, cost-efficiency, and feed safety through mycotoxin control.

Experimental Animals

Thirty local Dorper sheep were purchased from agro-pastoral farmers in Narok and Kajiado counties. The sheep were selected based on their age (3–4 months, weaners) to ensure uniform physiological development. Proper housing and disease control measures were implemented to ensure welfare, minimise stress, and prevent confounding variables, thereby maintaining experimental validity and promoting accurate data collection.

Housing

The experimental animals were raised indoors in a specially constructed feedlot shed. The shed featured a slatted concrete floor and an iron-sheet roof. It was oriented north-south with long sides facing east and west to maximise sunlight entry. Each pen measured 2 × 4 meters and was equipped with two troughs—one for the test feed supplement and the other for water. The test feed was offered as a Total Mixed Ration (TMR) at a 3:1 ratio to minimise feed selection during experimentation. Ad libitum access to mineral licks and clean water was provided in buckets.

Acclimatisation, Disease Control and Feeding

The experimental animals underwent a 14-day preliminary adaptation period to acclimatise to new environments, diets, and handling. This adaptation reduced stress, stabilised physiological responses, and ensured uniform baseline conditions for reliable data collection during the experiment. To safeguard animal health, the sheep were treated with a broad-spectrum anthelmintic (Super Ivermectin) based on body weight and sprayed with an acaricide against external parasites. Oxytetracycline (20%) was administered to all animals to control Contagious Caprine Pleuropneumonia (CCPP) before the experiment commenced. All experimental sheep were weighed and randomly assigned to 10 groups (three individuals per group) to correspond to the 10 experimental diets (D1–10). The experimental animals were placed under test feed treatments for 8-12 weeks to assess growth performance, optimise feed efficiency, and evaluate the impact of different nutritional strategies and overall health development.

Response Variables

The response variables included voluntary feed intake, initial and final live weights, average daily gain (ADG), total weight gain (TWG), feed conversion efficiency (FCE), final slaughter weight, and carcass quality. Growth performance measurements assessed the impact of dietary formulations on weight gain, feed efficiency, and overall health, providing critical data to optimise nutrition, enhance productivity, and ensure cost-effective livestock management.

Data Collection

Data collected included feed intake, initial and final live weights, average daily gain (ADG), and total weight gain (TWG). These parameters were used to compute feed conversion efficiency (FCE) and evaluate growth performance. Data were analysed using analysis of covariance (ANCOVA) with the General Linear Model (GLM) procedure in Statistical Package for the Social Sciences (SPSS, version 23), with diets as the main effect in the model.

Profitability Analysis

Cost-benefit assessment and profitability analysis of the formulated rations were integral to the study. Mean feed usage, carcass yield, and edible offal from each treatment were used to calculate feed costs and revenues. Expenses included feed, labor, veterinary costs, purchase price of animals, and other transaction costs. The best-performing ration was determined using analysis of covariance (ANCOVA) and subjected to profitability analysis using the Internal Rate of Return (IRR) method. A higher IRR indicated a more desirable ration. The ration with the highest IRR was identified as the most profitable.

RESULTS AND DISCUSSION

A one-way ANCOVA was performed on the weekly weight data to examine the effect of different rations on growth performance. The independent variable was the ration, categorised from Ration 0 to Ration 9, representing various dietary treatments. Age, considered a potential confounding factor, was included as a covariate, with the assumption that the

experimental animals were obtained at approximately 4 months of age (120 days). This statistical approach allowed for controlling the effect of age while assessing the impact of different rations on weight gain over time. ANCOVA results (Table 1) indicate that weekly weight varied statistically significantly with age $F(1,89) = 539.923, p \leq .001, partial\,\eta^2 = .858$ and ration $F(9,89) = 66.357, p \leq .001, partial\,\eta^2 = .870$, respectively.

Table 1 : Analysis of Variance for Average Weekly Weights

Source	Sum of Squares	*df*	Mean Square	*F*	*P*	(η^2)
Corrected Model	2568.273[a]	10	256.827	113.713	≤.001	.927
Intercept	88.605	1	88.605	39.231	≤.001	.306
Age	1219.443	1	1219.443	539.923	≤.001	.858
Ration	1348.830	9	149.870	66.357	≤.001	.870
Error	201.011	89	2.259			
Total	125329.561	100				

Comparison of adjusted group means reveals that ration 8($\bar{X} = 40.097$) performs statistically significant better compared with ration 6($\bar{X} = 38.194$), 9($\bar{X} = 36.263$), 7($\bar{X} = 34.652$), and 0($\bar{X} = 26.219$), respectively. Based on ANCOVA results, a profitability analysis for ration 8, in comparison with ration 6, 7, 9, and control, was conducted using IRR. Results (Table 2) indicate that ration 8 has an IRR of about 22 per cent, followed by ration 6 (18%), ration 7 (4%), and ration 9 (4%) respectively.

Table 2: Profitability Analysis of Finishing Ration

Source	Total Cost	Total Revenue	CBR	NPV	IRR
Ration 8	517,127.77	641,058.00	1.240	504,727.587	22%
Ration 6	505,590.22	619,178.88	1.225	465,407.979	18%
Ration 7	473,556.67	553,541.55	1.169	338,126.135	4%
Ration 9	515,309.18	592,923.95	1.151	333,044.287	4%
Ration 0	272,903.95	286,859.48	1.051	75,836.743	0%

Further analysis of the data revealed that the profitability indices (Table 2) can be achieved within five production seasons, equivalent to approximately 2.5 years. This conclusion is based on the finding that the finishing rations enabled the sheep to reach their target market weights within the 10-week treatment period, beyond which continuing the treatment did not yield additional economic benefits. The Internal Rate of Return (IRR) analysis indicated that the economically optimal flock size for Dorper sheep is approximately 40 animals (Table 3), which balances the investment cost and expected returns, ensuring sustainable profitability. This optimal flock size aligns with maximising economic efficiency in sheep production.

Table 3: Economic Number and Seasons of Dorper Sheep Using Ration 8

Season	Economic Number	Fixed Cost (KES)	Variable Cost (KES)	Total Cost (KES)	Revenue (KES)
0	40	300,000	-	300,000	-
1			375,727	394,514	527,400
2			402,028	422,130	553,770
3			430,170	451,679	581,458
4			460,282	483,296	610,531
5			492,502	517,127	614,058

The ANCOVA results suggest that Ration 8 is the most effective, as it led to a statistically significant increase in weekly average weight compared to other rations. The calculated effect size reveals that approximately 87 per cent of the variation in weekly weight gain is attributed to the ration, leaving 13 per cent accounted for by other variables. This underscores the importance of the ration in influencing growth performance, though other factors such as genetics, environmental conditions, and health management could contribute to the remaining variability.

In alignment with Qtaishat et al. (2012), it is important to recognise that profitability in sheep production does not solely depend on increasing lamb output or adopting intensive management practices. A more holistic approach, including optimising nutrition, health, and management systems, is crucial for enhancing overall productivity and sustainability. The financial analysis, measured using Internal Rate of Return (IRR), suggests that the investment in Ration 8 is financially viable, with an IRR of 22 per cent over 2.5 years, meaning that the returns from this investment would offset the initial cost at this rate. This finding is consistent with Khadka and Thapa (2020), who emphasised the importance of evaluating financial returns in livestock agribusinesses.

CONCLUSIONS AND RECOMMENDATION

Conclusions: The results of this study indicate that the rearing period of Dorper sheep from birth to market weight can be significantly reduced from 1.5 - 2 years to just 6.5 months, thereby enhancing farm profitability and improving return rates. Experimental animals fed Ration on best performing ration (TR 8) reached the target market/slaughter weight of 45 kilograms by 6 months of age, demonstrating the ration's effectiveness in promoting rapid growth. Ration 8 (TR8) emerged as the most efficient in terms of growth performance and should be recommended for adoption by smallholder pastoralists in ASALs (Arid and Semi-Arid Lands) and other sheep-rearing areas. Additionally, the utilisation of high-performing finishing rations could be a pivotal factor in advancing the commercialisation of sheep farming, driving increased productivity and economic sustainability within the sector.

Recommendation: Future research should focus on identifying the specific components of the best-performing ration (TR8) that contribute to its superior performance, particularly its nutrient composition and digestibility. Investigating the interaction between diet and genetics, especially breed-specific responses to various rations could provide valuable insights. Long-term studies assessing the impact of different rations on meat quality, reproductive performance, and overall flock health are essential for a more comprehensive understanding of optimised feeding strategies. Policy recommendations include promoting the adoption of scientifically designed, cost-effective feeding regimens for sheep producers. Extension services should offer

guidance on evaluating the financial feasibility of various rations and their effects on farm profitability. Furthermore, research investment should focus on the environmental sustainability of feeding practices, particularly regarding feed sourcing and waste reduction, to ensure the long-term viability of sheep farming in diverse ecological settings.

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