DOI: https://doi.org/10.59913/dagr.2024.17740

# Pasture farming as a sustainable method of goat milk and dairy product production

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## Abstract

Pasture represents an economical and sustainable way of feeding goats. However, to fully leverage the benefits of grazing, farmers must manage several aspects, including plant diversity, potentially poisonous plants, pasture load, and the pasture's nutritional value. Moreover, combined grazing with goats, sheep, and cows is the most effective way to utilise pasture resources. Pasture-based diets impact milk and dairy products' nutritional and fatty acid profiles. When goats graze on diverse pastures, their diet typically includes a range of plants, such as grasses, legumes, and herbs, which enhance the nutritional content of their milk. This dietary diversity increases the presence of protein, fat, and beneficial fatty acids, such as omega-3 and conjugated linoleic acid (CLA), both of which are associated with some health benefits. Additionally, pasture-based diets contribute to higher antioxidant levels in goat milk, including vitamins like A and E, which improve the milk's oxidative stability. Grazing improves goat's milk's nutritional and sensory quality, providing a natural method to enhance its value for consumers and dairy processors.

Keywords: pasture management, goat milk, dairy product, added value

## Introduction

Pasture is often regarded as an economical source of feed and nutrients. However, pasture use does not always guarantee adequate production levels, especially due to

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seasonal variations and climatic conditions that affect grass availability and quality (BONANNO et al., 2008). There is no universal grazing system that fits all situations; the effectiveness of different grazing methods depends on achieving optimal interaction between pasture and grazing animals, shaped by specific practical circumstances (BONANNO et al., 2008). Livestock grazing has positive effects on pasture biodiversity, as well as on animal health and welfare (WRÓBEL et al., 2023). Additionally, grazing significantly impacts the quality of goat milk and dairy products, influencing their nutritional profile and sensory characteristics (PASKAŠ et al., 2023). When goats graze on diverse pastures, their diet includes a variety of plants such as grasses, legumes, and herbs. They can select tannin-rich woody forage and a wide range of plant species, which can enhance forest rangeland biodiversity under rational forage resource management (CHEBLI et al., 2022). Year-round vegetation suitable for goats can be achieved by cultivating a mix of warm- and cool-season grasses (both annuals and perennials), legumes, and forbs, as well as by incorporating browse plants into the grazing system. Browse adds dietary variety, minimizes gastrointestinal parasite issues, and improves goat health and performance. Browse can be integrated into grazing systems by developing woodland grazing plots or by planting browse in designated paddocks (KARKI, 2020). Effective pasture management for goats requires understanding their grazing behaviour, selecting optimal plant species, employing appropriate grazing techniques, and determining the start, end, and frequency of grazing. Grazing frequency depends on plant height, which varies with seasonal grass growth, grazing intensity, pasture load, and the timing, quantity, and quality of supplemental nutrition. Moreover, an efficient grazing system should also protect the environment and landscape (BONANNO et al., 2008).

## Efficiency of pasture utilisation

### *1. Pasture load and poisonous plants*

The degree of pasture loading affects its utilization efficiency, but to increase profitability, this loading is often raised irrationally. In a study by ANIMUT et al. (2005), an increase in pasture loading reduced forage mass post-grazing, increased the proportion of grasses, and lowered the nutritional value of the available forage, though these effects varied with climatic conditions. Goats displayed neither a strong preference nor aversion to ragweed (*Ambrosia spp*.), indicating it was neither highly favoured nor rejected compared to other plants. However, both goats and sheep showed a higher preference for ragweed when pasture loading increased. As the loading level rose, the average daily gain slightly decreased, a trend more pronounced in sheep than in goats. Higher pasture loading also raises the risk of animal poisoning. Many plants employ secondary chemicals as defence mechanisms; these are toxic substances, but their effects depend on

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concentration and dose. Toxic compounds in plants include alkaloids in red canary grass and lupins, tannins in clovers and lespedeza, terpenes in fennel and other bitter plants, and endophyte toxins in marsh plants (PROVENZA et al., 2003). Although most plants, including grasses, contain toxins, they generally do not harm animals if consumed in limited quantities.Combined grazing reduces the risk of poisoning from plants like bitterweed (*Actinea odorata*) and sacahuista (toxic in flowers and fruit for cattle, sheep, and goats, though leaves can provide nutrients during sunny periods). In continuous grazing systems with high pasture loading, annual mortality from poisoning was 4% at high load levels, 3.3% at medium, and 1.7% at low. Poisoning was highest among goats grazed alone (5%), decreased with cattle-goat grazing (2.5%), and was lowest in mixed grazing with cattle, sheep, and goats (1.5%). Pastures should be free of poisonous plants like rhododendrons and azalea bushes, which can be fatal to goats. Goats should also be kept off clover- or alfalfa-rich pastures that are wet from rain or dew, as this can cause bloat. While certain plants are poisonous to some animals, they may be safe for sheep and goats. For instance, milkweed (*Euphorbia spp*.) causes hoof skin loss, digestive irritation, and sometimes death in cattle, but provides 20-27% protein for sheep and goats in season. The yellow star thistle, which is toxic to horses and can cause "chewing disease," has no negative effect on cattle, sheep, or goats (PASKAŠ, 2022).Additionally, poisoning in goats can result from plants containing grayanotoxins (*Pieris and Rhododendron species*) or cyanogenic glycosides (*e.g*.,cherry laurel, *Prunus laurocerasus*). Other plants known to cause goat poisoning include yew (*Taxus species*), and oak bark (*Quercus spp).* hemlock (*Conium maculatum*), leylandii (× *Hesperotropsis leylandii*), box (*Buxus sempervirens*), and those with cardiac glycosides, such as oleander (*Nerium oleander*), or pyrrolizidine alkaloids, such as ragwort (*Jacobaea vulgaris*) (BATES, 2022).

### *1. The botanical structure and usage of a pasture*

Sustainable goat production on pastures involves optimizing pasture use while reducing dependence on cereals and cultivated forage (PASKAŠ, 2022). Feed composition and digestibility impact dry matter intake, with high structural carbohydrate content and low organic matter digestibility generally reducing intake in both confined and pasture-fed animals. However, in grazing small ruminants, the relationship between intake and plant chemical composition may involve more complex mechanisms (PULINA et al., 2013). Animals have an innate sense of which plants are beneficial for them to consume. When grazing freely, animals quickly select the more palatable plants, allowing fewer desirable species to spread rapidly. Upon arriving at a new area, goats graze actively, but over time, they slow down, leaving large portions unused, which can lead to an increase in weeds (MEMIŠI et al., 2011). Excessive grazing, on the other hand, can cause erosion; therefore, controlled and planned grazing is recommended to prevent both underuse and overuse of pastureland. Neglecting pastures allows undesirable species,

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including aggressive neophytes like *Amorpha fruticosa*, to proliferate. While young *Amorpha* plants are susceptible to trampling and can be grazed, they become woody and unusable as they mature, altering the native flora. Other invasive shrubs, such as juniper (*Juniperus sp.*), blueberry (*Vaccinium sp.*), acacia, and hawthorn, also grow quickly and more vigorously than native plants, turning pastures into dense, unproductive thickets.Certain plants, like Chinese lespedeza (*Sericea lespedeza*) and bird's-foot trefoil (*Lotus corniculatus*), contain high levels of condensed tannins. *Sericea lespedeza* thrives on poor, acidic soils and helps control internal parasites, reducing parasite load in sheep and goats. Goats and sheep may require time to acclimate to this plant, while cattle will consume it if it is not overly mature. Other plants with similar effects include chicory, grape seeds, cranberries, pine bark, and others (PASKAŠ, 2022).

The protein level in the diets of pastured goats depends on the botanical composition of the pasture and the ratio of shrubs to grassland. While shrubs and certain plants provide nutritional benefits, they sometimes contain secondary metabolites-such as tannins, phenols, and terpenes-that can repel animals or be toxic. Tannins, a complex of high-molecular-weight polyphenolic compounds, are better tolerated by goats. Goats have mechanisms to neutralize the antinutritional effects of tannins, including salivary secretion with high proline levels and ruminal processes. Additionally, ruminal fermentation and the adaptation of ruminal microflora to terpenes enable goats to more effectively utilize terpene-rich feed (LANDAU et al., 2000). Generally, when additional energy and protein sources are available, goats can consume more plants containing tannins, terpenes, and saponins (PROVENZA et al., 2003). Although selected shrubs in research by CHEBLI et al. (2022) contained a high level of condensed tannins, goats consume them readily. By selectively grazing, goats generally consume plants richer in digestible organic matter, crude protein, and sugars while avoiding those higher in neutral detergent fibre (NDF) (PULINA et al., 2013). Proper pasture management enriches the soil by adding organic matter. Since goats typically consume grasses (*e.g.*, ryegrass, fescue, and sea buckthorn) and some broadleaf "weeds" (*e.g.*, chicory, wild carrot, and sweet potato), with less emphasis on legumes (*e.g.*, clover and alfalfa), pasture improvement efforts should focus on increasing vegetation density and enhancing soil fertility. During summer, goats can meet part of their nutritional needs by consuming plant species commonly rejected by other ruminants, such as *Rumex* spp., *Daucus carota*, and *Convolvulus arvensis* (BONANNO et al., 2008). Goats can graze plants at heights between 20 and 120 cm. High-quality cultivated pastures for goats include clover, with a recommended grass-to-legume ratio of 1:1. The optimal plant height on pastures is 8–12 cm; when available pasture mass falls below 1,000 kg/ha, goats tend to stop grazing (GRBEŠA et al., 2005).In a study by JORGENSEN et al. (2007) comparing goat grazing on natural and cultivated pastures (with *Phleum pratense* [Timothy] and *Festuca pratensis* [meadow fescue]), goats showed a preference for Timothy early in the summer (85% of their diet) but

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transitioned to a more varied diet later in the season, combining Timothy and fescue with couch grass (*Elytrigia repens*) and tufted hair grass (*Deschampsiacespitosa*). On natural pastures, goats had a more diverse diet, with access to shrubs, leaves, grasses, and ferns, among others. At the end of summer, with a decline in protein content, they spent more time in vegetated pasture areas while avoiding boggy, thorny patches. Benefits are more substantial in mixed grazing systems where goats graze with other ruminants, especially when animals have higher nutritional requirements and exhibit diverse feeding behaviours. Differences in selective feeding between sheep, cattle, and goats make these systems more efficient, significantly influencing the botanical and structural composition of pastures (BONANNO et al., 2008). Studies also showed that combining cattle, sheep, and goats on a single pasture can increase pasture utilization by about 25% (COFFEY, 2001).

### *2. Pasture quality and supplements*

Pasture quality is influenced by various factors, with plant composition and nutrient content significantly impacted by the physiological stage of plant maturity (PASKAŠ, 2022). TUDISCO et al. (2010) observed that pasture quality was poorest in July, while in May and September, protein content was higher and NDF levels were lower. Similarly, in research by PASKAŠ et al. (2019) was observed that in May and June, pastures contain the most soluble nutrients, inversely correlated with crude fibre content. CHEBLI et al. (2022) also found significant seasonal variations in forage availability, quality, and feeding behaviour. However, they noted that seasonal changes did not significantly affect the forage preferences of indigenous goats. LENG (1990) categorizes pastures as low to medium nutritional quality if they contain less than 55% organic matter and 8% crude protein. During summer, fermentable compounds (especially sugars) decrease significantly, while lignin content rises, further reducing the pasture's nutritional value (BONANNO et al., 2008). Legumes and grasses show contrasting values in digestibility and intake. Under similar growth conditions, legumes contain less NDF but have highly lignified cell walls, whereas grasses exhibit high NDF content and lower lignification. This results in comparable digestibility for grasses with higher NDF but lower intake for equal digestibility levels (VAN SOEST, 1965). Young pastures with easily digestible fibre offer higher energy levels (GRBEŠA et al., 2005). According to MORAND-FEHR et al. (2007), pastures alone may not always meet all of a goat's nutritional requirements, necessitating supplemental concentrates. However, accurately assessing actual pasture intake is challenging, making it difficult to determine the required concentration amounts. Seasonal variations and climate differences further complicate assessing the quality and availability of pasture biomass and predicting when supplemental concentrates might be needed. For goats grazing on both natural and cultivated pastures, concentrates generally help increase energy intake and improve milk production

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(BONANNO et al., 2008). Cereals rich in starch and energy, such as corn, barley, oats, and wheat, form the core of concentrated supplements. Goats, however, can struggle to adapt to high-concentrate diets, with rapid changes increasing the risk of acidosis, enterotoxemia, and urinary calculi. While young, leafy pastures can often meet goats' protein requirements, ruminants also need energy to utilize nitrogen from plant proteins for microbial protein synthesis, which requires additional energy from concentrated nutrients (GRBEŠA et al., 2007). Energy deficiency in grazing goats can result from their physical activity. For this reason, and to improve productivity, the addition of concentrated feed and mineral-vitamin supplements is generally recommended. However, concentrate supplementation can reduce the time goats spend grazing. LANDAU et al. (2000) observed that while high levels of concentrate aid body condition recovery in grazing goats, they also decrease grazing activity. Goats receiving small amounts of supplements spent more time grazing than those given larger amounts (75% *vs.* 59% of total observation time, respectively). FEDELE et al. (1993) observed that pasture intake decreases as concentrate supplementation increases, particularly when supplements are high in crude protein. Goats receiving 150g of concentrate with 18% crude protein consumed 51% more forage than those given 550g daily, suggesting self-regulation based on protein needs. Additionally, each kilogram of concentrate can reduce roughage intake by 0.5–0.6 kg of dry matter (GRBEŠA et al., 2005). While high-quality pasture generally meets protein requirements, concentrate supplementation is beneficial when pasture quality is low, as it supports milk yield. To optimize feeding, a maximum of 600g of concentrate per lactating goat per day is recommended (BONANNO et al., 2008).

## Influence of pasture feeding on milk quality

Numerous studies have confirmed the positive influence of pasture feeding on the fatty acid composition of goat milk (YAKAN et al., 2019; OTARU et al., 2020; PASKAŠ et al., 2023). Natural pastures provide significant benefits for goat dairy products compared to confinement systems, especially in the early stages. GIORGIO et al. (2019) noted that grazing on diverse grasses and legumes enhances the dairy profile with beneficial polyphenols and fatty acids. Furthermore, grazing livestock on diverse pastures concentrates a greater variety and higher amounts of phytochemicals in meat and milk compared to grazing on monoculture pastures, while phytochemicals are further reduced or absent in meat and milk from grain-fed animals (VLIET et al., 2021). Pasture-raised goats produce milk with higher levels of polyunsaturated n-3 linolenic acid (3.32% compared to 1.21%) and a more favourable fatty acid profile, including a lower n-6/n-3 ratio. In addition, healthier indices were observed, including lower atherogenic (AI) and thrombogenic indices (TI), as well as higher health-promoting index (HPI) and hypo-

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/hypercholesterolemic(HH) values. In addition, a higher cheese yield of 22.24% was observed compared to confinement (PASKAŠ et al., 2023). OTARU et al. (2020) also confirmed that higher levels of concentrates increase short and medium-chain fatty acids in cheese, while lower levels of concentrates increase long-chain, polyunsaturated, ruminal and n-3 fatty acids, resulting in a lower n-6/n-3 ratio. Research shows that milk from pasture-raised goats has lower saturated fatty acids and a more favourable fatty acid profile, especially in early lactation (YAKAN et al., 2019; CURRÒ et al., 2019). Pasture feeding also influences the quality of cheese and other dairy products. Thus, cheese from pasture-fed goats had lower fat and cholesterol content (12.3g/100g and 63.2mg/100g *vs*. 16.9g/100g and 80.4mg/100g) and higher tocopherol content (211mg/100g *vs*. 87mg/100g), with a favourable n-6/n-3 ratio and improved sensory qualities such as colour, texture, aroma and characteristic "goat smell" (GALINA et al., 2007; BARLOWSKA et al., 2018). It also had higher dry matter and protein content, with lower values of AI and TI indices, and higher HPI and HH (BARLOWSKA et al., 2018; PASKAŠ et al., 2023). In addition, grazing resulted in higher concentrations of vitamin A (0.026 *vs*. 0.036 mg/100 ml) and $D_3$ (0.075 *vs*. 0.089 mg/100 ml) compared to hay feeding (PAJOR et al., 2014), and several studies have found increased antioxidant activity in meat and milk of grass-fed *vs*. grain-fed animals (VLIET et al., 2021).

## Conclusion and recommendation

Pasture quality is influenced by various factors, including plant composition and nutrient content. The botanical composition of natural pastures may fluctuate throughout the year, potentially failing to meet all of a goat's nutritional needs. Supplementary concentrates are therefore often required, although their use may reduce the amount of time goats spend grazing. Nevertheless, pasture feeding remains one of the most economical and natural ways to sustain goat production, contributing to the sustainable development of this industry. This practice positively affects not only the nutritional value of goat milk and dairy products but also enhances sensory characteristics, with biochemical pathways contributing to unique flavours. Studies show that grazing animals tend to produce milk with slightly higher fat and protein content, which improves its suitability for cheese production. However, these benefits depend on factors such as pasture quality, availability, and seasonal variations.

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**Acknowledgement**

The study was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract number 451-03-66/2024-03/200143).

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