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V Ramakrishnan
Assistant Professor, TANUVAS-Krishi Vigyan Kendra, Kundrakudi, Sivaganga, Tamil Nadu, India

L Vimalendran
Assistant Professor, TANUVAS-Krishi Vigyan Kendra, Kundrakudi, Sivaganga, Tamil Nadu, India

Corresponding Author:
V Ramakrishnan
Assistant Professor, TANUVAS-Krishi Vigyan Kendra, Kundrakudi, Sivaganga, Tamil Nadu, India

Nutritional and growth benefits of azolla in backyard Poultry: Insights from field trials in Sivagangai district, Tamil Nadu

V Ramakrishnan and L Vimalendran

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Abstract
Backyard poultry farming remains a vital livelihood option in rural India, yet feed cost continues to limit its profitability. Azolla (*Azolla pinnata*), a protein-rich aquatic fern, offers a low-cost, sustainable feed alternative. This study evaluated the effect of Azolla supplementation on growth performance, feed conversion ratio (FCR), and biochemical profiles of backyard poultry over a 12-week trial in Sarugani village, Sivagangai district, Tamil Nadu. A total of 100 birds were divided into two groups: a control group receiving conventional feed and a treatment group supplemented with 100 g Azolla per bird daily. Results showed significantly higher weight gain (460.5 ± 15 g vs. 398.2 ± 12 g) and improved FCR (2.35 vs. 2.92) in the Azolla group ($P < 0.05$). Phytochemical analysis revealed high crude protein (28.5%), β-carotene (34.2 mg/kg), and calcium (0.72%), along with the presence of flavonoids, alkaloids, and saponins. Azolla supplementation is a promising, sustainable strategy to improve backyard poultry productivity.

Keywords: Azolla, poultry feed, growth performance, phytochemicals, feed conversion ratio

1. Introduction
Backyard poultry farming is a vital economic activity across rural India, offering both nutritional security and supplemental income for small and marginal farmers. It serves as a low-input livelihood option, especially empowering rural women and self-help groups. However, one of the major limitations in realizing the full potential of backyard poultry is the rising cost of commercial poultry feed, which accounts for nearly 60-70% of total production expenditure. This situation creates an urgent need to explore sustainable, affordable, and locally available feed alternatives.

Azolla (*Azolla pinnata*), a fast-growing aquatic fern, has emerged as a promising non-conventional feed resource due to its rich nutritional profile and ease of cultivation under rural farm conditions. Azolla contains approximately 28-30% crude protein, essential amino acids, vitamins such as A, B12, and β-carotene, and vital minerals including calcium, phosphorus, iron, and zinc (Singh and Sharma, 2023; Nair and Prasad, 2021) [10, 5]. Its digestibility exceeds 85%, and the plant is highly palatable for poultry, making it an ideal low-cost feed supplement (Thomas and Sen, 2020) [11].

Earlier research has demonstrated that incorporating Azolla in poultry diets can significantly improve weight gain, enhance feed conversion efficiency, and strengthen immune responses. For instance, Kumar and Gupta (2022) [3] observed that broilers fed with Azolla-supplemented diets showed significantly higher growth rates compared to those on conventional feed. Similar findings were reported by Nair and Prasad (2021) [5], who emphasized that β-carotene and other antioxidants in Azolla play a crucial role in improving poultry immunity and health status.

Azolla is also known to possess a variety of bioactive phytochemicals such as flavonoids, alkaloids, saponins, tannins, and phenolic compounds, which contribute to better gut health, enhanced nutrient absorption, and reduced microbial load in poultry intestines (Lee and Kim, 2019) [4]. These properties collectively help reduce mortality and improve overall productivity.

Economic analyses conducted by Das and Roy (2019) [2] and Rao and Subramaniam (2023) [8] indicate that partial replacement of commercial feed with Azolla can reduce feed costs by 15-

20% without compromising growth or production performance. Additionally, studies by Ahmed and Khan (2022) [1] have shown increased egg production and improved yolk pigmentation in layers when Azolla was included in the diet at 5-10% levels.

In Tamil Nadu, particularly in Sivagangai district, the agro-climatic conditions and widespread availability of organic waste materials make Azolla cultivation both feasible and scalable. The Krishi Vigyan Kendra (KVK) at Kundrakudi has been actively promoting Azolla production technologies among backyard poultry farmers in the region. Against this backdrop, the present study was undertaken to evaluate the effects of Azolla supplementation on growth performance, feed efficiency, and economic feasibility in backyard poultry systems through field trials conducted in Sarugani village, Sivagangai district.

2. Materials and Methods

2.1 Study Area and Experimental Design

The present study was carried out in Sarugani village of Sivagangai district, Tamil Nadu, a region where backyard poultry rearing is an integral part of rural livelihood. The climate and socio-agricultural practices in the district support smallholder poultry farming, often characterized by low inputs and traditional feeding systems. A total of 100 healthy backyard poultry birds, aged four weeks, were selected for the study. The birds were randomly divided into two groups of 50 birds each—namely the treatment group and the control group. The treatment group received freshly harvested Azolla at a rate of 100 grams per bird per day, in addition to a standard commercial poultry ration. The control group, on the other hand, was fed exclusively on the conventional commercial poultry diet without any Azolla supplementation. Both groups were managed under similar housing, lighting, and biosecurity conditions for the entire duration of 12 weeks.

2.2 Azolla Cultivation and Preparation

Azolla (*Azolla pinnata*) was cultivated under controlled conditions in rectangular cement tanks measuring approximately 2 m × 1 m × 0.3 m. The cultivation medium was prepared using cow dung slurry (1:10 ratio) and superphosphate (100 g/m²), which are known to promote rapid biomass accumulation (Nair and Prasad, 2021) [5]. The Azolla was harvested every five days, washed thoroughly to remove debris and potential contaminants, and sun-dried to a moisture level of around 10-12% for better mixing with the feed. Fresh Azolla was also used for direct feeding during the trial, depending on bird acceptance.

2.3 Feed Formulation and Administration

For the treatment group, Azolla was included in the diet at an approximate level of 20% of the daily feed intake. The inclusion rate was based on earlier findings which indicated optimal performance without negative effects on palatability or nutrient balance (Kumar and Gupta, 2022) [3]. The feed was administered twice daily, in the morning and evening, and clean drinking water was made available to all birds on an ad libitum basis.

2.4 Measurement of Growth Performance

Growth performance was assessed by measuring body weight gain (BWG) and calculating the feed conversion ratio (FCR). Body weights were recorded biweekly using a digital weighing scale with 0.1 g precision. FCR was determined as the ratio of total feed intake to weight gain during the study period. The feed intake was calculated based on daily feed offered minus feed refused, averaged per bird.

2.5 Biochemical and Phytochemical Analysis of Azolla

Azolla samples were analyzed for their nutritional composition and bioactive compounds. Crude protein was estimated by the Kjeldahl method, crude fiber using the Weende method, and total carbohydrates via the Anthrone method (Patel and Verma, 2020) [7]. β-carotene content was analyzed using High-Performance Liquid Chromatography (HPLC), while mineral analysis for calcium (Ca), phosphorus (P), iron (Fe), zinc (Zn), and copper (Cu) was performed using Atomic Absorption Spectroscopy (AAS), as described by Pandey and Bhatia (2021) [6].

To evaluate the phytochemical profile of Azolla, standard qualitative tests were conducted. The presence of alkaloids was confirmed using Mayer's test, where the addition of Mayer's reagent to the aqueous extract of Azolla resulted in a creamy white precipitate. Flavonoids were detected using the Shinoda test, wherein a reddish-pink coloration upon addition of magnesium ribbon and concentrated hydrochloric acid indicated a positive reaction. Tannins were identified through a deep blue or green-black coloration after treatment with ferric chloride solution, suggesting polyphenol presence. Saponins were confirmed using the foam test, in which stable froth formation after vigorous shaking indicated their presence (Lee and Kim, 2019) [4]. Phenolic compounds were again tested using ferric chloride, forming a blue-green coloration. Terpenoids were identified by the reddish-brown interface ring in the Salkowski test, following the addition of chloroform and concentrated sulfuric acid. Lastly, the Keller-Kiliani test confirmed glycosides, indicated by the formation of a reddish-brown layer at the junction of two solvents (Sharma and Rajan, 2021) [9]. These qualitative tests provided strong evidence for the presence of biologically active compounds in Azolla, many of which have been previously associated with antioxidant, antimicrobial, and gut-modulating functions in poultry nutrition (Ahmed and Khan, 2022; Singh and Sharma, 2023) [1, 10].

2.6 Statistical Analysis

All quantitative data were subjected to statistical analysis using SPSS software (Version 20.0). One-way Analysis of Variance (ANOVA) was used to test for significant differences between the treatment and control groups. When significance was detected ($P < 0.05$), Tukey's post-hoc test was applied for pairwise comparisons. The results are presented as mean ± standard error (SE).

3. Results and Discussion

3.1 Growth Performance

The growth performance of backyard poultry birds was significantly influenced by the dietary inclusion of Azolla (Azolla pinnata). As shown in Table 1, the average final body weight of birds in the Azolla-fed group was 460.5 ± 15.3 g, which was significantly higher ($P < 0.05$) than that of the control group (398.2 ± 12.7 g). The net weight gain in the Azolla group (350.2 ± 13.1 g) also exceeded that of the control (288.4 ± 11.8 g), suggesting that the protein-rich Azolla played a substantial role in muscle accretion and overall body mass development.

These results align with findings reported by Kumar and Gupta (2022) [3], who observed improved growth performance in broilers with Azolla supplementation. Similarly, Nair and Prasad (2021) [5] emphasized that the high levels of digestible protein and essential amino acids in Azolla improve protein synthesis and muscle development. The initial weights of both groups were comparable ($P = 0.87$), indicating that differences in final

performance were due to dietary intervention rather than initial variability.

Table 1: Effect of Azolla supplementation on body weight gain in backyard poultry

Parameter	Azolla-fed Birds	Control Group	P-value
Initial Weight (g)	110.3 ± 2.5	109.8 ± 2.3	0.87 (NS)
Final Weight (g)	460.5 ± 15.3	398.2 ± 12.7	<0.05
Weight Gain (g)	350.2 ± 13.1	288.4 ± 11.8	<0.05

The enhanced growth rate in Azolla-fed birds may also be attributed to the presence of micronutrients such as iron, zinc, and phosphorus, which play essential roles in enzymatic reactions and metabolism (Pandey and Bhatia, 2021) [6]. Furthermore, bioactive compounds like flavonoids and terpenoids present in Azolla might have enhanced nutrient absorption and gut health.

3.2 Feed Conversion Ratio (FCR)

Feed conversion ratio, a critical indicator of nutrient utilization efficiency, showed significant improvement in the Azolla-fed group. As shown in Table 2, birds in the treatment group recorded an FCR of 2.35 ± 0.05, which was superior to the control group's FCR of 2.92 ± 0.06. Although the average daily feed intake in the Azolla-fed group (98.2 g/day) was lower than that in the control group (105.4 g/day), the weight gain was higher, reflecting better feed efficiency.

Table 2: Effect of Azolla supplementation on feed conversion ratio

Group	Feed Intake (g/day)	Weight Gain (g/day)	FCR
Azolla-fed Birds	98.2 ± 4.2	4.17 ± 0.12	2.35 ± 0.05
Control Group	105.4 ± 3.9	3.60 ± 0.10	2.92 ± 0.06

These findings are in agreement with studies by Thomas and Sen (2020) [11] and Rao and Subramaniam (2023) [8], who reported significant improvements in FCR with Azolla inclusion. Saponins in Azolla may enhance intestinal absorption, while antioxidant compounds like flavonoids support metabolism and reduce oxidative stress, leading to improved nutrient utilization (Lee and Kim, 2019) [4].

3.3 Phytochemical and Nutritional Composition of Azolla

Phytochemical and proximate analysis of Azolla revealed its richness in protein, fiber, minerals, and bioactive compounds. As shown in Table 3, Azolla contained 28.5 ± 0.8% crude protein, 13.2 ± 0.6% crude fiber, and 42.5 ± 1.2% total carbohydrates. β-carotene content was 34.2 mg/kg, and calcium content was 0.72 ± 0.05%. These values are consistent with previous reports by Singh and Sharma (2023) [10] and Ahmed and Khan (2022) [1], confirming Azolla as a nutrient-dense feed resource.

Table 3: Nutritional and phytochemical composition of Azolla

Parameter	Value
Crude Protein (%)	28.5 ± 0.8
Crude Fiber (%)	13.2 ± 0.6
Total Carbohydrates (%)	42.5 ± 1.2
β-carotene (mg/kg)	34.2 ± 2.5
Calcium (%)	0.72 ± 0.05

In addition to its nutrient profile, qualitative phytochemical screening confirmed the presence of alkaloids, flavonoids, tannins, terpenoids, saponins, phenols, and glycosides. These compounds are known to have antimicrobial, antioxidant, and immune-enhancing effects in poultry (Sharma and Rajan, 2021; Kim and Park, 2022) [9, 12]. Flavonoids and phenolic compounds can enhance gut health and reduce oxidative damage, while saponins improve nutrient absorption and intestinal function.

The presence of β-carotene supports immune modulation and epithelial integrity, while calcium plays a critical role in bone mineralization and eggshell formation. Therefore, Azolla not only improves production parameters but also enhances health status, thereby reducing mortality and reliance on synthetic feed additives.

Fig 1: Backyard poultry birds feeding on fresh Azolla.

Fig 2: Distribution of Azolla kits and feed supplements to farmers in Sarugani village.

Fig 3: Demonstration of Azolla bed preparation

4. Conclusion

This field-based study from Sivagangai district, Tamil Nadu, highlights the efficacy of Azolla as a functional feed supplement in backyard poultry farming. Azolla-fed birds exhibited improved growth performance, better feed conversion ratios, and enhanced nutrient assimilation compared to birds on a conventional di*et al*one. The nutrient-rich profile of Azolla—including high protein, β-carotene, and essential minerals—along with the presence of beneficial phytochemicals, underpins its value as a sustainable alternative to commercial feed additives. Incorporating Azolla into poultry diets could reduce feed costs and support rural livelihood sustainability through low-cost production practices.

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