



## RESEARCH PAPER

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## Air-dried *Azolla* (*Azolla pinnata*) meal as a feed supplement for broilers

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**Key words:** Air-dried, *Azolla*, Broiler, Feed supplement, Growth performance

<http://dx.doi.org/10.12692/ijb/24.1.143-151>

Article published on January 08, 2024

### Abstract

Poultry farming is one of the most profitable businesses of agriculture that provides nutritious meat and eggs for human consumption within the shortest possible time. A large number of farms have been established in different parts of the country creating employment opportunities for the people but is facing problems because of the high price and economic availability of feed ingredients for the growth of commercial poultry. Feeds of plant origin, like green plants, are considered excellent sources of protein and fat. Recently, aquatic plants have gained much interest in food and biomedical research due to their broad range of uses such as human food, animal feed, and bio-fertilizers. Among these aquatic plants, the floating fern *Azolla* (*Azolla pinnata*) has been widely used as an alternative feed source for poultry. Hence, this study was conducted to determine the effect of different levels of air-dried *Azolla* (*Azolla pinnata*) meal as a feed supplement for broilers. Results of the study disclosed that the feed conversion efficiency of birds was not significantly influenced by the different levels of air-dried *Azolla* meal as a feed supplement. However, a significant result was noted on the final weight, gain weight of birds, feed consumption, feed conversion ratio, dressing percentage, liver weight, gizzard, profit above, medicine, and stock cost of birds.

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## Introduction

Poultry farming is one of the most profitable agricultural businesses because it produces nutritious meat and eggs for human consumption in the shortest amount of time. Among the various sectors of poultry production, the broiler industry has grown rapidly in recent decades. A large number of farms have been established in various parts of the country, creating employment opportunities for the people, but they are facing challenges due to the high price and economic availability of feed ingredients for commercial poultry growth.

According to Aleta and Rodriguez (2015), poultry production is the quickest and most efficient method of converting feeds into high-quality protein food in the form of meat and eggs. Broiler requires adequate nutrients for growth and development. It entails an adequate supply of energy-producing nutrients to support various growth processes as well as being essential for attaining physiological well-being, particularly during the growing-finishing stage.

The total chicken inventory was estimated to be 179.00 million birds as of January 1, 2022. This was an increase of 1.2 percent over the previous year's same-period population of 176.82 million birds. Native/improved chicken and layer chicken inventories increased by 1.1 percent and 4.2 percent, respectively. Broiler chicken stocks, on the other hand, fell by -0.9 percent. Native/improved chicken accounted for 45.2 percent of the total chicken inventory. This was followed by broiler chicken (29.8 percent) and layer chicken (25.0 percent) (PSA, 2022). Aleta and Rodriguez (2015) further stated that feed is a major component of the total cost of broiler production. Broiler rations should be formulated to supply the correct balance of energy, protein and amino acids, minerals, vitamins, and essential fatty acids to allow optimum growth performance.

According to Asim *et al.* (2022), *Azolla* (*Azolla pinnata*) is a heterosporous aquatic fern found all over the world. It resembles other green ferns, but it looks

more like duckweed or moss floating on the water's surface. It can be used as a protein source in animal and poultry feed. *Azolla* has a variety of pharmacological properties and can be used as an antioxidant, immune stimulant, hepatoprotective, phytoremediation, bioremediation, and nutritional material. *Azolla* is high in vitamins (B12, beta carotene, and A), biopolymers, minerals, and amino acids.

The search for concentrate substitutes led us to *Azolla*, a wonderful plant with the potential to provide a sustainable feed for livestock and poultry. *Azolla* is a type of floating fern in the *Azollaceae* family. The symbiotic blue-green algae *Aanabena Azollae* lives in *Azolla* and is responsible for atmospheric nitrogen fixation and assimilation. In turn, *Azolla* provides a carbon source as well as a conducive environment for algae growth and development. *Azolla* is a wonderful plant with high protein content because of this unique symbiotic relationship (Kamalasanana *et al.*, 2002). *Azolla* on a dry matter basis constituted 25.35 % crude protein, 10.15 % amino acids, bioactive substances, and biopolymers. Carbohydrate and oil content are very low in *Azolla*. Amino acid analysis shows lysine, methionine, histidine are probably limiting, although the protein content is high on a dry weight basis. Thus, *Azolla* appears to be a potential source of nutrients and has a considerably high feeding value. The present study was planned to evaluate the feeding of dried *Azolla* (*Azolla pinnata*) alone or in combination with exogenous feed enzymes in a commercial broiler diet (Basak *et al.*, 2002).

Pascal *et al.* (2010) added that *Azolla* is also high in proteins, essential amino acids, vitamins (B12, Beta-carotene), growth promoter intermediaries, and minerals (Calcium, phosphorus, potassium, iron, copper, magnesium, etc.) According to Kundo *et al.* (2013), to reduce production costs there is always a desire for alternative indigenous feed resources to replace commercial as well as compounded poultry feed. *Azolla* is a common aquatic fern found in ponds, ditches, and paddy fields throughout the world's tropical and subtropical regions.

Feeds of plant origin, like green plants, are considered excellent sources of protein and fat. Recently, aquatic plants have gained much interest in food and biomedical research due to their broad range of uses such as human food, animal feed, and bio-fertilizers. Among these aquatic plants, the floating fern *Azolla* (*Azolla pinnata*) has been widely used as an alternative feed source for poultry (Samad *et al.*, 2020).

The study aims to evaluate the effects of the different levels of air-dried *Azolla* (*Azolla pinnata*) meals as a feed supplement for broilers. Specifically, the study determined the growth performance of broilers and evaluated the profit above feed, medicine, and stock costs.

## Materials and methods

### Research design

A total of seventy-five (75) head broiler chicks were randomly distributed into five treatments replicated three times with five birds per replicate following the Complete Randomized Design (CRD). The treatments were as follows in Table 1.

**Table 1.** Treatments

To	Control (Pure Broiler Starter Crumble)
T1	10% air-dried <i>Azolla</i> leaf meal + 90% Broiler Starter Crumble
T2	15% air-dried <i>Azolla</i> leaf meal + 85% Broiler Starter Crumble
T3	20% air-dried <i>Azolla</i> leaf meal + 80% Broiler Starter Crumble
T4	25% air-dried <i>Azolla</i> leaf meal + 75% Broiler Starter Crumble

### Procedures

Before the arrival of chicks, cages including the feeders were disinfected to prevent the occurrence of parasite and diseases. Incandescent bulb was used in every cage. The old newspaper was used as breeding materials for the flooring of the brooder. Every cage was provided with a waterer and a feeder.

The newly arrived chicks were given medicated water and were fed with chick booster. The drinking

water was provided *ad libitum* and was changed daily. Feeding time with the experimental diet was started after two weeks of brooding. Commercial feeds were purchased at San Francisco Sur, Sudipen, and La Union. A weighing scale was used to measure the weight of the feeds that will be given to the birds as well as excess leftover feeds. It was used in weighing the initial weight, final weight, and dressed weight of the experimental birds.

### Collection and processing of *Azolla* (*Azolla pinnata*)

The fresh *Azolla* leaves were gathered from San Francisco Sur, Sudipen La Union. The gathered leaves were air-dried for four (4) days. The crispy leaves were grind manually. The grind *Azolla* was stored and kept airtight. The *Azolla* was then weighed by the required amount per treatment and then mixed with Broiler Starter Crumble (BSC).

### Data analysis

The data was computed, tabulated, and statistically analyzed using the Analysis of Variance. Significant differences between and among treatment means were further subjected to Tukey's Honest Significant Difference (HSD) Test.

## Results and Discussion

### Initial weight

The initial weight of broiler chickens is presented in Table 2. The average initial weight of chickens placed in different treatments is 0.31 kg. This implies that the birds assigned to the different treatments were of comparable body weight at the start of the study. This can be attributed to homogeneous conditions and uniform care and management of brooding birds.

### Final weight

The mean final weight of *Azolla* meal as a feed supplement is shown in Table 3. The birds have a mean final weight of 1.08 to 1.15 kg. The birds fed with pure broiler starter crumble got the heaviest mean weight of 1.15 kg while birds fed with 20% air-dried *Azolla* meal + Broiler Starter Crumble got the lightest mean weight of 1.08 kg.

**Table 2.** Initial weight of the bird (kg).

Treatment	Mean
To- Pure broiler starter crumble	0.31
T1- 10% Air- dried <i>Azolla</i> meal + 90% Broiler Starter Crumble	0.31
T2- 15% Air- dried <i>Azolla</i> meal + 85% Broiler Starter Crumble	0.31
T3- 20% Air -dried <i>Azolla</i> meal + 80% Broiler Starter Crumble	0.31
T4- 25% Air -dried <i>Azolla</i> meal + 75% Broiler Starter Crumble	0.31

Analysis of Variance revealed a significant result. Comparison among treatment means indicated that the birds fed with the pure starter crumble were statistically comparable to those birds fed with 10 % air-dried *Azolla* meal + 90% Broiler Starter Crumble and 15% air-dried *Azolla* meal + 85% Broiler Starter Crumble but significantly higher than those birds fed with 25% air-dried *Azolla* meal + 75% Broiler Starter Crumble.

However, it is comparable to those birds fed with 10% Air-dried *Azolla* meal + 90% Broiler Starter Crumble and 15% air-dried *Azolla* meal + 85% Broiler Starter Crumble. The result could be attributed to the composition of all essential amino acids, and minerals such as iron, calcium, magnesium, potassium, phosphorus and manganese (Chaterjee *et al.*, 2012).

**Table 3.** The final weight of birds fed with air-dried *Azolla* (*Azolla pinnata*) meal (kg).

Treatment	Mean
To- Pure broiler starter crumble	1.15a
T1- 10% Air- dried <i>Azolla</i> meal + 90% Broiler Starter Crumble	1.12ab
T2- 15% Air- dried <i>Azolla</i> meal + 85% Broiler Starter Crumble	1.11ab
T3- 20% Air -dried <i>Azolla</i> meal + 80% Broiler Starter Crumble	1.08b
T4- 25% Air -dried <i>Azolla</i> meal + 75% Broiler Starter Crumble	1.09b

#### Gain in weight

The mean gain in weight of birds fed with air-dried *Azolla* meal is shown in Table 4. The birds fed with Pure starter crumble were the heaviest (0.83 kg) while the birds fed with 20% Air -dried *Azolla* meal + 80% Broiler Starter Crumble and 25% Air -dried *Azolla* meal + 75% Broiler Starter Crumble were the lightest with the same result (0.77 kg). Analysis of Variance revealed a significant result. Comparison among treatment means indicated that the birds fed with pure starter crumble were statistically comparable to those birds fed with 10 % air-dried *Azolla* meal + 90% Broiler Starter Crumble and 15% air- dried *Azolla* meal + 85% Broiler Starter Crumble. The birds fed with 20% Air -dried *Azolla* meal + 80% Broiler Starter Crumble and 25% air-dried *Azolla* meal + 75%

Broiler Starter Crumble obtained significantly lower gain in weight than those birds fed with Pure Broiler Starter Crumble. However, it is comparable to those birds fed with 10% Air-dried *Azolla* meal + 90% Broiler Starter Crumble and 15% air-dried *Azolla* meal + 85% Broiler Starter Crumble. The results corroborated with the findings of Rathod *et al.* (2013) that birds fed with *Azolla* gain better and according to Basak *et al.* (2002), the diet containing 5% *Azolla* meal was best concerning the body weight in broiler chicken.

#### Feed consumption

The mean feed consumption of experimental birds was affected by the different level of *Azolla* is shown in Table 5. The mean feed consumption from 2.76 kg to 2.84 kg.

**Table 4.** Mean gain in weight of birds fed with air-dried *Azolla* (*Azolla pinnata*) meal (kg).

Treatment	Mean
To- Pure broiler starter crumble	0.83a
T1- 10% Air- dried <i>Azolla</i> meal + 90% Broiler Starter Crumble	0.81ab
T2- 15% Air- dried <i>Azolla</i> meal + 85% Broiler Starter Crumble	0.80ab
T3- 20% Air -dried <i>Azolla</i> meal + 80% Broiler Starter Crumble	0.77b
T4- 25% Air -dried <i>Azolla</i> meal + 75% Broiler Starter Crumble	0.77b

\*Means with the same letter are not significantly different.

Analysis of Variance showed significant differences among treatment means. Comparison among treatment means indicated that the birds fed with Pure broiler starter crumble are comparable to those birds fed with 10% Air-dried *Azolla* meal + 90% Broiler Starter Crumble. The birds fed with 15% Air-dried *Azolla* meal + 85% Broiler Starter Crumble are comparable to those birds fed with 20% air-dried *Azolla* meal + 80% Broiler Starter Crumble. However, it is comparable to those birds fed with 25% Air-dried *Azolla* meal + 75% Broiler

Starter Crumble and obtained significantly lower feed consumption of birds. This could be attributed to the findings of Pillai *et al.* (2005) that *Azolla* contains vitamins it has a growth promoter intermediaries and minerals, and it has a high crude protein content (26.4%). This result contradicts the findings of Rathod *et al.* (2013) that there is no effect of *Azolla* supplementation on feed consumption. The result showed that as the amount of air-dried *Azolla* increases the consumption of the birds decreases. This could be attributed to the fiber content found in *Azolla*.

**Table 5.** Feed consumption of birds fed with air-dried *Azolla* (*Azolla pinnata*) meal (kg).

Treatment	Mean
To- Pure broiler starter crumble	2.84a
T1- 10% Air- dried <i>Azolla</i> meal + 90% Broiler Starter Crumble	2.81ab
T2- 15% Air- dried <i>Azolla</i> meal + 85% Broiler Starter Crumble	2.80b
T3- 20% Air -dried <i>Azolla</i> meal + 80% Broiler Starter Crumble	2.78bc
T4- 25% Air -dried <i>Azolla</i> meal + 75% Broiler Starter Crumble	2.76bc

\*Means with the same letter are not significantly different.

#### Feed conversion ratio

The mean feed conversion ratio of birds fed with air-dried *Azolla* meal as a feed supplement for broilers is presented in Table 6. Birds fed with pure starter crumble were more efficient in converting feeds into meat registering a feed conversion ratio of 1.38 kg than those birds fed with 25% air-dried *Azolla* meal + 75% Broiler Starter Crumble (1.41kg)

Analysis of Variance revealed significant differences. This agreed to the result reported by Basak *et al.* (2002) that 10% and 15% of *Azolla* supplementation to the ratio of broilers improved the feed conversion

ratio of broilers. Naghshi *et al.* (2014) recorded an improvement in feed conversion ratio with the inclusion of *Azolla* as a feed supplement in the diet of broilers. However, on the contrary, Rathod *et al.* (2013) reported a non-significant effect of *Azolla* supplementation on feed conversion ratio. Previous workers have reported that the use of *Azolla* supplementation could enhance the feed conversion ratio and body weight gain (Alalade and Iyayi, 2006). As such Wuthijare *et al.* (2012) conform with the findings that supplementation of 10% and 15% of *Azolla* in the ratio of the broilers improved the feed conversion ratio.

**Table 6.** A feed conversion ratio of birds fed with air-dried *Azolla* (*Azolla pinnata*) meal (kg).

Treatment	Mean
T0- Pure broiler starter crumble	1.38b
T1- 10% Air- dried <i>Azolla</i> meal + 90% Broiler Starter Crumble	1.39ab
T2- 15% Air- dried <i>Azolla</i> meal + 85% Broiler Starter Crumble	1.39ab
T3- 20% Air -dried <i>Azolla</i> meal + 80% Broiler Starter Crumble	1.40ab
T4- 25% Air -dried <i>Azolla</i> meal + 75% Broiler Starter Crumble	1.41a

\*Means with the same letter are not significantly different.

#### Feed conversion efficiency

The mean feed conversion efficiency of birds fed with air-dried *Azolla* meal as a feed supplement for broilers is presented in Table 7. The feed conversion efficiency of birds fed with different levels of *Azolla* meal ranges from 27.82% to 29.22%. Birds fed with pure broiler starter crumble obtained the heaviest feed conversion efficiency of 29.22% while birds fed with 20% air-dried *Azolla* meal + 80% Broiler Starter Crumble the lowest.

Analysis of Variance revealed insignificant results.

The results indicate that the air-dried *Azolla* meal did not significantly affect the feed conversion efficiency of the birds. On contrary to the study of Rawat *et al.* (2015) dried *Azolla* meal when supplemented with 5% in the commercial feed of broiler chicks improves the cumulative feed intake, resulting in a higher gain in body weight and feed conversion efficiency.

**Table 7.** Feed conversion efficiency of birds fed with air-dried *Azolla* (*Azolla pinnata*) meal (%).

Treatment	Mean
T0- Pure broiler starter crumble	29.22
T1- 10% Air- dried <i>Azolla</i> meal + 90% Broiler Starter Crumble	28.80
T2- 15% Air- dried <i>Azolla</i> meal + 85% Broiler Starter Crumble	28.57
T3- 20% Air -dried <i>Azolla</i> meal + 80% Broiler Starter Crumble	27.82
T4- 25% Air -dried <i>Azolla</i> meal + 75% Broiler Starter Crumble	28.11

\*Means with the same letter are not significantly different.

#### Dressing percentage

Table 8 shows the dressing percentage of birds as affected by the different levels of air-dried *Azolla* meal. Birds fed with the air-dried *Azolla* has a dressing percentage of 63.31% to 74.92%.

Analysis of variance showed significant differences among treatment means. Comparison among treatment means revealed that birds fed with 10% air-dried *Azolla* meal are comparable with those birds fed with pure broiler starter crumble and significantly higher than those birds fed with 15% and 25% air-dried *Azolla* meal. The result implies that as high as 25% level could be used as feed extenders in broiler production.

Basak *et al.* (2002) and Parthasarathy *et al.* (2002) reported the highest dressing percentage in the birds fed with a 5 percent level of *Azolla* than control. However, Bhattacharyya *et al.* (2016) there was no significant difference among the treatment groups in the other carcass traits. Similarly, Dhumal *et al.* (2009) reported non-significant differences among the means of various carcass traits signifying the non-influence of *Azolla* meal on carcass quality.

#### Liver weight

The mean liver weight of birds is shown in Table 8. The mean liver weight of experimental birds fed with air-dried *Azolla* meal range from 25.67 g to 37.00g.



Analysis of Variance revealed a significant result. Comparison among treatment means indicated that the birds fed with 25% Air -dried *Azolla* meal + 75% Broiler Starter Crumble, 20% Air -dried *Azolla* meal + 80% Broiler Starter Crumble, and 15% Air- dried

*Azolla* meal + 85% Broiler Starter Crumble were significantly comparable. The Pure broiler starter crumbles obtained significantly lower liver weight. However, it is comparable with a 10% air-dried *Azolla* meal + 90% Broiler Starter Crumble.

**Table 8.** Dressing percentage of birds fed with air-dried *Azolla* (*Azolla pinnata*) meal (%).

Treatment	Mean
To- Pure broiler starter crumble	73.14ab
T1- 10% Air- dried <i>Azolla</i> meal + 90% Broiler Starter Crumble	74.92a
T2- 15% Air- dried <i>Azolla</i> meal + 85% Broiler Starter Crumble	63.31c
T3- 20% Air -dried <i>Azolla</i> meal + 80% Broiler Starter Crumble	66.49bc
T4- 25% Air -dried <i>Azolla</i> meal + 75% Broiler Starter Crumble	65.38c

\*Means with the same letter are not significantly different.

**Table 9.** Liver weight of birds fed with air-dried *Azolla* (*Azolla pinnata*) meal (g).

Treatment	Mean
To- Pure broiler starter crumble	25.67b
T1- 10% Air- dried <i>Azolla</i> meal + 90% Broiler Starter Crumble	31.33ab
T2- 15% Air- dried <i>Azolla</i> meal + 85% Broiler Starter Crumble	32.33a
T3- 20% Air -dried <i>Azolla</i> meal + 80% Broiler Starter Crumble	34.67a
T4- 25% Air -dried <i>Azolla</i> meal + 75% Broiler Starter Crumble	37.00a

\*Means with the same letter are not significantly different.

#### Gizzard weight

The performance of broilers in terms of gizzard weight can be seen in Table 10. Birds fed with 25% air-dried *Azolla* meal + 75% Broiler Starter Crumble got the heaviest gizzard (35.67g) while birds fed with pure broiler starter crumble got the lightest gizzard (25.33g).

Analysis of Variance revealed a significant difference among treatment means showing that birds fed with 25% air-dried *Azolla* meal + 75% broiler starter crumble is significantly higher than those birds fed with different levels of *Azolla*. Birds fed with 15% air-dried *Azolla* meal + 85% broiler starter crumble were

comparable with those birds fed with 20% air-dried *Azolla* meal + 80% broiler starter crumble, however, significantly higher than those birds fed with 10% air-dried *Azolla* meal + 90% broiler starter crumble. The result could be attributed to the presence of crude fiber 15.71% in the *Azolla* meal (Basak *et al.*, 2002).

The high crude fiber content (17.29%) of the *Azolla* might have elicited the weight of the gizzard. This is in occurrence with Mateos *et al.* (2012) who noted that increasing the insoluble fiber content of the diet resulted in an increased gizzard weight and gizzard contents, which in general is indicative of improved functioning of the GIT.

**Table 10.** Gizzard weight of birds fed with air-dried *Azolla* (*Azolla pinnata*) meal (g).

Treatment	Mean
To- Pure broiler starter crumble	23.33c
T1- 10% Air- dried <i>Azolla</i> meal + 90% Broiler Starter Crumble	28.67bc
T2- 15% Air- dried <i>Azolla</i> meal + 85% Broiler Starter Crumble	32.00b
T3- 20% Air -dried <i>Azolla</i> meal + 80% Broiler Starter Crumble	31.00b
T4- 25% Air -dried <i>Azolla</i> meal + 75% Broiler Starter Crumble	37.67a

\*Means with the same letter are not significantly different.

*Profit above the feed, medicine, and stock cost of the birds (Php)*

Table 11 shows the profit for feed, medicine, and stock cost of birds in pesos. The profit ranges from Php 21.75 to Php 29.00.

Analysis of variance revealed a significant result. A comparison of among treatment means showed that Pure broiler starter crumble than those fed with 10% Air-dried *Azolla* meal + 90% Broiler Starter Crumble and 20% Air-dried *Azolla* meal + 80% Broiler Starter Crumble.

However, it is comparable to those birds fed with a 15% Air-dried *Azolla* meal + 85% Broiler Starter Crumble and 25% air-dried *Azolla* meal + 75% Broiler Starter Crumble. In a previous study, Mahanthesh *et al.* (2018) said that the replacement of commercial feed by 20% *Azolla* reduced the feed cost. This result also agreed with Chatterjee *et al.* (2020) who recorded that birds fed with 5% *Azolla* reduced the production cost compared with the control group. Joysowal *et al.* (2018) mentioned that *Azolla* is an unconventional feed of low price that reduces the feed cost, so it can be used as poultry feed.

**Table 11.** Mean profit above the feed, medicine, and stock cost of birds fed with air-dried *Azolla* (*Azolla pinnata*) meal (Php).

Treatment	Mean
To- Pure broiler starter crumble	29.00a
T1- 10% Air-dried <i>Azolla</i> meal + 90% Broiler Starter Crumble	28.84b
T2- 15% Air-dried <i>Azolla</i> meal + 85% Broiler Starter Crumble	22.74ab
T3- 20% Air-dried <i>Azolla</i> meal + 80% Broiler Starter Crumble	21.75b
T4- 25% Air-dried <i>Azolla</i> meal + 75% Broiler Starter Crumble	26.12ab

\*Means with the same letter are not significantly different.

### Conclusion

Based on the result of the study, a significant result was noted on the final weight, gain in weight, feed consumption of birds, feed conversion ratio of bird's liver weight, gizzard weight, and dressing percentage. This implies that the different levels of air-dried *Azolla* meal. Significant results were also noted on the profit, above feed medicine, and stock cost as affected by the different levels of air-dried *Azolla* meal. Based on the result of the study, the *Azolla* meal can be used as a feed supplement for broilers if abundant in the locality.

### Acknowledgment

The authors recognize the support of the Don Mariano Marcos Memorial State University particularly the North La Union Campus-College of Agriculture, for providing moral support and financial resources leading to the completion and publication of the study. God is good all the Time.

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