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The Use of Azolla pinnata in Ruminant Feed as a Protein Source

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ABSTRACT

Feed cost is the major challenge in ruminant production, accounting for 60–70% of total expenses. Protein sources such as soybean meal, canola meal, and groundnut cake are essential for growth and milk production but remain expensive and often compete with human food and industrial use. Azolla pinnata, an aquatic fern symbiotically associated with nitrogen-fixing cyanobacteria, has emerged as an alternative, sustainable, and low-cost protein source. With crude protein ranging from 20–30% DM, balanced amino acids, minerals, vitamins, and high digestibility, Azolla has been successfully used as a partial replacement for conventional protein meals. Recent studies indicate that feeding Azolla to ruminants improves milk yield, growth rate, feed efficiency, and reduces feed cost by 15–20% Furthermore, Azolla provides environmental benefits, including methane reduction and nitrogen fixation, making it a climate-smart feed option .This article reviews the nutritional value, mode of action, profitability, comparison with conventional protein meals, and future perspectives of Azolla pinnata in ruminant diets.

Keywords: Azolla pinnata, protein replacer, ruminants, feed cost reduction, sustainable livestock, soybean meal, canola meal

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Introduction

Protein is the most expensive component of ruminant diets, with soybean meal and canola meal being commonly used sources [1]. The global livestock industry faces high feed costs, fluctuating raw material prices, and increasing competition with human food demand. In Pakistan, India, and other developing countries, dependence on imported soybean meal and oilseed cakes increases production costs and reduces profitability [2].

Non-conventional protein sources such as aquatic plants (Azolla pinnata, duckweed), agro-industrial byproducts, and insect meals are being explored to reduce dependence on conventional feeds [6]. Among these, Azolla pinnata has received significant attention due to its high protein content, fast growth, and ability to grow in ponds and paddy fields without competing for land used in food production [3].

Azolla pinnata contains 20–30% crude protein (dry basis), essential amino acids (lysine, methionine, arginine), vitamins (A, B12), minerals (Ca, Fe, Mg, P), and β-carotene [4]. Its biomass doubles every 3–5 days, providing a year-round renewable protein source [5]. Unlike soybean and canola meal, which require large-scale cultivation and processing, Azolla can be cultivated cheaply at the farm level, offering direct benefits to smallholder farmers [6].

Mode of Action

When consumed by ruminants, Azolla pinnata contributes to improved rumen fermentation and nutrient utilization. Its soft tissues are easily degradable by rumen microbes, enhancing microbial protein synthesis and digestibility of low-quality roughages [7].

The amino acid profile of Azolla complements crop residues and forages, balancing nitrogen metabolism in the rumen [8]. Its bioactive compounds may suppress methanogenic bacteria, thereby reducing methane emissions and improving energy efficiency [9]. Studies in India reported up to 12% methane reduction in cattle supplemented with Azolla [10].

Moreover, Azolla supplementation improves immunity, as it contains antioxidants and vitamins such as carotenoids and vitamin B12, which support rumen microbial activity and animal health [11].

Profitability

The profitability of using Azolla arises from its ability to reduce the inclusion of costly soybean and canola meals while sustaining or even improving animal performance.

Dairy cattle: Supplementing 1.5–2 kg fresh Azolla per day increased milk yield by 10–15% and improved milk fat percentage, while reducing concentrate cost by 18% [12].

Buffaloes: Feeding Azolla as 15–20% protein replacer improved milk yield and lactation persistence compared to conventional rations [13].

Goats and sheep: Growth trials revealed higher daily weight gain and feed conversion ratio when Azolla replaced up to 20% of concentrate mixture [14].

Calves: Inclusion of dried Azolla meal improved weight gain and reduced rearing cost compared to canola meal-based diets [15].

Table 1: Comparison with Conventional Protein Sources

Parameter	Soybean Meal	Canola Meal	Azolla pinnata
Crude Protein (%)	40–45	36–38	20–30
Fiber (%)	5–7	10–12	12–15
Amino Acid Balance	Excellent	Good (higher sulfur AAs, lower lysine)	Balanced (rich in methionine)
Energy Value	High	Moderate	Moderate
Cost (relative)	High	Moderate	Very low
Land Requirement	Arable land	Arable land	Non-arable (ponds)
Anti-nutritional Factors	Trypsin inhibitors	Glucosinolates	Minimal (perishable)
Environmental Benefit	Neutral	Neutral / Nitrogen fixation	Methane mitigation

This comparison highlights that although Azolla has lower crude protein than soybean and canola meal, it offers significant advantages in terms of cost reduction, environmental sustainability, and ease of cultivation [16].

Future Perspectives

For large-scale adoption, Azolla production must overcome challenges related to perishability and seasonality. Fresh Azolla spoils within 24–48 hours; hence, preservation methods such as sun-drying, pelletization, and silage preparation are essential [17]. Dry Azolla meal can be stored for months, allowing year-round feeding [18].

Integration of Azolla farming in rice paddies and community ponds offers dual benefits enhancing soil fertility and providing livestock feed [19]. In Africa, pilot projects show that community-based Azolla production can sustainably support dairy cooperatives [20].

Future research could focus on:

- Genetic improvement of Azolla for higher protein yield.
- Optimization of inclusion rates for different ruminants.
- Impact on rumen microbiome and methane emissions.
- Cost-benefit analysis across different production systems.

Conclusion

Azolla pinnata is a low-cost, nutrient-dense, and eco-friendly protein source for ruminants. Its inclusion in diets partially replacing soybean and canola meal reduces feed cost, enhances milk yield and growth, and improves farmer profitability. Unlike conventional protein meals, Azolla does not require arable land and contributes to sustainable livestock systems. With advancements in preservation and integration into farming systems, Azolla can play a vital role in climate-smart and profitable ruminant production

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