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SHAPING LIVESTOCK PRODUCTION TOWARDS SUSTAINABILITY FOR ENHANCED ANIMAL PRODUCTIVITY, MUSCLE GAIN, AND MEAT QUALITY

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I. INTRODUCTION

Sustainable animal-food production is critical for ensuring global food security and protecting ecosystems. Within this framework, an integrated approach encompassing agriculture, agrostology, and animal production systems is essential. Meat, a key source of essential nutrients and bioactive compounds, plays a pivotal role in the diets of diverse populations across both developed and developing nations [1]. Despite perceptions of meat production being resource-intensive, its sustainability can be significantly improved by incorporating alternative forages and agricultural by-products that are unsuitable for direct human consumption. This paper explores innovative dietary resource utilization and co-supplementation strategies aimed at enhancing livestock productivity, muscle growth, and meat quality. The objective is to highlight efficient, eco-friendly feeding approaches that align with the goals of sustainable and resilient meat production systems.

II. MATERIALS AND METHODS

The presented short paper is formulated from a review of 246 publications, sourced from reputed databases, e.g. PubMed, Scopus, Web of Science, and Google Scholar. Studies published between 1997-2025 were considered, with emphasis on those addressing ruminant nutrition, alternative feed resources, co-supplementation strategies, and meat quality. The collected information was critically analyzed and organized under thematic areas relevant to the review. For this short paper, four studies were described as an example, ensuring we captured the most recent advances over the recent period. Since no live animals were involved, ethical clearance was not applicable; however, ethical compliance was ensured in the respective original studies cited.

III. RESULTS AND DISCUSSION

Dietary protein and energy concentrations are a limiting factor for animal health and wellbeing along with animal performance and muscle mass production, especially when green pasture matures and becomes senesced. This can be addressed by offering a balanced diet with macro- (protein, fat & energy) and micro- (vitamins, minerals & bioactive compounds) nutrients. Dietary interventions with micronutrients (vitamin E & selenium) and bioactive compounds further, significantly enhance the muscle antioxidant status and overall meat quality in large and small ruminants. For instance, Table 1 shows the effect of the same in sheep and lambs. As illustrated in Figure 1a, these nutritional strategies effectively addressed forage-quality limitations while improving growth performance and carcass characteristics. Figure 1b further highlights their dual role: optimizing rumen function, reducing methane emissions and enriching meat with health-promoting fatty acids. These findings establish a direct correlation between precision nutrition, livestock productivity, and environmental sustainability, though optimal inclusion levels require further species-specific validation.

Table 1 – Effects of micronutrients on muscle antioxidative status and meat preservation in sheep and lambs.[1]

Breed	Micronutrient/ Ingredient	Dosage (Duration)	Basal Diet	Antioxidative Effects	Preservative Effects
White Dorper Lambs [2]	Vitamin E	Forage-based (49 days)	Brassica/lucerne + phalaris	↑ Vitamin E, ↓ lipid oxidation	Slowed colour deterioration ↓ MetMb after 40 days

Dorper Lambs [3]	Nigella sativa + Rosemary	1% (90 days)	Concentrate + rice straw	↓ MDA	↑ Redness (*a**), ↓ Cooking/drip loss
Hu Sheep [4]	Mulberry Leaf Powder	15–60% DM (84 days)	Corn silage + concentrate	↑ Cu/Zn SOD, GPX mRNA	↑ Redness (*a**), ↓ shear force, ↑ water-holding
Tan Sheep [5]	Selenium	28.94–564.60 mg/kg (60 days)	Standard diet	↓ MDA	↓ Drip loss, Improved colour stability

[1]Abbreviations include: ↑: Increase/improvement; ↓: Decrease/reduction; MetMb: metmyoglobin; MDA: malonaldehyde; SOD: Superoxide Dismutase; GPX: Glutathione Peroxidase

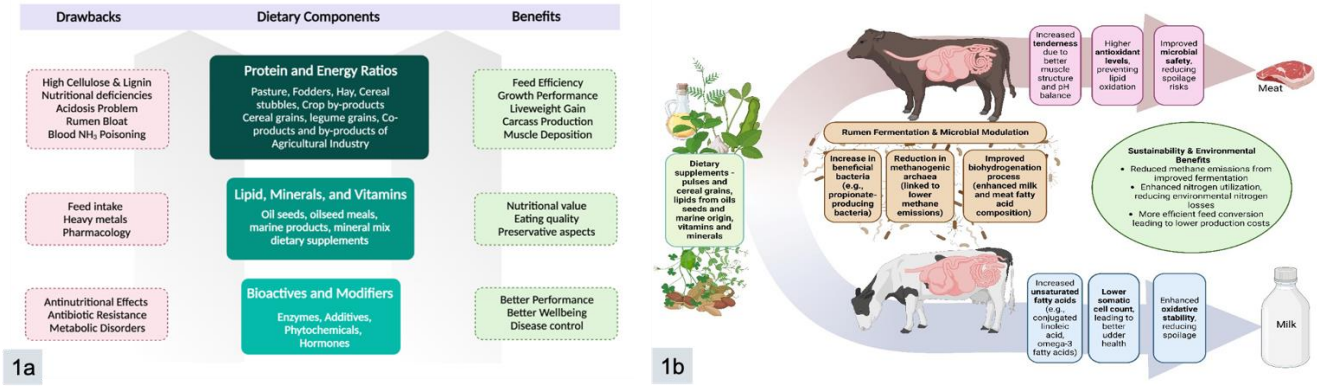


Figure 1a. Some drawbacks and benefits of different dietary components from animal feeds of forages and supplements on animal health, muscle gain, carcass value and meat quality. Figure 1b. The role of dietary nutrient composition on mitigation, environmental sustainability and livestock product quality (Created in BioRender. Priyashantha, H. (2025) https://BioRender.com/u84a807).

IV. CONCLUSION

Future livestock production systems must participate in the circular economy and adopt integrative dietary practices to remain relevant, sustainable, and advantageous for their stakeholders. There are diverse pathways by which dietary interventions and management can alter livestock performance, muscle gain, and meat quality. Decisions should be made on a case-by-case basis, depending on the local availability of pasture resources, special forages, and agrifood by-products.

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