



A Monthly e Magazine
ISSN:2583-2212

Popular Article

October 2024 Vol.4(10), 3962–3968

Azolla: The aquatic weed as a feed ingredient for sustainable aquaculture

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<https://doi.org/10.5281/zenodo.14001928>

Abstract

Aquaculture is one of the fastest growing food industries and plays a crucial role in the supply of protein worldwide. Providing nutrient rich feed is an important driving factor behind aquaculture sector growth and development. Traditionally, fishmeal was the primary source of protein supply in aquaculture practice for its growth. However, the aquaculture industry is shifting its focus to an alternative source of protein due to the increasing cost of fish meal and the depletion of wild stock. Plant based protein like azolla is one of the cheapest protein sources for aquafeed. Azolla is a aquatic weed which grows easily in aquaculture ponds. It is a great source of all the nutrients needed to stimulate growth and resist disease in aquatic organisms. Hence, this article emphasizes the cultural practice of Azolla, nutritional profiling, and its application in aquaculture.

Keywords: Azolla, Fish feed, Fish Growth, Disease resistance, Water quality

Introduction

Aquaculture helps to meet the protein needs of an increasing population but also supports the livelihoods of millions of people involved in the industry. Feed management is significant in aquaculture practices, accounting for 70-80% of total production costs. The nutrients present in the feed are crucial in defining the growth and health of cultured aquatic species. Among all nutrients, protein is an important, although it is expensive component in the formulation of aqua feeds. Therefore, fish meal is the most widely used primary protein source of aquafeed for several reasons, including its very high protein concentration and comprehensive amino acid profile. It also has excellent nutrient digestibility and the absence of anti-nutritional factors. Expansion of aquaculture sector leads to the increased demand for fish meal as protein source in aquafeed formulation. However, researchers looked at alternative protein-rich feed ingredients essential for sustainable aquaculture because of their high cost, limited availability, inconsistent supply, declining quality, and depletion of wild stock. Plant protein sources such as soybean meal, ground nut meal, cottonseed meal, wheat gluten meal, and aquatic plants have gained interest in replacing fish meal. Azolla is the



fastest-growing aquatic plant and contains high protein, making it a potential protein source for fish. It contains 19-30% protein content, which varies across azolla species. The plant also has critical minerals like calcium, magnesium, potassium, vitamins like A and B12, beta-carotene, and necessary amino acids like lysine and methionine (Yohana et al., 2023). Without adverse effects, Azolla plants can improve growth, disease resistance, feed conversion ratio, energy efficiency, and animal performance.

Many fish species, including tilapia, common carp, rohu, catla, pangasius, and freshwater prawn, were fed with Azolla directly or in dried form and showed positive results. However, the rate of incorporation of Azolla should be considered. It can also be used as a biofertilizer and water purifier in ponds due to its ability to fix nitrogen and carbon dioxide. Despite their potential advantages, the significant challenges associated with using plant proteins in aquafeed are the existence of ANFs (anti-nutritional factors), which affect the organism's protein digestibility and reduce the nutrient digestibility (Chekol et al., 2024). It is also high in non-digestible fibres, which carnivore fish species cannot digest. These anti-nutritional factors can be neutralized using chemical and thermal processing techniques during feed preparation. Therefore, using Azolla is the easiest way to reduce aquaculture's feed cost and sustainably increase aquaculture productivity.

Steps involved in Azolla culture and cultural conditions

Azolla can be cultured in pits, containers, ditches, swampy areas and ponds. Azolla culture requires less land. However, the area and the size of an Azolla culture unit depend on the quantity to be harvested and the availability of space. There are several steps to follow to cultivate Azolla successfully.

- Dig a pit of required dimensions to culture in ponds or fibre-reinforced plastic tanks, also used
- Remove all debris and roots in the pit and ensure all corners are equal.
- Spread silpaulin sheets to reduce water seepage.
- Apply 10-15 cm of fertile soil into a pit or FRP tank.
- Fill the pit or FRP tank with water to a 10-15cm depth. Add 1.5 kg cow dung and leave for three days to fertilize.
- Add 20 gm of single superphosphate.
- Azolla growth depends on nutrients like phosphorus and nitrogen, which can be obtained using fertilizers or animal manures like cow dung.
- Spread Azolla spores obtained from nurseries or Azolla mother plants on the water surface.
- Let azolla mother plant to multiply for 15 days.



- Harvest the 50-70% Azolla for every 2-3 weeks.

Constant monitoring and care should guarantee the best growth and yield for Azolla. Maintenance tips for thriving Azolla culture include regular water exchange, fertilization, checking for pests and inspection for diseases. Growth of azolla plant depends on various factors such as temperature, nutrients present in water, humidity and pH. Table 1 elicits the required parameters and their levels for Azolla culture.

Table 1: Required parameters for Azolla culture

Parameter	Desirable level
Temperature	15-35°C
pH	5.0-7.2
Relative humidity	80-90%
Water level	10-15cm
Phosphorous	20kg/ha
Light	Partial shade

Nutritional profiling of the Azolla plant

Various Azolla species, including *A. pinnata*, *A. rubra*, *A. caroliniana*, *A. filiculoides*, *A. microphylla* and *A. Mexicana* etc., are distributed worldwide. The chemical composition varies with various azolla species, growth phase and ecological conditions. Azolla is extensively used in different applications because of its unique chemical composition. Azolla contains high crude protein content, diverse essential amino acids like methionine, lysine and cysteine, minerals like calcium, phosphorus and potassium, and vitamin A. It also contains probiotics, polymers and neutral detergent. Table 2 displays the azolla's chemical composition on dry matter. The chemical composition of azolla on dry matter is shown in Table 2.

Table 2: Nutritional composition of Azolla (Swain et al., 2022)

Nutrients	Dry matter (%)
Protein	20-30
Fibre	12-17
Fat	3-5
Amino acids	7-10
Ash	15-20
Non digestible fibre	48-50
Ca	0.80-2.22
P	0.35-1.29
K	2.19-4.93
Cu (ppm)	9.10-26.2
Zn (ppm)	30.0-325
Mg	0.25-0.65
Fe (ppm)	283-1569
Carotene	206-632



Lysine	0.9-1.60
Met+Cys	0.23-0.49

Application of azolla in aquaculture

Feed is one of the most essential elements in aquaculture since it promotes fish growth. However, the feed cost accounts for 50-70% of total production cost. One of the primary protein sources in aquaculture diets is fish meal. This leads to the depletion of the fish in wild. Therefore, looking for alternative protein sources in aqua feed formulations for sustainable aquaculture is necessary. Hence, Azolla is the best alternative to replace fish meal in aquafeed. It can be used fresh or dried as an aqua feed ingredient. Azolla can be given with or without adding fish meal. Various applications of Azolla in aquaculture are shown in Figure 1.

Figure 1. Application of azolla in aquaculture



Azolla in fish feed to improve growth

The digestive and immune systems are improved due to high protein, essential amino acids, minerals, vitamins and carotene concentrations. Fish, including tilapia, common carp, rohu, catla, redbelly tilapia, pangasius, calabash, silver barb, etc., can be fed extensively with the Azolla plant. A diet incorporating Azolla can improve digestive enzymes, feed utilization, flesh quality, growth, oxidative stress and biochemical parameters. For example, Nile tilapia fry-fed feed containing 42% of Azolla outperformed growth (Lumsangkul, 2022). The daily growth of common carp fed Azolla was 1.65g/fish/day, higher than that of the control group (Majhi et al., 2006). Azolla feeding has improved pangasius catfish's feed conversion ratio, weight gain, specific growth rate, and protein efficiency ratio (Azolla Foundation). Incorporating azolla into the fish diet decreased the crude fat level and increased the



azolla percentage (Datta, 2011). However, some studies observed that incorporating high levels of Azolla into the diet reduces rohu's weight gain. High levels of azolla in diet can reduce digestion and feed consumption by impacting the activity of digestive enzymes. For this reason, optimizing the rate at which azolla is added to fish feed is essential to promoting fish growth.

Azolla in fish feed to improve immunity

In terms of immunology, fish and vertebrates are similar. It consists of innate and adaptive immunity systems. These elements support the defence systems in various ways against various infectious diseases. Fish nutrition has a significant impact on their immune systems. Fish's immune potential can be significantly increased by adding the proper nutrients and supplements to their diet, improving their health and increasing their disease resistance. Azolla contains phenols, flavonoids, carotenoids and tannins, which increase antioxidant and immunostimulant functions. Fish fed with Azolla can increase goblet cell production, which produces mucus and antimicrobial compounds to protect the mucosal barrier from infections. This promotes immunity and disease resistance in fish. Fish skin mucous fed with Azolla exhibited many lysozyme and peroxidase activities, which support innate immunity by stimulating phagocytosis (Lumsangkul et al., 2022). Nile tilapia fed with dietary Azolla showed enhanced resistance to streptococcus sps infection by improving the active immune system.

Azolla to improve water quality

The culture azolla plant in aquaculture ponds and fish tanks helps to improve water quality in aquaculture systems. In the aquatic environment, Azolla can absorb extra nutrients such as phosphates, nitrates, and ammonia. Hence, Azolla can play a role in reducing algal blooms within these systems and maintaining ecological balance. The mats by Azolla on the water surface of ponds provide shade and help regulate the water temperature.

Azolla as a biofertilizer

Azolla exists in a mutualistic association with cyanobacteria, aiding atmospheric nitrogen fixation. A higher concentration of nitrogen in Azolla improves soil fertility. The natural fertilization process would be enhanced; hence, the aquatic system may strengthen further and grow healthier. This eliminates the dependency on synthetic fertilizers. In integrated aquaculture systems, Azolla can be fed to fish, and the remaining Azolla plant is collected and used for crops as a biofertilizer. Because of this, azollas are exceptional resources for integrated aquaculture systems.

Azolla to enhance biodiversity.

It can be considered a complementary source of protein for aquafeed, which would decrease the over-exploitation of wild fish stocks by decreasing the usage of fish meal.



Moreover, this thick upper layer growth of Azolla facilitates many species of fish, crustaceans, and other aquatic animals for habitat and shelter.

Azolla to enhance carbon sequestration.

Azolla traps the amount of carbon gas in the air, which helps to fix the issue of global warming and, therefore, formulates a healthy and sturdy ecosystem. Additionally, it creates a more sustainable and productive environment.

Problems encountered while using Azolla in aquafeed

Plant-based protein sources like Azolla contain high amounts of anti-nutritional factors like saponins, protease inhibitors, gossypols, tannins, phytic acids, lectins, and oligosaccharides. ANFs can impede the absorption of nutrients and the digestion process, which can harm the growth and health of the animal. Hence, management or reduction of anti-nutritional factors is imperative to ensure better growth and health of aquatic species in aquaculture. Thus, anti-nutritional factors may be neutralized prior to incorporation into aquafeed. A feed such as azolla, which is a plant-based feed, comprises a high amount of fibre and starch. Due to the absence of enzymes, these plant-based sources are indigestible to carnivore fish.

Conclusion

Azolla is easily cultured in ponds or tanks. The high nutritional profile of Azolla plants makes them a cheap and potential protein source in aquafeed formulations. Utilizing azolla weed as a feed ingredient in the feed formulation of the aquaculture sector is economically feasible and sustainable by minimizing feed costs and depletion of wild stock.

References:

- Alebachew Chekol, S., Nigussie, T. Z., & Fenta, B. A. (2024). Azolla as a beneficial macrophyte for livestock feed: a review. *Cogent Food & Agriculture*, 10(1), 2367804.
- Azolla foundation, <https://theazollafoundation.org/growing-azolla/>
- Datta, S. N. (2011). Culture of Azolla and its efficacy in diet of *Labeo rohita*. *Aquaculture*, 310(3-4), 376-379.
- Lumsangkul, C., Linh, N. V., Chaiwan, F., Abdel-Tawwab, M., Dawood, M. A., Faggio, C., ... & Van Doan, H. (2022). Dietary treatment of Nile tilapia (*Oreochromis niloticus*) with aquatic fern (*Azolla caroliniana*) improves growth performance, immunological response, and disease resistance against *Streptococcus agalactiae* cultured in bio-floc system. *Aquaculture Reports*, 24, 101114.
- Majhi, S. K., Das, A., & Mandal, B. K. (2006). Growth performance and production of organically cultured grass carp *Ctenopharyngodon idella* (Val.) under mid-hill conditions of Meghalaya; North Eastern India. *Turkish Journal of Fisheries and Aquatic Sciences*, 6(2).
- Shernazarov, S., Davronova, S., Tashpulatov, Y., Rakhmonov, V., Muminov, S., & Nurniyozov, A. (2024). The importance of Azolla aquatic plants in creating a natural sustainable nutrient environment in the fisheries industry. In *E3S Web of Conferences* (Vol. 539, p. 02009). EDP Sciences.



- Swain, B. K., Naik, P. K., & Beura, C. K. (2022). Nutritive value of azolla as poultry feed-a review. *Indian Journal of Animal Nutrition*, 39(1), 1-11.
- Yohana, M. A., Ray, G. W., Yang, Q., Tan, B., Chi, S., Asase, A., ... & Derrick, A. (2023). A review on the use of azolla meal as a feed ingredient in aquatic animals' diets. *Aquaculture Research*, 2023(1), 2633412.

