OPEN ACCESS International Journal of Poultry Science

ISSN 1682-8356
DOI: 10.3923/ijps.2025.91.105

Research Article

Growth Performance of Broiler Chicken Fed with Different Levels of Fermented-Dried Azolla (*Azolla pinnata*) and IPIL-IPIL (*Leucaena leucocephala*) Leaf Meal

[1,2]Shyn G. Silvestre, [2]Sheryl Mae N. Lava and [3]Zandro O. Perez

[1]Capiz State University - Burias Campus, Burias, Mambusao, Capiz, Philippines
[2]Graduate School, Cebu Technological University - barili Campus, Barili, Cebu, Philippines
[3]Department of Animal Science, College of Agriculture, Food Science, Agribusiness and Development Communication, Cebu Technological University - Barili Campus, Barili, Cebu, Philippines

Abstract

Objective: The study aimed to evaluate the effects of fermented-dried *Azolla* (*Azolla pinnata*) and Ipil-Ipil (*Leucaena leucocephala*) leaf meal supplementation on the growth performance and carcass quality of broiler chickens. The research sought to identify sustainable, locally available and cost-effective feed alternatives that could support the Philippine poultry industry's shift toward environmentally friendly feeding practices. **Materials and Methods:** A total of 60-day-old broiler chicks were randomly assigned to four dietary treatments under a Completely Randomized Design for a period of 28 days. The treatments consisted of: (T_1) pure commercial feed (control), (T_2) 40 g *Azolla* + 40 g Ipil-Ipil/kg feed, (T_3) 80 g *Azolla*/kg feed and (T_4) 80 g Ipil-Ipil/kg feed. Parameters measured included feed consumption, feed conversion ratio (FCR), body weight gain, water intake, dressed weight, dressing percentage, carcass drip loss and net profit. Data were statistically analyzed to determine significant differences among treatment means. **Results:** Broilers supplemented with 80 g fermented-dried *Azolla*/kg feed exhibited the highest mean feed consumption (1.84 kg), the best FCR (1.73) and significantly greater weight gain (1.06 kg) compared to other treatment groups ($p<0.05$). No significant differences were observed in water intake, dressed weight, dressing percentage, or carcass drip loss among the treatments. Economic analysis indicated that birds receiving 80 g fermented-dried *Azolla*/kg feed achieved the highest net profit (Php 67.55 per head). **Conclusion:** The inclusion of fermented-dried *Azolla* at 80 g/kg feed improved growth performance and feed efficiency in broiler chickens without adversely affecting carcass quality. Given its local availability, high protein content and cost-effectiveness, fermented-dried *Azolla* presents a sustainable and eco-friendly alternative feed supplement for small-scale poultry producers in the Philippines. Further research is recommended to determine the long-term impacts and optimal inclusion levels for practical field applications.

Key words: Broiler chicken, carcass quality, feed supplementation, fermented-dried Azolla (FDA), fermented-dried ipil-ipil (FDI), growth performance

Citation: Silvestre, S.G., S.M.N. Lava and Z.O. Perez, 2025. Growth performance of broiler chicken fed with different levels of fermented-dried Azolla (*Azolla pinnata*) and IPIL-IPIL (*Leucaena leucocephala*) leaf meal. Int. J. Poult. Sci., 24: 91-105.

Corresponding Author: Sheryl Mae N. Lava, Graduate School, Cebu Technological University - barili Campus, Barili, Cebu, Philippines

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Poultry production represents the fastest-growing segment of the global meat industry. Poultry products have gained considerable popularity owing to their affordability, high nutritional value and short production cycle. As the global population continues to expand, food consumption patterns are changing rapidly, driving a substantial increase in the demand for animal-derived protein sources. This heightened demand has consequently increased the need for feed ingredients in the livestock, poultry and aquaculture industries. According to the United Nations[1], the world population is projected to increase by approximately 2 billion people within the next 30 years, rising from 7.7 billion to 9.7 billion by 2050. Several reports have emphasized that global food production must be doubled by 2050 to meet this growing demand[2,3].

Within this context, the Philippine poultry industry has shown promising growth, benefiting from favorable demand trends and consumer preference for poultry meat. Despite its relatively low per capita consumption, the sector is expected to expand further in response to projected increases in population and household income levels. Nevertheless, the industry faces several critical challenges, including heightened consumer expectations for food safety and product quality, public concern over animal welfare and the environmental consequences of intensive poultry production and intensified global market competition-issues that are similarly encountered by poultry industries worldwide[4].

In the Philippines, the advancement of innovative technologies aimed at enhancing poultry production systems has become a progressive trend. Many traditional backyard poultry enterprises have transitioned into large-scale commercial operations, reflecting the sector's rapid modernization. The poultry industry plays a significant role in the Philippine economy, primarily driven by the increasing global demand for high-quality meat products. This growing demand presents an opportunity for the Philippines to strengthen its competitiveness in international meat production markets.

A unique advantage of the Philippine poultry sector lies in the substantial contribution of smallholder poultry farmers. When collectively considered, these small-scale producers form a major component of national poultry output, giving the country a competitive edge in total meat production. These enterprises include privately owned local units that generate income for individual households, as well as government-supported initiatives designed to promote livelihood opportunities among citizens.

According to the Food and Agriculture Organization (FAO) of the United Nations, the rapid expansion of poultry production has led to a notable increase in total output, with chicken meat representing the dominant product. Chickens account for the largest share of the poultry sector compared to ducks, turkeys and other avian species. In the Philippines, native chickens raised under backyard systems remain an essential component of non-commercial poultry production. This accelerated growth in the poultry industry is largely attributed to the rising prices of alternative meats such as pork and beef, along with the increasing demand for affordable protein sources fueled by population growth and the proliferation of fast-food chains, which predominantly utilize poultry products[5].

The increasing demand for sustainable and cost-effective feed resources has intensified the search for alternatives to conventional concentrate feeds. Among the promising candidates is *Azolla*, a free-floating aquatic fern belonging to the family Azollaceae, which has shown great potential as a sustainable feed source for livestock. *Azolla* forms a unique symbiotic association with the nitrogen-fixing cyanobacterium *Anabaena azollae*, which is responsible for the fixation and assimilation of atmospheric nitrogen. In this mutualistic relationship, *Azolla* provides organic carbon and a favorable microenvironment for the growth and activity of the cyanobacterium, while *Anabaena* supplies nitrogen compounds essential for plant metabolism. This symbiosis enables *Azolla* to exhibit a remarkably high protein content and rapid biomass accumulation, making it a valuable biological resource for animal nutrition.

Nutritionally, *Azolla* is rich in proteins, essential amino acids, vitamins (notably vitamin A, vitamin B and β-carotene), minerals (including calcium, phosphorus, potassium, iron, copper and magnesium), as well as various bioactive compounds. On a dry matter basis, it contains approximately 25-35% protein, 10-15% minerals and 7-10% amino acids, bioactive substances and biopolymers, while its carbohydrate and fat contents remain relatively low. Due to its high protein and low lignin content, *Azolla* is easily digestible and well accepted by livestock. Additionally, its simple cultivation requirements, rapid growth rate and low production cost make it an economically and environmentally sustainable feed alternative[6].

Leucaena leucocephala (Lam.) de Wit, commonly known as *Leucaena* or *Ipil-ipil*, is a multipurpose leguminous forage plant recognized for its high nutritional value and adaptability. In recent years, it has been widely cultivated across Southeast Asia-particularly in the Philippines-as well as in Latin America and the West Indies. Its potential as a sustainable and protein-rich animal feed source has been well-documented[7,8]. Historically, *Ipil-ipil* has been regarded as a valuable fodder species for several centuries, with a nutritive profile comparable to or even superior to that of alfalfa (*Medicago sativa*), especially due to its high β-carotene content.

The leaves of *Leucaena leucocephala* are frequently utilized as feed for poultry and pigs and in some cases, they are processed into pellets for use in freshwater aquaculture. The plant exhibits a Dry Matter Digestibility (DMD) of approximately 57.7%, while its crude protein content on a dry matter basis averages 29.5%. Previous studies have indicated that *Ipil-ipil* (*Leucaena leucocephala*) can serve as a viable alternative protein source in poultry diets[9].

Among forage legumes, *Ipil-ipil* is one of the few species whose leaves and stems have been commercially incorporated into animal feed formulations throughout Asia. Although, its leaf meal is rich in protein, excessive inclusion levels should be avoided due to the presence of the toxic non-protein amino acid mimosine. In Thailand and the Philippines, *Ipil-ipil* leaf meal has been safely used at low inclusion rates (5-10%) in compounded fish feeds without adverse effects. However, one study reported poor growth performance in tilapia when *Leucaena* contributed 25% or more of the total dietary protein[10].

Given the increasing cost of commercial feed ingredients, there is a growing need to identify locally available, low-cost feed supplements that can sustain production efficiency. In this context, the present study aimed to evaluate the effects of fermented-dried *Azolla* (*Azolla pinnata*) and *Ipil-ipil* (*Leucaena leucocephala*) leaf meal supplementation on the growth performance and carcass quality of broiler chickens under Philippine conditions.

MATERIALS AND METHODS

Experimental methods

Experimental treatments: The experiment was conducted in Burias, Mambusao, Capiz, from December 20, 2024, to January 16, 2025. Four dietary treatments were formulated as follows:

- **Treatment 1 (T_1):** Pure commercial feed (control)
- **Treatment 2 (T_2):** 40 g of fermented-dried *Azolla* and 40 g of fermented-dried *Ipil-ipil* (*Leucaena leucocephala*) leaf meal per kg of commercial feed
- **Treatment 3 (T_3):** 80 g of fermented-dried *Azolla* per kg of commercial feed
- **Treatment 4 (T_4):** 80 g of fermented-dried *Ipil-ipil* leaf meal per kg of commercial feed

Each treatment was replicated three times to ensure the reliability of experimental results.

Experimental design and layout: The study was arranged using a Completely Randomized Design (CRD). The experimental house was divided into twelve pens, each corresponding to one of the four dietary treatments with three replications. All experimental units were managed under uniform housing, feeding and environmental conditions throughout the study period to minimize variability and ensure the accuracy of treatment comparisons as shown in Fig. 1.

Cultural management procedures

Preparation of the experimental area: One week prior to the experiment, the poultry facility-including pens, watering and feeding troughs-was thoroughly cleaned with soap and water, disinfected and air-dried. Electrical bulbs and wiring were properly installed in all cages before the arrival of the experimental birds.

Housing and management: Each pen, measuring 0.8 m × 0.8 m, was constructed from bamboo slats, wood, netting and nails to accommodate five experimental birds. A 50-watt incandescent bulb was installed in each pen as a heat source during brooding and adverse weather. Newspapers were used as flooring during the early growth stage, while rice hulls were later placed beneath the cages to control odor and facilitate waste collection. Chicken manure was collected and disposed of daily in a designated waste pit located away from the experimental area.

Experimental birds: A total of 80 healthy, day-old straight-run broiler chicks were procured from a reliable commercial source. Sixty chicks were randomly selected for the experiment and distributed into 12 cages, with five birds per cage. The remaining chicks were removed from the experimental site to prevent possible cross-contamination. During transport, the chicks were placed in open crates to ensure adequate ventilation and comfort. Upon arrival, their condition was closely monitored and any stressed individuals were identified and managed appropriately before the commencement of the study.

Brooding and vaccination of chicks: Upon arrival, chicks were immediately placed in the experimental cages and provided with drinking water containing one tablespoon of sugar per liter to aid recovery from transport stress. After three hours, this was replaced with vitamin-supplemented water. Feed was

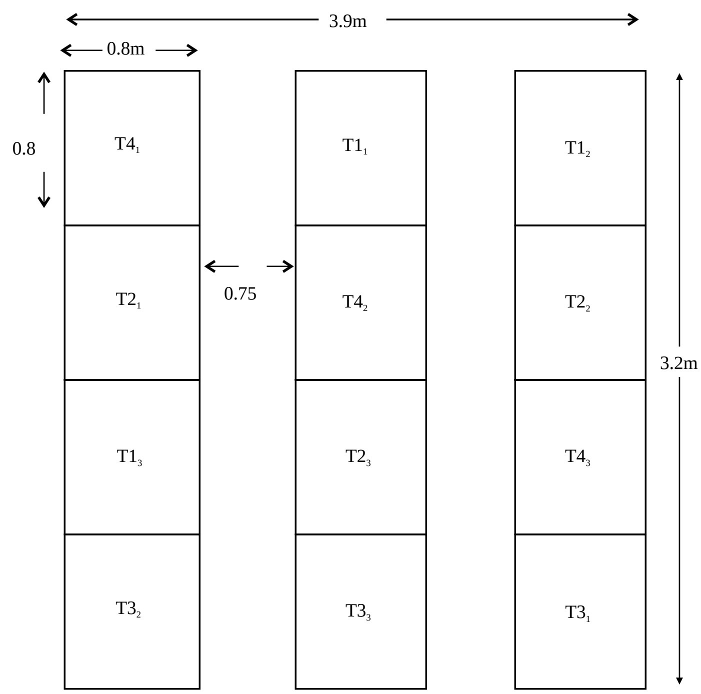

Fig. 1: The experimental design and lay-out of the study arranged in Completely Randomized Design (CRD) replicated three times

initially offered on newspaper matting placed on the brooder floor. Brooding temperature was regulated by adjusting the height of the electric bulbs according to chick behavior, ensuring optimal thermal comfort. Continuous lighting was maintained during the first two weeks, followed by nighttime lighting or as needed during cold or inclement weather.

At seven days of age, all chicks were vaccinated against Newcastle Disease (NCD) to ensure protection throughout the experimental period. Proper handling and disposal of unused biologics were observed and the health status of vaccinated chicks was regularly monitored and recorded.

Preparation of fermented *Azolla* and *Ipil-ipil* leaf meal: Fresh *Azolla* and *Ipil-ipil* (*Leucaena leucocephala*) leaves were collected from Burias, Mambusao, Capiz. The materials were thoroughly washed with tap water, chopped into small pieces and fermented following standard procedures. Each was mixed with molasses in a 1:1 ratio (1 kg plant material to 1 kg molasses) and placed in clean plastic containers covered with manila paper. The mixtures were allowed to ferment for seven days, after which they were squeezed, strained and air-dried for 3-5 days. The dried products were then stored in airtight containers at room temperature until use. This preparation was completed prior to the start of the experiment to ensure adequate supply for the feeding trial.

Grouping and treatment application: After a brief acclimation period, sixty straight-run broiler chicks were randomly assigned into twelve groups corresponding to the four dietary treatments with three replications each. Experimental treatments were introduced on the 14th day, once the chicks had fully recovered from transport stress and continued until the 28th day of feeding, consistent with standard broiler production practices.

Feeding and water management: During brooding, chicks were fed commercial chick booster feed until the 9th day. Feed shifting was gradually implemented from the 10th to the 13th day, transitioning from chick booster to starter ration and from the 20th to the 24th day, from starter to grower ration. Thereafter, grower feed was provided until the end of the experiment. Birds were fed ad libitum, with feed offered three times daily (6:00 a.m., 12:00 noon and 6:00 p.m.), ensuring constant feed availability. Daily feed intake was determined by subtracting the leftover feed weight from the total feed offered per cage.

Clean drinking water was supplied *ad libitum* throughout the experiment. Water availability was checked regularly and daily water intake was recorded by measuring the difference between the amount of water provided and the remaining quantity.

Sanitation practices: Strict sanitation was maintained throughout the experimental period. Pens, feeding troughs and watering troughs were cleaned daily and manure was removed and properly disposed of to minimize odor, fly infestation and disease risk.

Data collection: Data on Mean Feed Consumption (MFC) were collected daily by calculating the difference between the feed offered and the residual feed, divided by the number of birds per cage to obtain the average feed intake.

$$\text{MFC} = \frac{\text{Feed offered} - \text{feed refused}}{\text{Number of birds}}$$

Mean feed conversion ratio (MFCR) was calculated using the following formula

$$\text{MFCR} = \frac{\text{Mean feed consumption (kg)}}{\text{Mean gain in weight (kg)}}$$

Mean initial weight (kg): The mean initial body weight was recorded at the beginning of the experiment. The total weight of birds per replicate was divided by the number of birds to obtain the mean initial weight.

Mean final weight (kg): At the end of the experimental period, all birds in each cage were weighed collectively and the total weight was divided by five (the number of birds per cage) to determine the mean final weight.

Mean weight gain (kg): The mean weight gain was calculated as the difference between the mean final weight and the mean initial weight of the experimental birds.

Mean water intake (L): Water intake was measured daily by recording the volume of water offered to each replicate and subtracting the volume of residual water remaining in the drinkers the following morning before refilling. The total water intake over the experimental period was summed and divided by the number of birds per replicate to obtain the mean water intake per bird.

Dressed weight (kg): One bird per replicate was randomly selected and slaughtered for carcass evaluation. After removal of the head, neck, feet and internal organs, the weight of the eviscerated carcass was recorded as the dressed weight.

Dressing percentage (DP%): Dressing percentage was computed using the following formula:

$$\text{DP (\%)} = \frac{\text{Eviscerated dressed weight}}{\text{Fasting live weight}} \times 100$$

Carcass drip loss (CDL, %): Breast muscle samples were collected from freshly dressed birds representing each replicate. The samples were placed in Styrofoam containers and allowed to drain to collect the exudate. Thereafter, the samples were stored overnight under refrigerated conditions. The initial and final weights of the samples were recorded and CDL was computed using following formula:

$$\text{CDL (\%)} = \frac{\text{Initial weight-final weight}}{\text{Initial weight}} \times 100$$

Income over feed, chick and supplementation cost: Economic efficiency was determined by subtracting the total cost of feed, fermented *Azolla* and *Ipil-ipil* leaf meal consumed by the birds in each replicate from the market value of the birds at harvest time, based on the prevailing live weight price.

Statistical analysis: All experimental data, except for income-over-feed and supplementation cost, were subjected to One-way Analysis of Variance (ANOVA) using the F-test for a Completely Randomized Design (CRD). Differences among treatment means were compared using the Least Significant Difference (LSD) test and significance was determined at the 5% probability level ($p \leq 0.05$).

RESULTS

Mean feed consumption (kg): Table 1a presents the mean feed consumption of broiler chickens supplemented with varying levels of fermented-dried Azolla (FDA) and fermented-dried *Ipil-ipil* (FDI) meal. Broilers supplemented with 80 g FDA exhibited the highest feed consumption, with a mean of 1.84 kg, followed by those fed the control diet and 80 g FDI, with means of 1.83 kg and 1.80 kg, respectively. The lowest mean feed consumption (1.76 kg) was observed in broilers supplemented with 40 g FDA and 40 g FDI.

Analysis of variance (Table 1b) indicated no significant differences among treatments, suggesting that feed consumption was not significantly influenced by the varying inclusion levels of FDA and FDI meal.

Mean feed conversion ratio (kg): Table 2a shows the mean Feed Conversion Ratio (FCR) of broiler chickens supplemented with different levels of FDA and FDI. Broilers supplemented

Table 1a: Mean feed consumption (kg) of broilers supplemented with different levels of FDA and FDI in feeds

	Replication				
Treatment	I	II	III	Total	Mean
Commercial feeds (control)	1.779	1.784	1.935	5.498	1.83
40g FDA and 40g FDI/kg of feeds	1.790	1.610	1.891	5.291	1.76
80g FDA/kg of feeds	1.811	1.684	2.029	5.524	1.84
80g FDI/kg of feeds	1.665	1.741	1.995	5.401	1.80
Grand total/mean				21.714	1.81

FDA: Fermented dried *Azolla* and FDI: Fermented dried *Ipil-ipil*

Table 1b: Analysis of Variance of the mean feed consumption (kg) using the data in Table 1a

				F-value		
					Tabular	
SOV	DF	SS	MS	Computed	5%	1%
Treatment	3	0.0112	0.0037	0.17^{ns}	4.07	7.59
Error	8	0.1769	0.0221			
Total	11	0.1881				

ns: Not significant and CV= 8.22%

Table 2a: Mean feed conversion ratio (kg) of broilers supplemented with different levels FDA and FDI meal

	Replication				
Treatment	I	II	III	Total	Mean
Commercial feeds (control)	1.739	1.764	1.917	5.42	1.81
40 g FDA and 40g FDI/kg of feeds	1.768	1.590	1.855	5.21	1.74
80 g FDA/kg of feeds	1.695	1.587	1.915	5.20	1.73
80 g FDI/kg of feeds	1.642	1.706	1.912	5.26	1.75
Grand total/mean				21.09	1.76

FDA: Fermented dried *Azolla* and FDI: Fermented dried *Ipil-ipil*

Table 2b: Analysis of Variance of the mean feed conversion ratio (kg) using the data in Table 2a

				F-value		
					Tabular	
SOV	DF	SS	MS	Computed	5%	1%
Treatment	3	0.0104	0.0035	0.18^{ns}	4.07	7.59
Error	8	0.1508	0.0188			
Total	11	0.1611				

ns: Not significant and CV= 7.81%

with 80 g FDA achieved the most efficient FCR, with a mean of 1.73 kg, followed by those receiving 40 g FDA and 40 g FDI, with means of 1.74 kg and 1.75 kg, respectively. The least efficient FCR (1.81 kg) was recorded in the control group.

As shown in Table 2b, the ANOVA results were not significant, indicating that supplementation with FDA and FDI at the tested levels did not significantly affect feed conversion ratio.

Mean weight gain (kg): The mean weight gain of broilers after 30 days of supplementation with varying levels of FDA and FDI is presented in Table 3a. Birds supplemented with 80 g FDA exhibited the highest mean weight gain (1.06 kg), followed by those receiving 80 g FDI (1.03 kg). The lowest mean gain (1.01 kg) was observed in birds given the control diet, 40 g FDA and 40 g FDI.

Analysis of variance (Table 3b) revealed highly significant differences ($p<0.01$) among treatments, indicating that supplementation with FDA and FDI significantly affected body weight gain. The Least Significant Difference (LSD) test further showed that birds in the control, 40 g FDA, 40 g FDI and 80 g FDI groups exhibited comparable mean weight gains, while those supplemented with 80 g FDA had significantly higher weight gain than other treatments.

Mean water intake (L): Table 4a shows the mean water intake of broiler chickens fed diets supplemented with different levels of FDA and FDI. The highest mean water intake (4.28 L) was observed in birds supplemented with 80 g FDI, followed by the control (4.25 L) and 80 g FDA (4.22 L) groups. The lowest water intake (4.19 L) was recorded in birds given 40 g FDA and 40 g FDI.

Table 3a: Mean gain in weight (kg) of broilers supplemented with different levels of FDA and FDI meal

	Replication				
Treatments	I	II	III	Total	Mean
Pure feeds (control)	1.023	1.011	1.009	3.043	1.01b
40 g FDA and 40 g FDI/kg of feeds	1.012	1.012	1.019	3.043	1.01[b]
80 g of FDA/kg of feeds	1.068	1.061	1.059	3.188	1.06[a]
80 g of FDI/kg of feeds	1.014	1.020	1.043	3.077	1.03[b]
Grand total/mean				12.351	1.03

FDA: Fermented dried *Azolla*, FDI: Fermented dried *Ipil-ipil*, Means with the same letter are not statistically different from each other

Table 3b: Analysis of Variance of the mean gain in weight (kg) using the data in Table 3a

				F-value		
					Tabular	
SOV	DF	SS	MS	Computed	5%	1%
Treatment	3	0.0047	0.0016	619.07**	4.07	7.59
Error	8	0.0007	0.0001			
Total	11	0.0054				

**Highly significant and CV= 0.8829%

Table 4a. Mean water intake (L) of broilers supplemented with different levels FDA and FDI meal

	Replication				
Treatments	I	II	III	Total	Mean
Pure feeds (control)	4.403	4.036	4.301	12.74	4.25
40 g FDA and 40 g FDI/kg of feeds	4.395	4.121	4.058	12.57	4.19
80 g of FDA/kg of feeds	4.232	4.094	4.339	12.67	4.22
80 g of FDI/kg of feeds	4.183	4.175	4.482	12.84	4.28
Grand total/mean				50.82	4.23

FDA: Fermented dried *Azolla* and FDI: Fermented dried *Ipil-ipil*

Table 4b: Analysis of Variance of the mean water intake (L) using the data in Table 4a

				F-value		
					Tabular	
SOV	DF	SS	MS	Computed	5%	1%
Treatment	3	0.0127	0.0042	0.15[ns]	4.07	7.59
Error	8	0.2274	0.0284			
Total	11	0.2401				

ns: Not significant and CV= 3.98%

According to the analysis of variance (Table 4b), differences among treatments were not significant, indicating that water intake was not affected by the inclusion levels of FDA and FDI meal.

Mean dressed weight (kg): Table 5a presents the mean dressed weight of broilers supplemented with different levels of FDA and FDI. Birds receiving 80 g FDA had the highest dressed weight (1.07 kg), followed by those fed 40 g FDA, 40 g FDI and 80 g FDI, each with a mean of 1.05 kg. The lowest dressed weight (1.03 kg) was observed in the control group.

Analysis of variance (Table 5b) indicated no significant differences among treatments, implying that the varying levels of FDA and FDI supplementation did not significantly influence dressed weight.

Dressing percentage (%): Table 6a summarizes the mean dressing percentage of broilers supplemented with varying levels of FDA and FDI meal. The highest dressing percentage (71.83%) was recorded in birds receiving 80 g FDA, followed by 40 g FDA and 40 g FDI (71.83%) and 80 g FDI (70.97%). The lowest dressing percentage (69.73%) was observed in the control group.

Analysis of variance (Table 6b) revealed no significant differences, suggesting that dressing percentage was not significantly affected by dietary inclusion of FDA and FDI.

Carcass drip loss (%): Table 7a presents the mean carcass drip loss of broilers supplemented with different levels of FDA and FDI meal. The highest drip loss (2.10%) occurred in the control

Table 5a: Mean dressed weight (kg) of broilers supplemented with different levels of FDA and FDI meal

	Replication				
Treatments	I	II	III	Total	Mean
Pure feeds (control)	1.035	1.025	1.040	3.1	1.03
40 g FDA and 40 g FDI/kg of feeds	1.060	1.045	1.045	3.15	1.05
80 g FDA/kg of feeds	1.090	1.070	1.055	3.22	1.07
80 g FDI/kg of feeds	1.025	1.075	1.065	3.17	1.05
Grand total/mean				12.64	1.05

FDA: Fermented dried *Azolla* and FDI: Fermented dried *Ipil-Ipil*

Table 5b: Analysis of Variance of the mean dressed weight (kg) using the data in Table 5a

				F-value		
					Tabular	
SOV	DF	SS	MS	Computed	5%	1%
Treatment	3	0.0022	0.0007	2.62[ns]	4.07	7.59
Error	8	0.0023	0.0003			
Total	11	0.0045				

ns = Not significant and CV= 1.61%

Table 6a: Mean dressing percentage (%) of broilers supplemented with different levels of FDA and FDI meal

	Replication				
Treatments	I	II	III	Total	Mean
Pure feeds (control)	69.90	69.30	70.0	209.20	69.73
40 g FDA and 40 g FDI/kg of feeds	72.10	70.80	70.60	213.50	71.17
80 g FDA/kg of feeds	73.20	71.30	71.00	215.50	71.83
80 g FDI/kg of feeds	69.30	72.10	71.50	212.90	70.97
Grand total/mean				851.10	70.92

FDA: Fermented Dried *Azolla* and FDI: Fermented dried *Ipil-ipil*

Table 6b. Analysis of Variance of the mean dressing percentage (%) using the data in Table 6a

				F-value		
					Tabular	
SOV	DF	SS	MS	Computed	5%	1%
Treatment	3	6.9158	2.3053	2.09[ns]	4.07	7.59
Error	8	8.8067	1.1008			
Total	11	15.7225				

ns: Not significant and CV= 1.48%

Table 7a: Mean carcass drip loss (%) of broilers supplemented with different levels of FDA and FDI meal

	Replication				
Treatments	I	II	III	Total	Mean
Pure feeds (control)	2.00	2.10	2.20	6.30	2.10
40 g FDA and 40g FDI/kg of feeds	2.10	2.10	2.00	6.20	2.07
80 g FDA/kg of feeds	2.00	2.00	2.00	6.00	2.00
80 g FDI/kg of feeds	2.10	2.10	2.00	6.20	2.07
Grand total/mean				24.70	2.06

FDA: Fermented dried *Azolla* and FDI= Fermented dried *Ipil-ipil*

group, followed by birds receiving 40 g FDA, 40 g FDI and 80 g FDI, each with a mean of 2.07%. The lowest carcass drip loss (2.00%) was observed in birds supplemented with 80 g FDA.

The ANOVA results (Table 7b) indicated no significant differences among treatments, suggesting that carcass drip loss was not influenced by FDA and FDI supplementation levels.

Table 7b. Analysis of Variance of the mean carcass drip loss (%) using the data in Table 7a

				F-value		
					Tabular	
SOV	DF	SS	MS	Computed	5%	1%
Treatment	3	0.0158	0.0053	1.27^{ns}	4.07	7.95
Error	8	0.0333	0.0042			
Total	11	0.0492				

ns: Not significant and CV= 3.14%

Table 8: Income-over-feed, chicks and supplementation costs (Php) of broiler supplemented with different levels of FDA and FDI meal

	Treatments			
Particulars	Pure feeds (control)	40 g FDA and 40g FDI/kg of feeds	80 g of FDA/kg of feeds	80 g of FDI/kg of feeds
Gain in weight (kg)	1.01	1.01	1.06	1.03
Value of birds (Php)[a]	161.60	161.60	169.60	164.80
Feed Consumption (kg)	1.83	1.76	1.84	1.80
Amount of commercial feeds	1.83	1.62	1.69	1.66
Cost of CF (Php)[b]	73.20	70.40	73.60	72.00
Cost Chicks (Php)[c]	25.00	25.00	25.00	25.00
Amount of FDA and FDI (kg)	--	0.14	0.15	0.14
Cost of FDA and FDI (Php)[d]	--	3.22	3.45	3.22
Total feed, chick and FS (Php)	98.20	98.62	102.05	100.22
Net Profit	63.40	62.98	67.55	64.58

[a]Based on the prevailing market price of birds at Php160.00 per kilogram live weight, [b]Based on the market price of commercial feeds at Php40.00 per kilogram, [c]Based on the market price of chicks at Php25.00/head and [d]Based on the price of fermented squash at Php23.00/kg

Income over feed, chicks and supplementation cost: Based on the actual cost and return analysis (Table 8a), the highest profitability was recorded in birds supplemented with 80 g FDA, yielding a net profit of P 67.55 per bird. This was followed by birds receiving 80 g FDI (P 64.58 per bird) and the control group (P 63.40 per bird). The lowest income was obtained from birds supplemented with 40 g FDA and 40 g FDI, with a net profit of 62.98 per bird.

DISCUSSION

Mean feed consumption (kg): As shown in Table 1a, broilers supplemented with 80 g FDA/kg feed exhibited the highest feed consumption (1.84 kg), whereas those receiving 40 g/kg FDI had the lowest (1.76 kg). However, statistical analysis revealed no significant differences among treatments, indicating that dietary inclusion of FDA or FDI did not significantly influence feed consumption. These findings are consistent with those of Abdelatty *et al.*[11] and Seth *et al.*[12], who reported that *Azolla* could be incorporated into poultry diets at levels exceeding 5% without any adverse effects on growth performance or productivity. The slight reduction in feed consumption observed in some treatments may be attributed to decreased palatability[13] and increased bulk density of *Azolla* meal[14], which could limit feed utilization efficiency.

Similarly, Sharif *et al.*[15] reported that inclusion of 10% dried *Azolla* meal in broiler diets did not adversely affect feed intake, suggesting that *Azolla* meal, when properly processed through drying and fermentation, maintains good palatability. Moreover, several studies have demonstrated that dietary incorporation of *Azolla* up to 15% in broiler rations does not significantly affect feed consumption[16-18]. Variations in the observed trend of feed intake among different studies may be due to differences in nutrient composition of experimental diets, *Azolla* species, or processing methods used. Additionally, dietary supplements or additives such as multivitamins, acidifiers and *Azolla* have been shown to modulate feed intake and growth performance in broilers[19]. Fermented feed ingredients, when included at 10-15% of the basal diet, can effectively replace conventional feed components; however, further increases in their proportion do not necessarily enhance growth performance[20].

Mean feed conversion ratio (kg): As presented in Table 2a, the improvement in feed conversion efficiency observed in birds receiving 80 g of FDA per kilogram of feed indicates enhanced nutrient utilization. Previous studies of Zhang *et al.*[21] and Zhang *et al.*[22] have similarly demonstrated the efficacy of fermented leaf-based supplements in promoting growth rate and feed efficiency in broiler chickens. Fermentation is known to improve the nutritional composition of unconventional feed ingredients such as *Azolla*. For instance, fermentation of *Azolla* using *Bacillus subtilis*, *Saccharomyces cerevisiae*, or their combinations has been shown to increase crude protein content from 29.20 to 35.80% while reducing crude fiber from 35.56 to 30.60%. This finding corroborates the observations of Ismail *et al.*[23], who reported that fermentation significantly enhanced the crude protein and reduced the fiber content of *A. pinnata*.

Comparable benefits were also observed in fermented *Ipil-Ipil* leaves, where the use of effective microorganisms (EM-4 containing *Rhizopus oligosporus*, *Aspergillus niger* and *Saccharomyces cerevisiae*) improved nutrient digestibility and utilization. The fermentation process effectively reduces crude fiber by approximately 18% while enhancing protein quality[2]. Moreover, supplementation with Fermented Leaf Meal (FLM) of *Ipil-Ipil* at 4-8% in laying quails was found to improve energy, protein, fat, calcium and phosphorus intake while reducing the Feed Conversion Ratio (FCR).

Previous findings also indicate that dried *Azolla* can be effectively included in broiler rations up to a 5% level to reduce production costs[25]. However, higher inclusion levels may adversely affect feed intake and growth performance due to increased fiber content. Saikia *et al.*[26] reported that excessive *Azolla* inclusion diminished bird appetite and growth, findings consistent with Sharma[27], who observed no significant ($p \geq 0.05$) differences in FCR among treatment groups-likely due to reduced feed intake associated with high *Azolla* content. Conversely, some researchers have reported minimal or no effects of *Azolla* supplementation on poultry performance. Elevated inclusion levels of aquatic plants have been associated with reduced body weight and possibly attributed to high neutral detergent fiber[28] and tannin concentrations[29], which act as limiting factors for FCR and overall nutrient utilization[30].

Mean gain in weight (kg): As presented in Table 3a, broiler body weights varied significantly after 30 days of supplementation with different levels of fermented-dried *Azolla* (FDA) and fermented-dried *Ipil-ipil* (FDI). The markedly higher body weight observed in the group supplemented with 80 g FDA indicates the pronounced growth-promoting potential of fermented *Azolla*. These results are consistent with the findings of Swain *et al.*[31], who reported improved growth performance in birds fed *Azolla*-based diets. Similarly, Basak *et al.*[32] observed that inclusion of 5% *Azolla* meal in broiler diets resulted in optimal body weight gain. Furthermore, dietary incorporation of *Azolla* at 15, 30 and 45% has been shown to improve both body weight and Feed Conversion Ratio (FCR) without adverse effects on the normal physiological functions of broilers, potentially reducing production costs in the poultry industry by over 30%[33].

Azolla possesses a relatively high protein content (19-30%) compared with most green forages and aquatic macrophytes, along with a favorable essential amino acid profile-particularly rich in lysine-making it a valuable protein supplement for various livestock species, including ruminants, poultry, pigs and fish[34]. Supplementation with *Azolla pinnata* Meal (APM) at 3 g/kg feed has been shown to significantly enhance broiler performance indicators such as weight gain and dressing percentage[35]. Sharma *et al.*[25] reported comparable results, demonstrating that a 5% substitution of dried *Azolla* in broiler diets led to significantly higher weight gain during both the starter and finisher phases. These findings align with Khan *et al.*[35], who emphasized that fermentation enhances nutrient bioavailability and reduces anti-nutritional factors, thereby explaining the superior performance of fermented feed supplements compared to unfermented forms.

Similarly, Khan *et al.*[35] reported that broilers receiving 3 g *A. pinnata* meal per kg of feed exhibited the highest weight gain (1,816 g), while supplementation at 7.5% in concentrate feed improved body weight by 2.6% (1.99 kg) compared to the control (1.93 kg). Moreover, feed intake was lower among broilers fed 7.5% *Azolla*, suggesting improved feed efficiency[36].

The nutrient composition of *A. pinnata* further supports its suitability as a feed ingredient. It contains substantial levels of linolenic acid (9.8-37.95%) and linoleic acid (5.11-15.38%), exceeding those of several edible oils, thus contributing to its superior nutritional value[37]. Additionally, *Azolla pinnata* provides essential amino acids such as leucine and alanine, as well as vital minerals including iron, calcium and magnesium, reinforcing its potential as a functional component in broiler rations[32,38].

In contrast, *Leucaena leucocephala* (*Ipil-ipil*) leaf meal can be incorporated safely into broiler diets up to a 10% inclusion level without adverse effects on growth performance, as reported by Guodao and Dongjing[39]. However, higher inclusion levels may impair performance due to the presence of residual mimosine. Similarly, Thamaga *et al.*[9] observed that broilers fed up to 10% Ipil-ipil leaf meal exhibited growth comparable to control groups, whereas performance declined at 15% inclusion, likely due to reduced palatability and increased fiber content.

Mean water intake (L): The study evaluated the water intake of broiler chickens supplemented with varying levels of Fermented Dried *Azolla* (FDA) and Fermented Dried *Ipil-ipil*

(FDI) over a 30-day feeding period. The average water consumption among treatment groups ranged from 4.19 to 4.28 liters per bird. Broilers supplemented with 80 g FDI per kilogram of feed exhibited the highest water intake, whereas those receiving a combined supplementation of 40 g FDA and 40 g FDI per kilogram recorded the lowest. Despite these numerical variations, the differences among treatment groups were not statistically significant, indicating that supplementation with FDA or FDI did not alter water consumption behavior.

Supplementation with *Azolla* has been consistently associated with improved growth performance and biochemical balance while maintaining normal drinking patterns in poultry[33]. The findings of the present study therefore suggest that *Azolla* inclusion does not increase water requirements nor induce metabolic stress that could affect hydration or thermoregulatory behavior. Previous research investigating the effects of *Azolla* supplementation in broiler diets has reported similar trends, showing that appropriate inclusion levels can enhance growth performance and Feed Conversion Ratio (FCR) without adverse effects on physiological parameters or water intake. For example, dietary inclusion of *Azolla* at 15, 30 and 45% improved body weight and maintained normal water consumption, suggesting that fermented or dried *Azolla* supports efficient nutrient utilization without impairing hydration[33].

Samad *et al.*[40] likewise demonstrated that *Azolla* supplementation up to 15% in broiler diets promotes growth and biochemical stability without disturbing water balance or physiological homeostasis. Their findings showed no significant variation in water consumption among treatment groups, further confirming that *Azolla*-based feed additives do not impose physiological stress[16].

Similarly, Abawi and Diambra[41] and Ahmed and Abdelati[42], reported that inclusion of *Ipil-ipil* (*Leucaena leucocephala*) leaf meal in broiler diets supports stable water intake and maintains overall physiological equilibrium. However, excessive inclusion levels may reduce both feed and water intake due to the presence of antinutritional compounds such as mimosine, which diminish palatability. Processing methods such as soaking and roasting have been shown to effectively reduce these compounds, thereby enabling safer dietary inclusion of *Ipil-ipil* without negatively affecting intake or hydration.

Dressed weight (kg): The present study evaluated the effects of varying inclusion levels of Fermented Dried *Azolla* (FDA) and Fermented Dried *Ipil-ipil* (FDI) on the carcass performance of broiler chickens during a 30-day feeding trial. Dressed weight, defined as the carcass weight obtained after slaughter and removal of feathers, head, feet and internal organs, served as a key indicator of meat yield. As shown in Table 5a, broilers supplemented with 80 g FDA (T_3) achieved the highest average dressed weight of 1.07 kg, followed by T_2 and T_4, both recording 1.05 kg, while the control group exhibited the lowest dressed weight at 1.03 kg.

Although, the differences among treatments were not statistically significant, the observed trend of higher dressed weight and dressing percentage in FDA-supplemented birds suggests improved carcass output, likely resulting from enhanced growth rate and nutrient utilization efficiency. The dressing percentages obtained in this study (69-72%) fall within the normal commercial range for broilers, indicating that FDA and FDI supplementation did not adversely affect carcass quality.

These findings are consistent with those of Amoyen and Garcia[43], who reported that supplementation with air-dried *Azolla* improved dressing percentage and final body weight, despite showing no significant differences in feed conversion efficiency. Similarly, Alem[44] concluded that moderate inclusion of *Azolla* (up to 10%) enhances growth performance and carcass characteristics without compromising meat quality. Sahu *et al.*[45] further demonstrated that incorporating dried *Azolla* up to 7.5% in broiler diets had no detrimental effect on carcass traits, with dressed weights remaining comparable across treatments.

In support of these results, El-Ghany *et al.*[16] emphasized that *Azolla* can be safely utilized in broiler rations without negatively impacting carcass yield, particularly when used in fermented or dried form to minimize anti-nutritional factors. This aligns with the current study's findings, suggesting that fermentation improves digestibility and nutrient absorption, thereby promoting better carcass performance. The slightly lower dressed weights observed in FDI treatments compared with FDA may be attributed to compositional differences in the two feed materials, particularly in fiber content and protein availability.

Dressing percentage (%): This study assessed the effects of different inclusion levels of Fermented Dried *Azolla* (FDA) and Fermented Dried *Ipil-ipil* (FDI) on the dressing percentage of broiler chickens. Differences among treatment groups were not statistically significant, indicating that supplementation with FDA or FDI did not markedly affect the proportion of carcass yield relative to live body weight. As shown in Table 6a, the highest dressing percentage was recorded in Treatment 3 (80 g FDA/kg feed) with a mean value of 71.83%, followed by Treatment 2 (40 g FDA+40 g FDI) with 71.17% and Treatment 4 (80 g FDI) with 70.97%. The control group exhibited the lowest dressing percentage at 69.73%.

The dressing percentages observed in this experiment (69.73-71.83%) fall within the normal commercial range for broiler chickens (70-75%), suggesting normal carcass development and no adverse effects on yield. Comparable findings have been reported in previous studies demonstrating that fermented feed additives can enhance carcass traits by promoting muscle accretion and improving protein utilization, often without causing significant differences in dressing percentage[46].

This trend is consistent with improvements in overall growth performance and supports previous evidence that fermentation-based feed supplements enhance carcass yield through better nutrient digestibility and efficient protein and fat deposition[47,48]. The results therefore confirm that dietary inclusion of FDA and FDI maintains carcass quality within acceptable production standards.

Basak *et al.*[32] also reported a significant improvement in dressing percentage at 5% *Azolla* meal inclusion, while higher inclusion levels showed no significant difference compared to controls. Similarly, El-Ghany *et al.*[16] found that broiler diets containing up to 15% *Azolla* improved performance without significant variation in dressing percentage relative to unsupplemented groups. These findings suggest that moderate inclusion of *Azolla* supports efficient production without compromising carcass yield.

Furthermore, some researchers have noted that dressing percentage is influenced more strongly by genetic makeup, age and management conditions than by moderate dietary modifications such as the inclusion of fermented dried *Azolla* or *Ipil-ipil*[49]. Consistent with this, *Ipil-ipil* supplementation at optimized levels similarly did not produce significant differences in dressing percentage, indicating its safe and effective use as a complementary protein source in broiler nutrition.

Carcass drip loss (%): Results indicated that carcass drip loss did not differ significantly among treatment groups, suggesting that supplementation with fermented feed additives had no measurable effect on meat water-holding capacity or overall quality. The observed drip loss values ranged from 2.00-2.10%, which falls within the optimal range for broiler meat, as values below 3% are indicative of high water retention capacity. Notably, birds supplemented with 80 g FDA/kg feed exhibited slightly lower drip loss, suggesting a potential beneficial effect of fermented feed components on meat quality; however, this difference was not statistically significant.

A recent study reported that *Azolla* powder supplementation exerted no significant influence on the proximate composition of broiler carcasses, with moisture, protein, fat and ash contents of breast and thigh meat remaining unaffected, thereby supporting the present findings that drip loss remains stable with *Azolla* inclusion[46]. Previous research has further demonstrated that *Azolla* supplementation may enhance carcass yield and meat quality attributes such as tenderness and juiciness, owing to its balanced amino acid composition and antioxidant properties. The non-significant differences observed in dressing percentage and carcass drip loss between supplemented and control groups suggest that fermented-dried *Azolla* and *Ipil-Ipil* supplementation do not adversely affect carcass yield or water-holding capacity[33]. Moreover, studies have documented improvements in sensory characteristics and consumer acceptability of broiler meat supplemented with *Azolla* meal, while the inclusion of *Ipil-Ipil* within recommended levels similarly showed no negative effects on carcass traits[50].

Samad *et al.*[40] investigated the physiological and productive responses of broilers to varying inclusion levels of *Azolla* and found no adverse effects on meat quality parameters, including drip loss. Their findings revealed that *Azolla* supplementation up to 45% enhanced growth performance and feed conversion ratio without significantly altering water retention capacity. Likewise, Al-Shwilly[33] and Samad *et al.*[40] reported that *Azolla* inclusion up to 15% improved growth and nutrient digestibility, with no significant influence on drip loss or other meat quality indices. Additionally, Acharya *et al.*[51] observed that *Azolla* supplementation improved performance parameters by up to 7.5% without affecting carcass drip loss[16].

Income-over-feed, chicks and supplementation cost: The economic evaluation revealed that broilers supplemented with 80 g FDA/kg feed (T_3) achieved the highest net profit (Php 67.55 per bird), followed by those fed 80 g FDI/kg feed (T_4, Php 64.58) and the control group (T_1, Php 63.40). The lowest profitability was observed in birds receiving the combined 40 g FDA+40 g FDI diet (T_2, Php 62.98). The 80 g FDA treatment yielded a 6.5% higher profit than the control, indicating the economic viability of fermented *Azolla* supplementation in broiler diets.

CONCLUSION

The results of the present study demonstrate that dietary supplementation with 80 g/kg fermented-dried *Azolla* significantly improved growth rate and feed efficiency in broiler chickens compared with the control and *Ipil-Ipil* treatments, without exerting detrimental effects on carcass characteristics or water intake. The enhanced performance consequently resulted in greater economic returns, indicating that fermented-dried *Azolla* is a cost-effective alternative feed additive for broiler production. Although, most carcass traits remained unaffected, the favorable growth response supports the inclusion of fermented-dried *Azolla* in broiler diets. Overall, the findings confirm that fermentation enhances the nutritional quality and digestibility of unconventional feed resources such as *Azolla* and *Ipil-Ipil*.

RECOMMENDATION

It is recommended that broiler producers incorporate fermented-dried Azolla at a dietary inclusion level of 80 g/kg feed to enhance growth performance and improve economic efficiency. Further investigations are warranted to determine the long-term effects and optimal inclusion rates beyond 80 g/kg, as well as to assess potential influences on meat quality and physiological health parameters. Continued research on the utilization of fermented unconventional feed resources in poultry production systems across diverse Philippine settings is strongly encouraged. Moreover, comprehensive studies should be conducted to evaluate the long-term impacts of fermented-dried Azolla supplementation on broiler health, immune response and meat quality attributes, including detailed sensory analyses to assess consumer acceptability.

ACKNOWLEDGMENT

Great appreciation is extended to Cebu Technological University - Barili Campus and Capiz State University - Burias Campus for providing the necessary resources and facilities to conduct this study. Special thanks to DOST-Strand N for making this study possible.

REFERENCES

1. Population Division, United Nations Division of Economic and Social Affairs, 2022. Sustainable development and the world at 8 billion. Population Council (associated with UN). https://knowledgecommons.popcouncil.org/series_pdr_essays-8-billion/3/
2. Ray, D.K., N.D. Mueller, P.C. West and J.A. Foley, 2013. Yield trends are insufficient to double global crop production by 2050. PLoS ONE., Vol. 8. 10.1371/journal.pone.0066428.
3. Fróna, D., J. Szenderák and M. Harangi-Rákos, 2019. The challenge of feeding the world. Sustainability, Vol. 11. 10.3390/su11205816.
4. Chang, H.-S. and C.T. Dagaas, 2004. The Philippine duck industry: issues and research needs. School of Economics, University of New England. https://agecon search.umn.edu/record/12904
5. Habito, C.F, 2002. Annex IV: Impact of International Market Forces, Trade Policies and Sectoral Liberalization Policies on the Philippines Hogs and Poultry Sector. Food and Agriculture Organization of the United Nations (FAO). Technical FAO publication (Annex of a larger FAO report). https://www.fao. org/4/x6115e/x6115e0e.htm
6. Huis, A.V, 2013. Potential of insects as food and feed in assuring food security. Annu. Rev. Entomol., 58: 563-583.
7. National Research Council, 1977. Leucaena: Promising Forage and Tree Crop for the Tropics. National Academies Press, Washington, D.C., ISBN: 9780309360050, Pages:129.
8. D'Mello, J.P.F. and T. Acamovic, 1989. *Leucaena leucocephala* in poultry nutrition: A review. Anim. Feed Sci. Technol., 26: 1-28.
9. Thamaga, M.W., H.K. Mokoboki, N.A. Sebola and K.E. Ravhuhali, 2021. Apparent digestibility and nutritional composition of *Leucaena leucocephala* (Lam) leaf meal incorporated in the diets of Black Australorp and Potchefstroom Koekoek chicken breeds. Trop. Anim. Health Prod., Vol. 53. 10.1007/s11250-021-02922-w.
10. Jackson, A.J., B.S. Capper and A.J. Matty, 1982. Evaluation of some plant proteins in complete diets for the tilapia *Sarotherodon mossambicus*. Aquaculture, 27: 97-109.
11. Abdelatty, A.M., M. Mandouh, A.K. Al-Mokaddem, H.A. Mansour, H.M.A. Khalil and M. Bionaz *et al*, 2020. Influence of level of inclusion of Azolla leaf meal on growth performance, meat quality and skeletal muscle p70S6 kinase α abundance in broiler chickens. Animal., 14: 2423-2432.
12. Seth, N., C.R. Pradhan, S.K. Mishra, P. Pati and S.K. Panda, 2013. Performance of Vanaraja chicken fed fresh *Azolla* as a protein substitute. M.V.Sc. Thesis. Orissa University of Agriculture and Technology, Bhubaneswar.
13. Bested, S.B. and S.E. Morento, 1985. The effect of different percentage of *Azolla* on fattening pigs. J. Mt. State Agric. Collage, 17: 31-40.
14. Becerra, M., T.R. Preston and B. Ogle, 1995. Effect of replacing whole boiled soya beans with *Azolla* in the diets of growing ducks. Livest. Res. Rural Dev., Vol. 7.
15. Sharif, M., M.A. Shahzad, S. Rehma, S. Khan, R. Ali and K. Khan *et al*, 2012. Nutritional evaluation of distillery sludge and its effect as a substitute of canola meal on performance of broiler chickens. Asian-Australas. J. Anim. Sci. s, 25: 401-409.
16. El-Ghany, W.A.A. and Y.A.Y. Soyadı, 2020. A review on the use of azolla species in poultry production. J. World's Poult. Res., 10: 378-384.

17. Bhuyan, M.A.H., M.R. Hasanat, M.A. Ali and M.A. Rahman, 1998. Effect of feeding Azolla (*Azolla pinnata*) on the performance of broiler. Bangladesh J. Anim. Sci., 27: 77-82.
18. Sreemannayryana, O., K. Ramachandraiah, K.M.S. Kumar, N.V. Ramanaiah and J. Ramaprasad, 1993. Utilization of *Azolla* as rabbit feed. Indian Vet. J., 70: 285-286.
19. Islam, M.A. and M. Nishibori, 2016. Use of multivitamin, acidifier and azolla in the diet of broiler chickens. Asian-Australas. J. Anim. Sci., 30: 683-689.
20. Sugiharto, S. and S. Ranjitkar, 2019. Recent advances in fermented feeds towards improved broiler chicken performance, gastrointestinal tract microecology and immune responses: A review. Anim. Nutr., 5: 1-10.
21. Zhang, X., F. Cao, Z. Sun, W. Yu, L. Zhao and T. Wang *et al*, 2012. Effect of feeding *Aspergillus niger*-fermented *Ginkgo biloba*-leaves on growth, small intestinal structure and function of broiler chicks. Livest. Sci., 147: 170-180.
22. Zhang, X., Z. Sun, F. Cao, H. Ahmad, X. Yang and T. Wang *et al*, 2015. Effects of dietary supplementation with fermented *Ginkgo* Leaves on antioxidant capacity, intestinal morphology and microbial ecology in broiler chicks. Br. Poult. Sci., 56: 370-380.
23. Ismail, T., E. Hegazi, E. Nassef, O.A. Habotta and M.S. Gewaily, 2022. The optimized inclusion level of bacillus subtilis fermented *Azolla pinnata* in Nile tilapia (*Oreochromis niloticus*) diets: Immunity, antioxidative status, intestinal digestive enzymes and histomorphometry and disease resistance. Fish Physiol. BioChem., 48: 767-783.
24. Utami, M.M.D. and A. Akbar, 2025. Enhancing nutrient intake, egg production and egg quality by fermented *Leucaena leucocephala* leaf meal in a diet of laying quail. Vet. World, 18: 133-140.
25. Sharma, K., A. Sharma, M.S. Sambyal, Sunidhi and S. Katoch, 2024. Growth performance of commercial broiler chicken fed dried *Azolla*. Indian J. Anim. Nutr., 41: 541-548.
26. Saikia, N., D. Sapcota and R. Hazarika, 2014. Effect of feeding *Azolla* (*Azolla pinnata*) meal to broilers: A field study in Assam. Indian J. Poult. Sci., 49: 113-114.
27. Sharma, R.K, 2020. *Azolla* cultivation to produce sustainable feed ingredient: Chemical composition and its impact on performance of broiler chickens. J. Anim. Res., 10: 1067-1075.
28. Buckingham, K.W., S.W. Ela, J.G. Morris and C.R. Goldman, 1978. Nutritive value of the nitrogen-fixing aquatic fern *Azolla* filiculoides. J. Agric. Food Chem., 26: 1230-1234.
29. Hidayat, C., A. Irawan, A. Jayanegara, M.M. Sholikin, T.R. Prihambodo and I. Isbandi *et al*, 2021. Effect of dietary tannins on the performance, lymphoid organ weight and amino acid ileal digestibility of broiler chickens: A meta-analysis. Vet. World, 14: 1405-1411.
30. Muztar, A.J., S.J. Slinger and J.H. Burton, 1978. Chemical composition of aquatic macrophytes. III. mineral composition of freshwater macrophytes and their potential for mineral nutrient removal from lake water. Can. J. Plant Sci., 58: 851-862.
31. Swain, B.K., P.K. Naik and C. Beura, 2022. Nutritive value of *Azolla* as poultry feed-A review. Indian J. Anim. Nutr., Vol. 39.
32. Basak, B., M.A.H. Pram, M.S. Ra, S.U. Tarafda and B.C. Roy, 2001. Azolla (*Azolla pinnata*) as a feed ingredient in broiler ration. Int. J. Poult. Sci., 1: 29-34.
33. AL-Shwilly, H.A.J., 2022. *Azolla* as a new dietary source in broiler feed: A physiological and production study. Arch. Razi Institute, 77: 2175-2180.
34. Hasan, M.R. and R. Chakrabarti, 2009. Use of algae and aquatic macrophytes as feed in small-scale aquaculture: A review. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy, ISBN: 978-92-5-106420-7, Pages:123.
35. Khan, F., R. Ullah, L. Kinkpe, S.U. Hassan, I.S. Ahamba and M. Shuaib *et al*, 2024. Substitution of soybean meal with azolla pinnata meal improves gut histomorphology and growth performance in commercial broilers. Braz. J. Poult. Sci., Vol. 26. 10.1590/1806-9061-2024-1954
36. Prabina, B.J. and K. Kumar, 2010. Dried *Azolla* as a nutritionally rich cost effective and immuno-modulatory feed supplement for broilers. Asian J. Anim. Sci., 5: 20-22.
37. Lejeune, A., J. Peng, E.L. Boulengé, Y. Larondelle and C.V. Hove, 2000. Carotene content of *Azolla* and its variations during drying and storage treatments. Anim. Feed Sci. Technol., 84: 295-301.
38. Mudgal, V., P. Jaiswal, G. Abraham, Y. Singh, P.K. Singh and S.S. Dahiya, 2022. *Azolla* (*Azolla microphylla*) supplementation improves nutrient utilization in lactating murrah buffaloes. Philipp. J. Sci., 151: 2183-2189.
39. Guodao, L. and W. Dongjing, 1996. Preliminary study of *Leucaena leucocephala* as feed for livestock. In: Leucaena - Adaptation, Quality and Farming Systems, Shelton, H.M., R.C. Gutteridge, B.F. Mullen and R.A. Bray, (Eds.). Australian Centre for International Agricultural Research, Canberra, Australia, pp: 284-286.
40. Samad, F.A.A., L.H. Idris, H.A. Hassim, Y.M. Goh and T.C. Loh, 2020. Effects of *Azolla* spp. as feed ingredient on the growth performance and nutrient digestibility of broiler chicken. J. Anim. Physiol. Anim. Nutr., 104: 1704-1711.
41. Abawi, A.G. and O. Diambra, 1993. Leucaena leaf meal and local limestone in the diet of laying hens. Micronesica, 26: 147-153.
42. Ahmed, M.E. and K.A. Abdelati, 2008. Effect of dietary levels of processed *Leucaena leucocephala* seeds on broiler performance and blood parameters. Int. J. Poult. Sci., 7: 423-428.

43. Amoyen, D.A. and J.M. Garcia, 2024. Air-dried *Azolla* (*Azolla pinnata*) meal as a feed supplement for broilers. Int. J. Biosci., 24: 143-151.
44. Alem, D., 2024. Effect of feeding *Azolla* (*Azolla pinnata*) diet on growth performance and carcass characteristics of broilers: A review. Greener J. Agric. Sci., 14: 199-202.
45. Sahu, V.K.R.S.P., S.S.S. Kumar and S.K.S.R. Kumari, 2021. Influence of dietary supplementation of dried *Azolla* on the growth performance of broiler chickens. Int. J. Curr. Microbiol. Appl. Sci., 10: 706-712.
46. Borkar, V.D., S.T. Pachpute, D.K. Kamble, D.K. Deokar, S.B. Adangle and A.T. Lokhande, 2024. Effect of dietary supplementation of *Azolla* powder on carcass, blood serum and proximate properties of breast and thigh muscles of Japanese quail. Int. J. Vet. Sci. Anim. Husb., 9: 417-420.
47. Kumar, D.S., R.M.V. Prasad, K.R. Kishore and E.R. Rao, 2025. Effect of *Azolla* (*Azolla pinnata*) based concentrate mixture on nutrient utilization in buffalo bulls. Indian J. Anim. Res., 46: 268-271.
48. Alem, D., 2024. Effect of feeding *Azolla pinnata* diet on growth performance and carcass characteristics of broilers: A review. Global J. Anim. Sci. Res., 12: 19-24.
49. Tawasoli, M.J., P.A. Kahate, R.R. Shelke, S.D. Chavan, S.R. Shegokar and S.P. Nage, 2020. Performance of *Azolla* (*Azolla pinnata*) meal on body weight gain and dressing percentage of vanraja poultry birds. Int. J. Curr. MicroBiol. Appl. Sci., 9: 4001-4008.
50. Balana, R.R., C.M. Desades, L.V.J. Cortes and M.G. Lao, 2021. Growth performance and carcass quality of broilers (*Gallus domesticus*) fed with aguingay (*Rotboellia cochinchinensis*) and *Azolla* (*Azolla pinnata*) supplements. J. Vet. Sci. Anim. Husb., 2: 132-136.
51. Acharya, P., G.P. Mohanty, C.R. Pradhan, S.K. Mishra, N.C. Beura and B. Moharana, 2015. Exploring the effects of inclusion of dietary fresh *Azolla* on the performance of white Pekin broiler ducks. Vet. World, 8: 1293-1299.