

Azolla as a Natural Feed Supplement in Aquaculture

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ABSTRACT

Azolla, a fast-growing aquatic fern, is gaining recognition as a sustainable and cost-effective feed supplement in aquaculture. Rich in protein, essential amino acids, vitamins, and minerals, Azolla enhances fish growth, feed efficiency, and water quality through nutrient absorption. Its integration into aquafeeds, particularly at optimal inclusion levels, can reduce reliance on traditional protein sources and lower feed costs. However, challenges such as anti-nutritional factors and nutrient variability require further research and innovation in processing and cultivation. Overall, Azolla presents significant potential for advancing sustainable aquaculture practices and supporting environmental and economic benefits.

INTRODUCTION

The intensification of aquatic farming has increased the demand for sustainable, cost-effective feed options that promote optimal fish growth while maintaining water quality. In this context, Azolla, a fast-growing aquatic fern, has gained attention due to its high protein content, essential amino acids, vitamins, and minerals. Moreover, its symbiotic relationship with the



Figure 1 *Azolla pinnata*

nitrogen-fixing cyanobacterium *Anabaena azollae* enhances its nutritional value, making it a promising candidate for aquafeed supplementation (Chandrababu and Parvathy, 2025).

Recent studies have suggested the potential benefits of incorporating Azolla in the fish diet, which may be beneficial. For example, partial replacement of Azolla with traditional feed has improved growth and feed efficiency in species such as *Nile Tilapia* and *Grass Carp* (Ibrahim *et al.*, 2021). In addition, Azolla's ability to absorb additional nutrients can contribute to better water quality in Aquaculture systems. However, the efficacy of Azolla as a feed component is affected by factors such as inclusion levels and processing methods. High inclusion rates can introduce anti-nutritional factors and indigestible fiber, which can potentially affect fish growth and health (Refaey *et al.*, 2023). Therefore, it is essential to determine the optimal inclusion level to maximize profit by minimizing potential deficiencies. This article explores the nutritional benefits of Azolla, its use in aquaculture feed, and its influence on water quality, with the aim of evaluating its potential as a sustainable and long-term feed option in aquaculture.

Nutritional composition of Azolla

Azolla, a rapidly growing aquatic fern, offers significant nutritional benefits in aquaculture due to its rich composition and sustainability. On a dry weight basis, Azolla contains approximately 15-25% crude protein, 10-15% minerals, and 7-10% bioactive substances, including essential amino acids, vitamins (A, B12, beta-carotene), and minerals such as calcium, phosphorus, potassium, and iron. Its low fat and carbohydrate content makes it suitable for species requiring leaner diets. Incorporating Azolla into fish diets has been demonstrated to enhance growth performance and improve feed conversion ratios. For

example, replacing 10% of fishmeal with Azolla meal in the diet of *Cyprinus carpio* fingerlings resulted in comparable growth rates and feed efficiency.

Azolla's rapid growth and ease of cultivation make it an



affordable feed option, reducing dependence on traditional protein sources like fishmeal.

Additionally, its nitrogen-fixing capacity diminishes the need for chemical fertilizers, promoting environmentally sustainable aquaculture practices. However, due to its high fiber content, inclusion rates should be monitored to ensure optimal digestibility and fish health.

Table 1: Proximate composition of Azolla.

Nutrient Category	Component	Value (Range)	References
Proximate composition	Crude Protein	15-25.0 (%)	Chandrababu <i>et al.</i> , 2024
	Fat	1-3.2 (%)	Abu <i>et al.</i> , 2025
	Crude Fiber	11-22 (%)	Chandrababu <i>et al.</i> , 2024
	Ash	10.8-15 (%)	Chandrababu <i>et al.</i> , 2024
	Moisture	5 (%)	Ayyappan (2000)
Minerals	Calcium (Ca)	5.6-17 g/kg	Bhatt <i>et al.</i> , 2021
	Phosphorus	0.3-15.5 g/kg	Bhatt <i>et al.</i> , 2021
	Sodium	0.77 (%)	Chatteraji <i>et al.</i> , (2013)
	Potassium	2.19 (%)	Kavya (2014)
Vitamins	Vit A	Present	Chandrababu <i>et al.</i> , 2024
	Vit B 12	Trace amount	Naggar <i>et al.</i> , 2022

Growth and Cultivation of Azolla

Azolla is a highly productive aquatic fern capable of yielding up to nine tons of protein per hectare of pond per year. Under laboratory conditions, its biomass can double in less than

two days, while in optimal field conditions, this occurs within three to five days. In standard field environments, the growth cycle extends to five to ten days.



Azolla in Aquaculture Feed

Azolla is increasingly recognized as a valuable component in aquaculture feed due to its high protein content, essential amino acids, vitamins, and minerals, as well as its ability to be cultivated rapidly and cost-effectively (Yohana *et al.*, 2023). Azolla is easy to cultivate, has high productivity, and can significantly reduce feed costs, enhancing the profitability and sustainability of aquaculture operations (Sapna and Lingaraju, 2022). As a fast-growing aquatic plant, Azolla can be produced with minimal inputs, making it an eco-friendly feed option. Azolla has been most extensively studied with the tilapia species. Research shows that partial replacement of commercial fish feed with Azolla (typically 10-25%) can improve growth performance, feed conversion ratio, and overall fish health (Refaey *et al.*, 2023). Positive effects have also been observed in Common carp, Rohu, Catla, orange fin labeo, black tiger shrimp, and others, with Azolla inclusion rates ranging from 15% to 40% depending on species and feed formulation (Shernazarov *et al.*, 2024; Refaey *et al.*, 2023).

Future directions

The future of Azolla as a natural feed supplement in aquaculture lies in optimizing

its use through improved processing, genetic enhancement, integration with sustainable systems, and addressing current limitations. Its dual role as a feed and bioremediation agent, combined with economic and environmental benefits, makes Azolla a promising component of next-generation aquaculture practices.

CONCLUSION

Azolla holds significant promise as a natural feed supplement in aquaculture, offering a sustainable, cost-effective, and environmentally friendly alternative to conventional feed ingredients. Its high protein content, rapid growth, and ability to improve water quality through nutrient absorption make it a valuable resource for integrated aquaculture systems. However, to fully realize its potential, further research is needed to optimize inclusion levels, enhance processing methods, and address challenges such as anti-nutritional factors and nutrient variability. With continued innovation in cultivation, genetic improvement, and feed formulation, Azolla can play an essential role in advancing sustainable aquaculture practices and reducing the industry's reliance on traditional feed sources.

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