

linear decline in ADG as feed level decreased, accompanied by lower shrunk and empty body weights, hot carcass weight and tissue yields at slaughter (Huang et al., 2024). Under thermal stress, Boer goats given fermented *Pennisetum giganteum* feed achieved higher ADG (48.2 g vs. lower in controls) and carcass weight while consuming less feed, illustrating how diet quality can counter environmental constraints on growth. Similar improvements in final weight and ADG have been reported when diets were supplemented with garlic skin, cecropin, or optimized concentrate levels, confirming that body weight gain indicators are sensitive tools for discriminating among feeding strategies.

2.2 Feed conversion efficiency and nutrient utilization

Feed conversion efficiency expresses how effectively goats transform feed into live weight and is central to evaluating and comparing feeding strategies economically and environmentally. FCR or feed-to-gain ratios are usually calculated as total feed intake per unit of weight gain over a defined period, while related indices such as Kleiber ratios (growth rate relative to metabolic weight) capture efficiency across growth stages. Meta-analysis of *Saccharomyces cerevisiae* supplementation in growing goats showed that yeast preparations increased ADG while having smaller overall effects on dry matter intake and FCR, indicating potential efficiency gains from altered rumen fermentation and health status (Ogbuewu and Mbajorgu, 2023). In intensive systems, concentrate feeding frequency changed daily feed intake and ADG in Sirohi kids, but did not markedly alter FCR, suggesting that higher intake and gain can occur without proportional improvements in conversion.

Nutrient utilization is evaluated by measuring intake and apparent digestibility of dry matter and key nutrients, as well as rumen fermentation characteristics. Young Kacang goats fed diets with increasing energy density (TDN 70.0%-73.3%) showed higher intakes of organic matter, crude protein and metabolizable energy and achieved better ADG and feed efficiency at the highest energy level, even though dry matter intake and most digestibilities remained high and similar across treatments (Tahuk et al., 2024). Under heat stress, goats receiving fermented *Pennisetum* feed had reduced average daily feed intake yet improved F:G ratio, accompanied by enhanced antioxidant and immune status, suggesting more efficient nutrient use under challenging conditions (Figure 1) (Qiu et al., 2023). Functional additives such as garlic skin or cecropin have been linked to higher volatile fatty acid production and favorable shifts in acetate-to-propionate ratios, which support more efficient energy capture from fiber and starch, reinforcing the value of combining FCR with nutrient and rumen measurements when assessing feeding interventions.

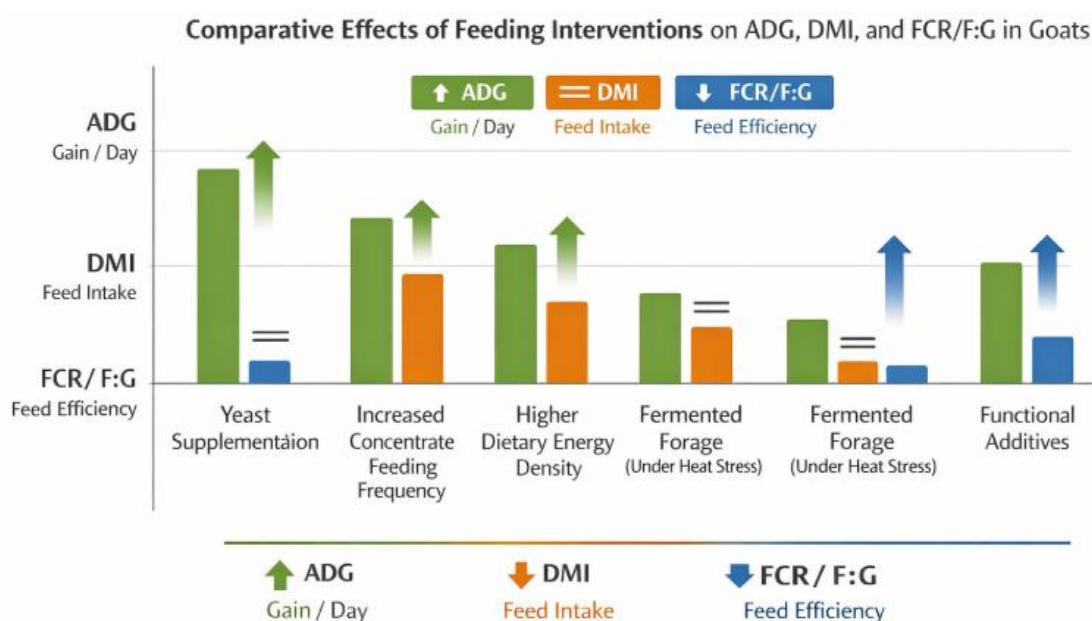


Figure 1 Comparative effects of feeding interventions on average daily gain, dry matter intake, and feed conversion efficiency in goats. The figure summarizes the relative responses of goats to yeast supplementation, concentrate feeding frequency, dietary energy density, fermented forage, and selected functional additives (Adopted from Qiu et al., 2023)