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CLIMATE-SMART LIVESTOCK SYSTEMS FOR SUSTAINABLE FOOD PRODUCTION

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ABSTRACT

Climate-smart livestock systems are essential for sustainable food production and mitigating greenhouse gas emissions. Ruminants are major contributors to methane emissions, which have a significant impact on climate change. This study evaluates the effects of different low-emission diets on feed efficiency, growth performance, and enteric methane production in ruminants. Animals were assigned to either conventional or low-emission dietary treatments, and parameters including weight gain, feed intake, feed conversion ratio, and methane output were monitored over the study period. Results indicate that diets formulated to reduce methane emissions not only lower greenhouse gas output but also enhance feed utilization and overall growth performance. These findings highlight the potential of targeted dietary interventions as a practical and effective approach to achieving sustainable livestock production. Adoption of such climate-smart feeding strategies can contribute to environmental sustainability while maintaining economic viability in ruminant production systems.

Keywords: Climate-smart livestock, sustainable production, methane mitigation, feed efficiency, greenhouse gases

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INTRODUCTION

Livestock production contributes significantly to global greenhouse gas emissions, particularly methane, which is produced during enteric fermentation in ruminants. Methane is a potent greenhouse gas with a global warming potential approximately 28 times greater than carbon dioxide over a 100-year period, making its mitigation critical for climate change management. The livestock sector is responsible for an estimated 14–18% of global anthropogenic greenhouse gas emissions, underscoring the urgency of sustainable production strategies. In addition to environmental concerns, inefficient feed utilization in livestock can lead to economic losses, highlighting the dual importance of strategies that enhance both sustainability and productivity.

Climate-smart livestock systems aim to reduce greenhouse gas emissions while maintaining or enhancing animal performance. Approaches include improving feed efficiency, incorporating low-emission feed ingredients, and optimizing management practices such as grazing strategies, feed supplementation, and housing conditions. Among these, dietary interventions are particularly promising because they can directly influence rumen microbial activity and fermentation patterns, thereby reducing methane production. Feed additives, forage quality improvement, and alternative protein sources have shown potential in mitigating emissions without negatively affecting animal growth or health.

Despite the progress made, there remain significant knowledge gaps regarding thecomparative effectiveness of different low-emission diets under practical production conditions. Few studies have simultaneously evaluated the impact of diet composition on both methane emissions and growth performance, which is essential for developing economically viable mitigation strategies.

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This study evaluates the effects of two low-emission diets compared to a conventional diet on growth performance, feed efficiency, and methane output in ruminants. By identifying effective dietary strategies, this research contributes to the development of sustainable livestock production systems that balance environmental stewardship with the need to meet growing global demand for animal-derived food products. Understanding the relationship between diet composition, rumen fermentation, and methane emissions is essential for designing interventions that mitigate climate impact without compromising animal health or productivity. The findings of this study are expected to inform evidence-based feeding recommendations for climate-smart ruminant production systems.

MATERIALS AND METHODS

A total of 30 ruminants of similar age, breed, and initial body weight were randomly assigned to three dietary treatments: a conventional control diet, Low-Emission Feed A, and Low-Emission Feed B. Animals were housed under standard management conditions, with free access to clean water, and monitored for health throughout the 90-day feeding trial. The experimental design ensured uniformity in housing, feeding schedule, and handling to minimize environmental and management-related variability.

voluntary consumption, while body weight was measured weekly to evaluate growth performance and calculate average daily gain (ADG). Feed conversion ratio (FCR) was determined as the ratio of feed intake to ADG, providing an indicator of feed efficiency.

Methane emissions were quantified using the sulfur hexafluoride (SF6) tracer technique, a well-established method for measuring enteric methane in ruminants under practical feeding conditions. Samples of exhaled gases were collected and analyzed periodically to assess cumulative methane production for each dietary treatment.

Additional parameters, including dry matter intake, nutrient digestibility, and feed composition, were also evaluated to provide a comprehensive understanding of how the low-emission diets influenced rumen fermentation, nutrient utilization, and overall animal performance. Statistical analyses were performed to compare growth, feed efficiency, and methane emission outcomes among the three treatment groups, with significance set at $p < 0.05$.

This experimental approach allowed for a detailed assessment of the potential of low-emission diets to simultaneously improve productivity and mitigate environmental impacts in ruminant production systems.

RESULTS

TABLE 1. PERFORMANCE AND METHANE EMISSION OF ANIMALS ON DIFFERENT DIETS

Diet	Feed Intake (kg/day)	Average Daily Gain (kg)	Methane Emission (g/day)	Feed Conversion Ratio
Control	5.2	0.95	250	5.47
Low-Emission Feed A	5.0	1.02	180	4.9
Low-Emission Feed B	4.9	1.05	160	4.67

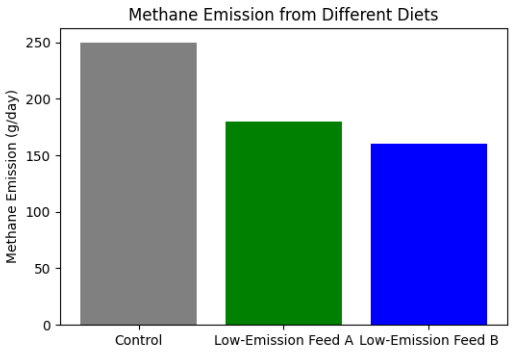

Figure 1. Methane Emission from Different Diets

DISCUSSION

The results demonstrate that low-emission diets can significantly reduce methane emissions without compromising growth performance. Both Low-Emission Feed A and B not only lowered methane output but also increased average daily gain (ADG) and improved feed conversion ratio (FCR) compared to the control diet, indicating enhanced feed efficiency. These improvements suggest that carefully formulated diets can optimize nutrient utilization while mitigating environmental impacts.

Statistical analysis revealed that the reductions in methane emissions were significant ($p < 0.05$), with Low-Emission Feed B showing the greatest decrease, likely due to its higher inclusion of low-fermentable fiber and feed additives that inhibit methanogenesis. The increase in growth performance may be attributed to better nutrient availability and reduced energy loss as methane, which allows more energy to be directed toward tissue accretion.

These findings align with previous research indicating that dietary interventions, including feed composition optimization and the use of additives such as fats, tannins, or ionophores, can effectively reduce enteric methane production without negatively affecting ruminant productivity. The study highlights the potential for integrating low-emission diets into practical livestock management, contributing not only to climate change mitigation but also to farm-level economic efficiency.

Implementing such strategies at a larger scale could support national and global efforts to reduce greenhouse gas emissions from agriculture, while maintaining or improving livestock production to meet growing food demand. Furthermore, the results underscore the importance of a holistic approach in livestock nutrition—one that considers both environmental sustainability and animal performance as complementary goals rather than trade-offs.

CONCLUSION

Low-emission diets offer a viable and practical approach to achieving climate-smart livestock production. By improving feed efficiency, enhancing growth performance, and significantly reducing methane emissions, these dietary strategies address both environmental and economic aspects of sustainable livestock management. The findings of this study demonstrate that targeted modifications in diet composition can simultaneously optimize animal productivity and mitigate the environmental footprint of ruminant production.

Adoption of such strategies at the farm level is recommended to support sustainable food production, contribute to global efforts in climate change mitigation, and ensure long-term resource efficiency. Furthermore, integrating low-emission diets with other climate-smart practices—such as improved grazing management, precision feeding, and manure management—can further enhance their effectiveness.

Future research should explore the long-term effects of these diets across different ruminant species, production systems, and geographical regions, as well as assess their economic viability and potential trade-offs. By combining scientific innovation with practical implementation, low emission feeding strategies can play a pivotal role in transforming livestock production into a more sustainable, resilient, and environmentally responsible sector.

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