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Commentary

Optimizing Calf Growth on Low-Protein Diets: The Role of Leucine and Tryptophan Supplementation

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DESCRIPTION

With the rising demand for sustainable livestock practices, nutritionists and producers alike are exploring dietary strategies that reduce environmental impact without compromising animal performance. One such approach is the formulation of low-protein diets, which can lower nitrogen excretion and reduce feed costs. However, this strategy often leads to reduced growth rates and compromised immunity in preweaning calves if not nutritionally balanced. The present study provides compelling evidence that targeted amino acid supplementation specifically with leucine and tryptophan can counteract these negative effects and restore health and productivity in calves fed reduced-protein diets.

Improving growth and health with balanced amino acids

In this study, seventy-five Holstein male calves were fed five different diets to evaluate the effects of dietary protein levels and amino acid supplementation on growth performance, blood biochemistry, immunity and antioxidant status. The positive High Protein (HP) received a standard diet containing 22% Crude Protein (CP), while the negative Low Protein (LP) received a lower protein diet with 19% CP. Three additional groups received the same low-protein diet supplemented with leucine (L group), tryptophan (T group), or both (LT group).

Results revealed that calves fed the unsupplemented LP diet exhibited significantly lower Average Daily Gain (ADG) compared to the HP group, confirming the detrimental effect of protein reduction. However, when leucine or leucine combined with tryptophan were added to the LP diet, growth performance improved to match the HP group. This indicates that these amino acids, particularly in combination, play a pivotal role in compensating for reduced dietary protein and supporting anabolic processes in growing calves.

Feed efficiency, as measured by the feed-to-gain (F/G) ratio, also showed improvement in the L group, suggesting that leucine alone can enhance nutrient utilization. In addition, fecal scores and diarrhea rates were significantly higher in the LP group from day 10 to day 34, indicating compromised gut health and immunity. These issues were notably alleviated in the supplemented groups, particularly the LT group, pointing to the benefits of targeted amino acid fortification in preventing digestive disturbances.

Restoring biochemical and immune balance through supplementation

Low-protein diets led to elevated levels of serum Uric Acid (UA) and Blood Urea Nitrogen (BUN), indicators of protein catabolism and reduced nitrogen utilization. These levels normalized with the supplementation of leucine and tryptophan, demonstrating improved amino acid balance and reduced metabolic stress. Serum Total Protein (TP) and albumin, both of which decreased with protein restriction, also returned to normal levels with amino acid supplementation. These changes underscore the capacity of leucine and tryptophan to support protein metabolism and liver function even under reduced dietary protein conditions.

Further reinforcing the systemic impact of supplementation, significant changes were observed in hormone and immune parameters. Calves on the LP diet exhibited reduced serum growth hormone and Insulin-Like Growth Factor 1 (IGF-1) levels, consistent with stunted growth. Supplementation with leucine and tryptophan restored these hormone levels, facilitating normal growth trajectories.

Equally important was the effect on the calves' antioxidant and immune status. The LP group showed a reduction in key antioxidant enzymes, such as Superoxide Dismutase (SOD) and catalase, as well as immune markers including interferon- γ, interleukin-2 and immunoglobulin M. These reductions can predispose calves to inflammation and infection. Notably, supplementation with both amino acids significantly elevated the levels of these biomarkers, effectively enhancing the antioxidant defense and immune capacity of the animals.

Amino acid profiling of the blood further demonstrated the biochemical impact of the intervention. histidine levels, which

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declined under the LP diet, were restored in the L and LT groups. Similarly, levels of leucine, threonine, tryptophan and total essential amino acids were markedly higher in the supplemented groups, confirming improved amino acid availability and absorption. The most substantial increase in serum tryptophan was observed in the T and LT groups, validating the effectiveness of supplementation.

CONCLUSION

This study provides strong experimental evidence that supplementing low-protein diets with leucine and tryptophan can effectively mitigate the adverse effects of protein restriction in preweaning calves. While a simple reduction in dietary protein compromises growth, immune function and metabolic balance, the strategic addition of these amino acids restores critical physiological functions, enhances feed efficiency and supports optimal development.

The broader implications of this research extend beyond individual calf performance. By enabling the use of lower-protein diets without sacrificing productivity, this approach supports more sustainable animal production practices by reducing nitrogen excretion and feed costs. Moreover, it highlights the importance of precision nutrition in young ruminants, where balanced amino acid profiles not just total protein content is important for healthy growth.

As the livestock industry moves toward environmentally conscious and economically viable production systems, strategies such as amino acid fortification of low-protein diets will become increasingly relevant. Future research may expand on these findings by exploring the roles of other limiting and branched-chain amino acids in calf development, further refining dietary models for optimal performance and health.