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Evaluating Fresh Duckweed (Lemna minor) as a Sustainable Alternative Feed for Broiler Chickens: Implications for Poultry Production

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ABSTRACT This study evaluated the effects of fresh duckweed (Lemna minor) supplementation on the growth performance of broiler chickens as a potential sustainable alternative feed resource. A Completely Randomized Design (CRD) was employed, consisting of four treatments with three replications, where each replicate contained four birds, totaling 48 broilers. The treatments included a control group and varying levels of fresh duckweed supplementation (low, moderate, and high). Growth performance parameters measured were initial weight, final weight, weight gain, feed intake, and feed conversion efficiency (FCE). Data were analyzed using Analysis of Variance (ANOVA) at a 5% level of significance. Results revealed no significant differences ($p > 0.05$) among treatments for all measured parameters, indicating that duckweed supplementation did not adversely affect broiler performance. However, birds under moderate inclusion levels exhibited higher numerical values in final weight and weight gain, suggesting a potential optimal inclusion level. Feed intake and feed conversion efficiency were comparable across treatments, demonstrating that duckweed did not negatively influence feed utilization. These findings highlight the potential of fresh duckweed as a locally available, cost-effective, and environmentally sustainable feed ingredient. The study supports the integration of duckweed into poultry production systems, particularly in resource-limited settings, while recommending further research on nutrient standardization, inclusion levels, and long-term performance evaluation to optimize its utilization.

Keywords: Alternative feed, Duckweed utilization, Feed conversion efficiency, Poultry nutrition, Sustainable agriculture

INTRODUCTION

The increasing demand for poultry meat has historically driven the intensification of feed resource utilization, with conventional ingredients such as soybean meal and corn dominating broiler diets due to their high nutritional value. However, the rising cost and fluctuating availability of these feed inputs have prompted global research into alternative protein sources. Among these, duckweed (Lemna minor), a small aquatic plant, has been recognized for its rapid biomass production and high crude protein content, typically ranging from 20% to 40% depending on growth conditions (Sońta et al., 2019; Devlamynck et al., 2021; Paguia et al., 2022). Early studies have highlighted its potential as a feed ingredient for livestock and aquaculture, positioning duckweed within the broader context of sustainable and circular agricultural systems.

In recent years, the relevance of duckweed has increased due to growing concerns on environmental sustainability, feed security, and climate-resilient agricultural practices. Its ability to grow in nutrient-rich water systems, including wastewater, enables efficient nutrient recycling while reducing dependence on conventional feed resources (Devlamynck et al., 2021; Appenroth et al., 2021; Sree et al., 2022). This aligns with global and national priorities, including sustainable livestock production and circular bioeconomy initiatives

supported by agencies such as PCAARRD. Furthermore, duckweed cultivation offers opportunities for integration into smallholder farming systems, particularly in developing countries like the Philippines, where feed cost remains a major constraint in poultry production.

Despite its promising nutritional profile and sustainability benefits, existing literature presents inconsistent findings regarding the effects of duckweed supplementation on broiler growth performance. Some studies report improvements in weight gain and feed efficiency at moderate inclusion levels, while others indicate no significant effects or even reduced performance at higher inclusion rates (Baghban-Kanani et al., 2023; Roman et al., 2021; Hamouda et al., 2023). Variability in results has been attributed to differences in duckweed species, cultivation conditions, processing methods (fresh versus dried), and dietary inclusion levels (Sońta et al., 2019; Devlamynck et al., 2021). Moreover, limited studies have specifically evaluated the use of fresh duckweed, which differs nutritionally and physically from processed forms, particularly in terms of moisture content and digestibility. Given these gaps, there is a need for more controlled and context-specific studies to determine the optimal utilization of duckweed in broiler diets. Future research should focus on standardizing nutrient composition, evaluating different processing methods, and conducting dose–response trials to identify optimal inclusion levels. Additionally, integrating economic and environmental assessments is essential to determine the feasibility of large-scale adoption in poultry production systems. Addressing these gaps will support evidence-based recommendations and contribute to the development of sustainable, locally sourced feed alternatives for the poultry industry.

Thus, this study aimed to evaluate the growth performance of broilers supplemented with fresh duckweed. Specifically, it examined final weight (g), average weight gain (g), feed consumption (g), and feed conversion efficiency.

METHODOLOGY

Research Design

The study utilized a Completely Randomized Design (CRD) comprising four dietary treatments with three replications per treatment. Each experimental unit consisted of four broiler chickens, resulting in a total sample size of 48 birds. Random allocation of birds to treatments was implemented to minimize experimental bias and ensure homogeneity across groups. This design is appropriate for evaluating treatment effects under controlled conditions where experimental units are assumed to be relatively uniform.

Experimental Treatments and Layout

The experimental treatments consisted of graded levels of fresh duckweed (Lemna minor) supplementation incorporated into the basal diet of broiler chickens. Specifically, Treatment A served as the control group with no duckweed inclusion, while Treatments B, C, and D received increasing levels of duckweed corresponding to low, moderate, and high inclusion rates, respectively. This treatment structure was designed to evaluate the dose-dependent effects of fresh duckweed on growth performance and feed utilization efficiency.

The study followed a Completely Randomized Design (CRD) with four treatments and three replications per treatment. Each replication consisted of four birds, randomly assigned to minimize bias and ensure comparability among experimental units. The total population comprised 48 broiler chickens.

B	A	C
C	B	A
C	D	A
B	D	D

Figure 1. Experimental Layout as arranged using the Completely Randomized Design (CRD) in three replicates.

Data Collection

The following growth performance parameters were measured and computed to evaluate the effects of fresh duckweed (Lemna minor) supplementation on broiler chickens:

Initial Weight (g): The body weight of each bird at the start of the experimental period, measured using a digital weighing scale.

Final Weight (g):The body weight of each bird at the end of the experimental period.

Weight Gain (g): The increase in body weight over the experimental period, calculated as:

Weight Gain (g) = Final Weight – Initial Weight

Feed Intake (g): The total amount of feed consumed per bird during the experimental period, determined using the formula: Feed Intake (g) = Total Feed Offered – Feed Refused

Feed Conversion Efficiency (FCE): A measure of the efficiency with which birds convert feed into body mass, computed as: FCE = Feed Intake (g) / Weight Gain (g)

Statistical Analysis

The data collected were subjected to Analysis of Variance (ANOVA) appropriate for a Completely Randomized Design (CRD) to determine the effects of varying levels of fresh duckweed (Lemna minor) supplementation on the growth performance of broiler chickens. The statistical model used in the analysis is expressed as:

$$Y_{ij} = \mu + T_i + \epsilon_{ij}$$

Where:

Y_{ij} = observed value of the j^th replicate under the i^th treatment;
μ = overall mean;
T_i = effect of the i^th treatment;
ϵ_{ij} = random error associated with each observation, assumed to be independently and normally distributed with mean zero and constant variance.

The significance of treatment effects was tested at a 5% level of probability (α = 0.05). When significant differences among treatment means were detected, Duncan's Multiple Range Test (DMRT) was recommended to identify specific differences between treatments.

All statistical analyses were performed using appropriate statistical software (SPSS), ensuring that assumptions of ANOVA—namely normality, homogeneity of variance, and independence of observations—were satisfied prior to analysis.

Limitations of the Study

This study is subject to several limitations that should be considered when interpreting the results. The relatively small sample size may have reduced the statistical power of the analysis, limiting the ability to detect significant differences among treatments. Additionally, the short duration of the experiment constrained the assessment of long-term growth performance and potential cumulative effects of duckweed supplementation. The absence of a detailed nutrient composition analysis of the duckweed used further limits the ability to account for variability in its protein, fiber, and mineral content. Moreover, the lack of explicitly defined inclusion rates affects the reproducibility and comparability of the findings with other studies. Finally, the use of fresh duckweed introduces variability in moisture content and nutrient consistency, which may have influenced feed intake, digestibility, and overall performance outcomes.

RESULTS AND DISCUSSION

Growth Performance

Final Weight

The final body weight of broiler chickens across treatments ranged from 1774.9 g to 1926.5 g, with Treatment C(moderate duckweed supplementation) recording the highest mean final weight (1926.5 g), followed by Treatment A (1883.9 g), Treatment D (1805.8 g), and Treatment B (1774.9 g). Statistical analysis revealed no significant differences ($p > 0.05$) among treatments, as indicated by the ANOVA results. The coefficient of variation (CV = 7.3%) suggests moderate variability among experimental units, which is acceptable in biological experiments involving live animals.

The absence of significant differences indicates that the inclusion of fresh duckweed (Lemna minor) did not adversely affect the growth performance of broilers in terms of final body weight. The numerically higher value observed in Treatment C suggests that moderate inclusion levels may support optimal growth, although such differences were not statistically validated. This trend is consistent with previous findings where duckweed supplementation showed comparable or slightly improved growth performance at moderate inclusion levels, but inconsistent results overall depending on diet composition and processing methods (Sońta et al., 2019; Baghban-Kanani et al., 2023; Hamouda et al., 2023). The relatively moderate CV further indicates that observed variations are likely due to biological variability rather than treatment effects alone.

These findings imply that fresh duckweed can be incorporated into broiler diets without compromising final body weight, supporting its potential as a sustainable alternative feed ingredient. From a production perspective, this suggests that poultry producers may partially replace conventional protein sources with duckweed while maintaining acceptable growth performance. Moreover, the ability of duckweed to be locally cultivated aligns with sustainable agriculture initiatives and feed cost reduction strategies, particularly in resource-limited settings such as the Philippines. However, to fully optimize its use, further research is needed to determine optimal inclusion levels, nutrient standardization, and processing methods to enhance its consistency and effectiveness in broiler nutrition (Devlamynck et al., 2021).

Weight Gain

The weight gain of broiler chickens ranged from 1179.1 g to 1317.5 g, with Treatment C recording the highest mean weight gain (1317.5 g), followed by Treatment A (1303.6 g), Treatment D (1209.0 g), and Treatment B (1179.1 g). Statistical analysis indicated no significant differences ($p > 0.05$) among treatments. The coefficient of variation (CV = 5.4%) suggests low variability, indicating good experimental precision and uniformity among replicates .

The non-significant differences imply that fresh duckweed supplementation did not significantly influence weight gain in broilers. However, the higher numerical value observed in Treatment C suggests that moderate inclusion levels may support improved growth performance. This trend aligns with previous studies reporting that duckweed can contribute to weight gain when included at optimal levels, although results are often inconsistent due to variations in nutrient composition, digestibility, and feeding strategies (Sońta et al., 2019; Roman et al., 2021; Hamouda et al., 2023). The relatively low CV further indicates that observed differences are consistent and not due to random variation.

The findings suggest that fresh duckweed can be utilized as a partial feed supplement without negatively affecting weight gain, thereby supporting its role as an alternative protein source. For poultry producers, this indicates the feasibility of incorporating duckweed into feeding programs without compromising growth performance. However, optimization of inclusion rates and processing methods remains necessary to maximize its nutritional benefits and ensure consistent performance outcomes (Devlamynck et al., 2021).

Feed Intake

Feed intake among treatments ranged from 2808.2 g to 2981.8 g, with Treatment C exhibiting the highest intake (2981.8 g), followed by Treatment A (2954.0 g), Treatment D (2846.0 g), and Treatment B (2808.2 g). Statistical analysis showed no significant differences ($p > 0.05$) among treatments. The coefficient of variation (CV = 3.4%) indicates very low variability, reflecting high consistency in feed consumption across treatments .

The similarity in feed intake suggests that the inclusion of fresh duckweed did not negatively affect the palatability or acceptability of the diet. The slightly higher intake observed in Treatment C may indicate that moderate levels of duckweed are well tolerated by broilers. Previous studies have reported that feed intake remains largely unaffected by duckweed inclusion, although higher inclusion levels may sometimes reduce intake due to increased fiber content or moisture associated with fresh duckweed (Sońta et al., 2019; Hamouda et al., 2023). The low CV reinforces the reliability of the observed trends.

These results imply that fresh duckweed can be incorporated into broiler diets without adversely affecting feed consumption, which is critical for maintaining growth performance. From a practical standpoint, this supports the use of duckweed as a viable feed ingredient that does not compromise diet palatability. Nevertheless, careful formulation is required to balance nutrient density and fiber content, especially at higher inclusion levels, to avoid potential reductions in feed intake.

Feed Conversion Efficiency (FCE)

Feed conversion efficiency (FCE) values ranged from 2.26 to 2.39, with Treatments A and C exhibiting the lowest (more efficient) FCE values (2.26), followed by Treatment D (2.37) and Treatment B (2.39). Statistical analysis revealed no significant differences ($p > 0.05$) among treatments. The relatively narrow range of FCE values indicates minimal variation in feed utilization efficiency across treatments .

The absence of significant differences suggests that duckweed supplementation did not affect the efficiency with which broilers converted feed into body mass. The comparable FCE values across treatments indicate that duckweed can replace part of conventional feed ingredients without reducing feed efficiency. This finding is consistent with literature reporting that duckweed inclusion often results in comparable feed conversion ratios, particularly at moderate inclusion levels (Baghban-Kanani et al., 2023; Roman et al., 2021). Slightly higher FCE values in some treatments may be attributed to differences in fiber content or nutrient digestibility associated with fresh duckweed.

The results indicate that fresh duckweed can be utilized in broiler diets without compromising feed efficiency, supporting its potential as a cost-effective and sustainable feed resource. For poultry producers, maintaining comparable FCE is essential to ensure profitability, particularly when substituting conventional feeds. These findings further highlight the potential of duckweed to contribute to sustainable poultry production systems, although further studies are needed to optimize nutrient utilization through processing or supplementation strategies (Devlamynck et al., 2021).

Table 1. Growth Performance of Broiler Chickens Supplemented with Duckweed

Treatments	Initial Wt. (g)	Final Wt. (g)	Wt. Gained (g)	Feed Intake(g)	FCE
A	580.3	1883.9	1303.6	2954.0	2.26
B	595.9	1774.9	1179.1	2808.2	2.39
C	601.9	1926.5	1317.5	2981.8	2.26
D	596.8	1805.8	1209.0	2846.0	2.37
F-test	ns	Ns	ns	Ns	Ns
CV%	6.1	7.3	5.4	3.4	CV%

CONCLUSION

The results of this study demonstrate that the supplementation of fresh duckweed (Lemna minor) in broiler diets did not significantly affect growth performance in terms of final weight, weight gain, feed intake, and feed conversion efficiency ($p > 0.05$). Despite the absence of statistically significant differences, the numerical trends—particularly in Treatment C—suggest that moderate inclusion levels of duckweed may support comparable or slightly improved performance outcomes. These findings indicate that fresh duckweed can be utilized as a sustainable and alternative feed resource without adversely affecting broiler productivity. Furthermore, its potential for local cultivation and integration into circular agricultural systems highlights its relevance in addressing feed cost challenges and promoting environmentally sustainable poultry production, especially in resource-limited settings. However, to fully establish its efficacy and optimize its utilization, further studies incorporating defined inclusion rates, nutrient standardization, and longer experimental durations are recommended.

RECOMMENDATIONS

Based on the findings of the study, it is recommended that fresh duckweed (Lemna minor) be considered as a supplementary feed ingredient in broiler production, particularly at moderate inclusion levels where favorable numerical performance was observed. Poultry producers, especially in resource-limited and rural settings, may explore the integration of duckweed into feeding systems to potentially reduce feed costs and enhance sustainability without compromising growth performance. However, future research should focus on determining optimal inclusion rates, conducting comprehensive nutrient and digestibility analyses, and evaluating the effects of different processing methods (e.g., drying or fermentation) to improve nutrient consistency and utilization. Additionally, longer-term studies with larger sample sizes are recommended to validate these findings and assess economic feasibility. Extension programs and collaboration with local government units (LGUs) and agencies such as DOST-PCAARRD should also be strengthened to promote duckweed cultivation and its adoption as part of sustainable and circular poultry production systems .

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