

3.3 Application of functional additives

Functional additives, particularly probiotics and enzyme preparations, have emerged as effective tools to enhance growth performance and rumen efficiency in goats, especially in high-concentrate or stressful conditions. Supplementation with *Bacillus subtilis* and *B. licheniformis*, alone or combined with multi-enzyme complexes, has repeatedly improved average daily gain and final body weight in fattening goats relative to unsupplemented controls (Lu et al., 2025). These combinations can increase average daily feed intake and growth rate simultaneously, resulting in higher slaughter weights without adverse effects on serum biochemical or antioxidant indices (Lu et al., 2021). In weaned goats, complexes of *Candida utilis*, *Bacillus coagulans*, *Lactobacillus acidophilus* and multi-enzymes significantly increased end weight and ADG, while tending to improve digestibility of dry matter and crude fat, suggesting better exploitation of both fiber and non-fiber nutrients (Lu et al., 2022).

Beyond growth, functional additives modulate rumen fermentation, epithelial integrity, and immune status. Probiotic–enzyme combinations elevate total volatile fatty acids or specific branched-chain VFAs, improve rumen papilla morphology, and enrich fiber-degrading taxa such as Prevotellaceae and Fibrobacteres, thereby supporting more efficient fermentation of high-concentrate diets. In goats fed high-concentrate rations, probiotic supplementation increased concentrations of acetate, propionate, butyrate and total VFAs, while upregulating tight-junction proteins and anti-inflammatory cytokines (e.g., IL-10) and downregulating pro-inflammatory mediators, ultimately enhancing rumen barrier function and growth performance. Under heat stress, supplementation with *Saccharomyces cerevisiae* and *Clostridium butyricum* improved rumen pH, cellulolytic enzyme activities, volatile fatty acid concentrations, dry matter intake and ADG, indicating a protective effect on rumen function and productivity in challenging environments (Cai et al., 2021). Together, these findings support the targeted use of probiotics and enzymes as part of scientific diet formulation to improve growth, health and resilience in modern goat production systems (Barsila et al., 2025).

4 Optimization of Feeding and Management Practices

4.1 Comparison of intensive and grazing-combined systems

Intensive stall-feeding generally supports higher growth rates than continuous grazing, primarily through better control of nutrient supply and reduced energy expenditure on walking and thermoregulation. In Black Bengal does, daily live weight gain was significantly higher under stall feeding than under tethering, restricted grazing, or full-day grazing, even though all groups received the same level of concentrate supplementation (Moniruzzaman et al., 2002). Similar patterns were observed in Kanni Adu and Osmanabadi goats, where stall-fed or high-supplement groups achieved the greatest average daily gain and body size, while goats maintained on sole grazing showed markedly poorer performance (Jeyakumar, 2020; Da et al., 2021). These results indicate that intensive systems are particularly advantageous where high-quality forages or concentrates can be reliably supplied.

However, integrating grazing with strategic supplementation often narrows the performance gap with intensive systems while exploiting low-cost pasture resources. Reviews of small ruminant feeding systems show that kids and lambs grazing with concentrate supplementation can reach average daily gains and carcass yields comparable to or higher than those of stall-fed animals, especially when pastures are of good quality (Huang et al., 2023; Ke et al., 2023). Time-limited or restricted grazing with concentrate has also been proposed as a finishing strategy that maintains growth performance while reducing feed costs and improving some meat quality traits relative to purely indoor systems. In practical goat production, semi-intensive or grazing-combined systems thus represent a compromise, trading some control over intake for lower feed costs, more natural behavior, and potential product quality advantages.

4.2 Optimization of feeding regimes and frequency

Beyond system type, growth performance in goats is strongly influenced by the level of concentrate supplementation within a given diet. In intensively raised Barbari kids, increasing concentrate mix from 0.7% to 2.1% of body weight improved daily weight gain, dry matter intake, digestible crude protein, and total digestible