Research Article

Fresh Water Hyacinth Supplementation Enhances Growth and Profitability in Guinea Fowls

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Abstract | This is a first study to evaluate the effect of varying levels of fresh water hyacinth (WH) supplementation on the performance of Guinea fowls. A total of 150 fowls, aged five weeks, were randomly assigned to five treatments with three replications in a completely randomized design. The experimental treatments included supplementation of WH at 0%, 1.5%, 3.0%, 4.5%, and 6.0% of body weight (on a dry matter basis). The basal diet for all groups contained 20.0% crude protein (CP), 6.35% crude fiber (CF), and 10.8 MJ metabolizable energy (ME) per kg of dry matter. Results indicated significant differences (P<0.01) in daily dry matter intake across the treatments, with values of 57.3, 57.6, 59.0, 58.5, and 58.4 g for the WH0, WH1.5, WH3.0, WH4.5, and WH6.0 groups, respectively. Daily intakes of CP and ME also differed significantly (P<0.05), with the highest values recorded in the WH3.0 treatment. The WH3.0 group achieved the highest daily weight gain (17.7 g). Additionally, the carcass and breast meat weights were significantly greater (P<0.05) in the WH3.0 group compared to the WH0 group. The findings suggest that supplementing the diet of Guinea fowls with 3-6% fresh water hyacinth, based on body weight, can enhance growth performance and improve profitability per bird.

Keywords | Guinea fowls, Green forages, Supplementation, Growth performance, Meat production, Water hyacinth

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INTRODUCTION

Guinea fowl (*Numida meleagris*) are valued for its distinct gamey flavor and nutritious eggs, characterized by yellowish yolks, a result of its scavenging habits (Jacob and Pescatore, 2022). In Vietnam, Guinea fowl meat and its processed products have gained popularity among consumers, often fetching a price 20.0-25.0% higher than native chicken products. This preference can be attributed to the meat's high protein content, rich mineral profile, beneficial fatty acids, and low cholesterol levels, alongside its exceptional taste (Moreki, 2005). Furthermore, guinea fowls exhibit remarkable adaptability to diverse environmental conditions, including resistance to diseases and a wild foraging nature, making them a suitable breed for ecological poultry farming systems. These characteristics, combined with low maintenance costs, make Guinea fowl an attractive option for farmers in Vietnam, where they were introduced to diversify poultry production and enhance farm income.

Typically raised in extensive farming systems, Guinea fowl rely heavily on foraging, which serves as their primary feed source. This unique ability to efficiently utilize available forages plays a significant role in reducing feed costs, an important factor in light of the rising prices of commercial feed, which have led to increased production costs and reduced profitability for many poultry farms (Kusi *et al*., 2015; Adams *et al*., 2022). In the Mekong Delta region of Vietnam, water hyacinth (WH) has proliferated across rivers, ponds, and lakes, creating an environmental challenge due to its invassive character, while simultaneously offering a potential feed resource. The WH, rich in protein (12.6% CP), fiber (56.6% NDF), and energy (9.52 MJME/kg DM), has been effectively utilized as a feed source for ruminants and rabbits (Nguyen and Nguyen, 2023), for pigs (Chhay *et al*., 2007) and for ducks (Jiano *et al*., 2008). However, its application in Guinea fowl diets remains underexplored.

This study aims to evaluate the inclusion of water hyacinth in Guinea fowl diets, specifically investigating the optimal inclusion levels for improving meat production. Given the increasing importance of sustainable farming practices and feed cost management, the findings of this research hold practical implications for enhancing Guinea fowl production in Vietnam.

MATERIALS AND METHODS

Location and Time

The study was conducted from May to Nov 2022 at the experimental farm Nam Can Tho in Can Tho City, Vietnam. The chemical analysis of the experimental feeds was carried out in the Laboratory of the Department of Animal Science at the College of Agriculture of Can Tho University.

Experimental Design and Feeds

A total of 150 Guinea fowls, sourced from Hungary and delivered to Can Tho University, were used in this experiment. At the beginning of the trial, the birds were 5 weeks old, with an average initial body weight of 427 ± 8.54 g per bird. The birds were randomly allocated to five treatment groups, each with three replicates, and 10 birds per replicate. The experimental design followed a completely randomized design (CRD) by using 4 steps of Minitab software (Minitab, 2017). The treatments consisted of varying supplementation levels of fresh water hyacinth (*Eichhornia crassipes*), included at 0%, 1.5%, 3.0%, 4.5%, and 6.0% of the birds' body weight (DM basis). The birds were also acclimated pre-trial and the trial duration was 9 weeks. Fresh water hyacinth was harvested in early morning (around 6.00 am), chopped into small pieces (1.0 to 1.5 cm in length), and fed separately from the concentrate to prevent nutrient loss by the concentrate-sticking refusals, which were removed in the morming if they were mixed. While the rest of the intact fresh water hyacinth was covered by plastic sheet, then it was chopped and fed for other times in a day. The concentrate used in the study was composed of 20% crude protein (CP) and 10.8 MJ metabolizable energy (ME) per kilogram dry matter (DM).

Measurements Taken

Housing and feeding management: The Guinea fowls were housed in steel wire-net cages, each measuring 1.20 m^2, with 10 birds per cage. Birds were fed three times a day at 07:00, 13:00, and 17:00 hours. The water hyacinth and the concentrate were offered separately during each feeding session. Fresh water was provided ad libitum throughout the trial.

Chemical analysis: Samples of the offered feeds (concentrate and water hyacinth) as well as refusals were analyzed for chemical composition, including dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), crude fiber (CF), and ash, using standard AOAC (2000) procedures. The neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were determined according to the method described by Van Soest *et al*. (1991). The metabolizable energy (ME) content was calculated based on the equations outlined by Janssen (1989) and Maertens *et al*. (2002).

Data collection and measurements: Data were collected on a variety of parameters, including daily feed intake, nutrient consumption, body weight gain, and feed conversion ratio (FCR). Growth rate and feed conversion efficiency were calculated based on the daily intake and weight gain of the birds. At the end of the experiment, all birds were humanely slaughtered for the evaluation of meat production. Carcass value and meat quality were assessed, and body measurements were recorded. Live-weight (g) of the birds was measured as the weight of an individual completing the fasting process before slaughtering. Then, the feathers, head, feet, and giblet were removed, the carcass weight (g) was measured, and the carcass rate (%) was calculated as the following: Carcass rate (%) = Carcass weight (g) / Live weight (g) × 100. While the nutrients of breast meat were analyzed as meat quality following the methodology described AOAC (2000).

Data Analysis

All data were analyzed using the General Linear Model (GLM) procedure of Minitab version 18.1 (Minitab, 2017). Tukey's multiple compar ison test was employed to identify significant differences between treatment means, with statistical significance accepted at $p < 0.05$.

RESULTS AND DISCUSSIONS

Nutrient Intakes

Chemical composition and metabolizable energy (ME) of feeds: The chemical composition and ME content of the feeds used in this study are shown in Table 1. The water hyacinth (WH) had a dry matter (DM) content of 9.31%, while the concentrate had a higher DM content of 89.5%. These values were consistent with those reported by Aboud *et al*. (2005), who observed a DM content of 10.7% in water hyacinth. The crude protein (CP) content of WH in the experiment was slightly different to the other ones due to the differences of growing places and stages. The crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and ME values of water hyacinth were comparable to those indicated by Nguyen and Nguyen (2010), who found values of 11.7%, 57.3%, 35.6%, and 9.28 MJ/kg DM, respectively. The concentration of ME in the concentrate was 10.8 MJ/kg DM, which is in line with the values reported by Maertens *et al*. (2002).

Table 1: Chemical composition (%DM) and ME of feeds used (n = 3) in the experiment.

Feeds	DM	OM	CP	EE	CF	NDF	ADF	Ash	ME (MJ/ kgDM)
Water hyacinth	9.31	84.0	11.3	3.20	23.8	58.3	35.3	16.0	8.26*
Concentrate	89.5	92.2	19.9	7.35	6.35	25.2	8.30	7.80	10.8**

DM: dry matter, **OM:** organic matter, **CP:** crude protein, **EE:** Ether extraction, **CF:** crude fiber, **NDF:** neutral detergent fiber, **ADF:** acid detergent fiber, and **ME:** Metabolizable energy (**Janssen (1989) and *Maertens (2002).

Feed and nutrient intake: Table 2 presents the daily feed and nutrient intakes of Guinea fowls supplemented with varying levels of fresh water hyacinth (0%, 1.5%, 3.0%, 4.5%, and 6.0% of live weight). As the supplementation of water hyacinth increased, the concentrate intake was gradually reduced ($P<0.05$). The daily intake of dry matter (DM), organic matter (OM), and crude protein (CP) were significantly higher for the WH3.0 treatment compared to the other treatments ($P<0.05$). Additionally, the intake of crude fiber (CF) increased significantly with the rising levels of water hyacinth, which is consistent with the findings of Tufarelli *et al*. (2018), who reported similar increases in fiber intake when forages were added to poultry diets. The metabolizable energy (ME) intake was highest for the WH3.0 treatment ($P<0.05$), which corresponds with the findings of Ebrahim *et al*. (2020), who observed improved energy intake in poultry when supplemented with plant-based forages.

Table 2: Daily feed, nutrient intakes of Guinea fowls supplemented water hyacinth (WH).

Item, g/bird	Treatment					± SE	P
	WH 0	WH 1.5	WH 3.0	WH 4.5	WH 6.0		
WH	–	1.51^{d}	2.92^{c}	4.28^{b}	5.38^{a}	0.02	0.001
Concentrate	57.3^{a}	56.1^{b}	56.0^{b}	54.3^{c}	53.0^{d}	0.20	0.001
DM	57.3^{b}	57.6^{b}	59.0^{a}	58.5^{a}	58.4^{ab}	0.20	0.001
OM	52.8^{b}	53.0^{b}	54.0^{a}	53.6^{ab}	53.4^{ab}	0.17	0.002
CP	11.4^{ab}	11.3^{b}	11.5^{a}	11.3^{b}	11.2^{b}	0.04	0.001
EE	4.40^{a}	4.30^{b}	4.23^{c}	4.21^{c}	4.19^{c}	0.01	0.001
CF	3.64^{e}	4.02^{d}	4.44^{c}	4.74^{b}	4.99^{a}	0.01	0.001
NDF	14.4^{e}	15.0^{d}	15.8^{c}	16.2^{b}	16.5^{a}	0.04	0.001
ADF	4.75^{e}	5.18^{d}	5.67^{c}	6.00^{b}	6.28^{a}	0.02	0.001
Ash	4.47^{e}	4.61^{d}	4.84^{c}	4.92^{b}	5.00^{a}	0.02	0.001
ME(MJ/bird)	0.619^{b}	0.618^{b}	0.629^{a}	0.622^{ab}	0.617^{b}	0.003	0.003

WH0, WH1.5, WH3.0, WH4.5 and WH6.0: fresh water hyacinth supplemented at levels of 0%, 1,5%, 3,0%, 4,5% and 6,0% of live weight (LW), respectively. ^{a,b,c,d,e} mean values with different superscripts within the same row are different at P<0 05.

Table 3: Daily weight gain, feed conversion ratio (FCR) of the Guinea fowls supplemented fresh water hyacinth.

Item	Treatment					±SE	P
	WH 0	WH 1.5	WH 3.0	WH 4.5	WH 6.0		
Initial live weight, kg/bird	0.421	0.426	0.425	0.430	0.433	3.57	0.265
Final live weight, kg/bird	1.48^{c}	1.50^{ab}	1.54^{a}	1.52^{ab}	1.51^{ab}	7.73	0.006
Daily weight gain (DWG), g	16.9^{b}	17.0^{b}	17.7^{a}	17.3^{ab}	17.1^{b}	0.12	0.007
FCR	3.39	3.38	3.34	3.38	3.41	0.03	0.396
CP/WG (g/kg)	675^{a}	665^{ab}	650^{b}	651^{b}	652^{ab}	4.94	0.018
ME/WG (MJ/kg)	36.3	36.1	35.5	35.6	35.6	0.28	0.230
CP/ME (g/MJ)	18.6^{a}	18.4^{b}	18.3^{c}	18.3^{c}	18.3^{c}	0.01	0.001

^{a,b,c,} mean values with different superscripts within the same row are different at P<0 05.

Growth performance and feed conversion: The growth performance of Guinea fowls in terms of final live weight and daily weight gain (DWG) is shown in Table 3. The final live weight was significantly higher for the WH3.0 and WH4.5 treatments ($P<0.05$), with the WH3.0 treatment achieving the highest DWG of 17.7 g/bird/day. While in the WH6.0 treatment it was lower due to the higher dietary fiber. This suggests that supplementation with fresh water hyacinth, particularly at the 3.0% level, promoted optimal growth performance. These results are similar to those of Bonsu *et al*. (2023), who reported improved growth rates in poultry when supplemented with forages. Chhay *et al.* (2007) reported that using the mixture of WH and water spinach in pig diets improved DM intake and growth perfomance. It was also stated that replacing 20% soybean meal by *Moringa oleifera* leaf meal in diets of meat chicken improved the growth rate and feed conversion ratio (Hoang, 2021). The DWG of the Guinea fowls observed in the present study was higher than those reported by Saina (2005) and Tien *et al.* (2006), who reported DWGs of 12.3 g and 16.9 g, respectively, in Guinea fowls.

Effect of WH supplement and DM intakes in diets on daily weight gain (DWG) of Guinea fowls in this study were presented in Figure 1 and 2 with regression equations following $y = -0.054x^2 + 0.370x + 16.81$ ($R^2 = 0.638$) and $y = 0.357x^2 - 41.1x + 1200$ ($R^2 = 0.955$), respectively. Due to the complex of non-linear relationship between daily weight gain and WH intake, the quaratic models are suitably used for evaluation.

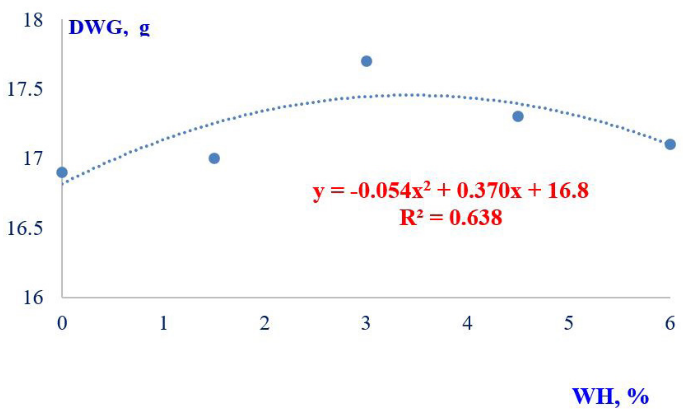

Figure 1: Effect of WH supplement levels on DWG.

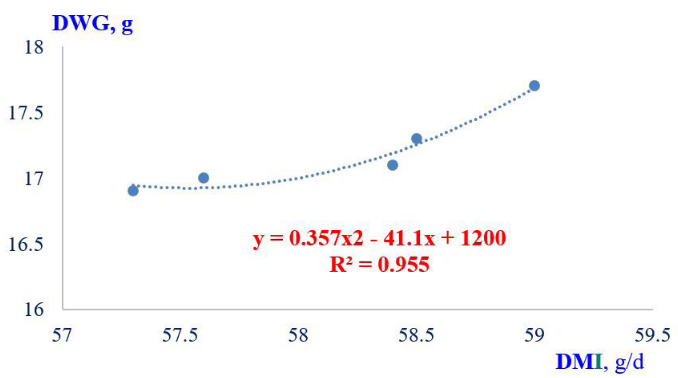

Figure 2: Effect of DM intakes/d on DWG.

Carcass Traits Evaluation

Carcass characteristics of Guinea fowls supplemented with water hyacinth are shown in Table 4. The WH3.0 treatment had the highest carcass weight (P<0.05), with a significant increase in breast meat weight (300 g) compared to the control group (271 g). However, no significant differences in the nutrient composition of meat were observed among the dietary treatments, which aligns with the findings of Bonsu *et al.* (2023), who also noted that supplementary forage feeding had no adverse effect on meat quality. This suggests that while water hyacinth supplementation may enhance certain carcass traits, it does not compromise meat quality. The lack of significant differences in breast meat percentage across treatments is consistent with the results of Kumari *et al.* (2019), who found no substantial effects on breast meat percentage in poultry fed foraged diets.

Table 4: Carcass values of Guinea fowls supplemented fresh water hyacinth.

Item	Treatment					±SE	P
	WH 0	WH 1.5	WH 3.0	WH 4.5	WH 6.0		
Live weight (g)	1,504[c]	1,543[bc]	1,633[a]	1,594[ab]	1,578[ab]	12.1	0.001
Carcass weight (g)	1,082[b]	1,135[ab]	1,178[a]	1,135[ab]	1,118[ab]	12.2	0.004
Carcass rate (%)	72.0	73.5	72.2	71.2	70.9	0.80	0.232
Breast meat weight (g)	271[a]	279[ab]	300[b]	284[ab]	282[ab]	5.73	0.048
Breast meat (%)	25.0	24.5	25.5	25.1	24.1	1.07	0.891
Thigh meat weight (g)	136	144	148	144	144	4.13	0.348
Thigh meat (%)	12.5	12.7	12.6	12.7	12.9	0.32	0.941

[a ,b, c,] mean values with different superscripts within the same row are different at P<0 05.

Table 5: Nutrient composition of Guinea fowl meat supplemented fresh water hyacinth (%, in fresh meat).

Item, %	Treatment					± SE	P
	WH0	WH1.5	WH3.0	WH4.5	WH6.0		
DM	26.7	27.0	26.8	26.2	26.8	0.25	0.06
OM	98.7	98.9	98.7	98.6	98.8	0.10	0.07
CP	20.6	20.4	20.5	20.6	20.7	0.14	0.18
EE	1.94	1.89	1.84	1.93	1.85	0.11	0.41
Ash	1.25	1.04	1.35	1.53	1.42	0.12	0.07

Nutrient Composition of Guinea Fowl Breast Meat in the Experiment

In Table 5, the composition of dry matter (DM), organic matter (OM), crude protein (CP), and ash in the breast meat of Guinea fowl did not differ significantly among treatments (P>0.05). This finding indicates that a gradual increase in metabolizable energy (ME) levels in the diet does not affect the quality of breast meat in the experimental Guinea fowl. The DM values obtained in the present study are in ranging from 22–26% in Guinea fowl meat, reported by Adeyemi and Sazili (2014). The results also indicated that Guinea fowl meat contained higher protein-to-fat ratio, being similar with the finding of Adeyemo *et al.* (2016).

Table 6: The economic analysis of the Guinea fowl supplemented fresh water hyacinth.

Items	Treatment				
	WH0	WH1.5	WH3.0	WH4.5	WH6.0
Total Expenses	4.09	4.05	4.05	4.01	3.97
- Chick, USD/bird	1.67	1.67	1.67	1.67	1.67
- Concentrate feed, USD/bird	1.86	1.82	1.82	1.78	1.74
- Housing, cages, vaccine, medicines, electricity, water hyacinth and labors, USD/bird	0.557	0.557	0.558	0.559	0.558
Income, USD/bird	6.38	6.43	6.57	6.52	6.48
Profit, USD/bird	2.3	2.38	2.52	2.51	2.51
Profit compared to WH0, %	100	103	110	110	109

WH0, WH1.5, WH3.0, WH4.5 and WH6.0: fresh water hyacinth supplemented at levels of 0%, 1.5%, 3.0%, 4.5% and 6.0% of live weight (LW), respectively. Chick at 1 day of age: 1.67 USD/bird, Concentrate: 0.381 USD/kg, Price of chicken sold: 4.29 USD/kg.

Economic Analysis

The economic analysis, presented in Table 6, shows that water hyacinth supplementation resulted in improved economic returns. The treatment with 3.0% water hyacinth supplementation (WH3.0) yielded the highest profit (USD 2.52 per bird), followed closely by the 4.5% supplementation (USD 2.51 per bird). The reduction in feed costs from the concenrate in diets when inclusion of water hyacinth contributed to better profitability, supporting findings by Tufarelli *et al.* (2021), who observed that the inclusion of alternative feeds such as forages could reduce feed costs and enhance profit margins in poultry production. It was reported that Reducing concentrate feed by 15% and incorporating *A. pintoi* in the diet improves weight gain, final live weight, and carcass traits of the Guinea fowl while yielding the highest profit (Tran, 2013).

In summary this experiment provided compelling evidence that water hyacinth, when used appropriately, could serve as a nutritionally viable, cost-effective, and sustainable feed resource for Guinea fowl. Its practical applicability could be high across both smallholder and commercial systems, particularly at a 3.0% inclusion rate, where performance and economic benefits are maximized. However due to the variability of WH nutrients in different places, ensuring quality control and developing simple logistical strategies for harvest and preparation will be critical for scaling this practice effectively.

CONCLUSIONS AND RECOMMENDATIONS

The supplementation of fresh water hyacinth in the diets of Guinea fowls significantly enhanced growth performance, carcass weight, and economic returns. The optimal inclusion level was identified as 3.0% of live weight, which yielded the highest growth rates and profitability. These findings highlight the potential of water hyacinth as a cost-effective, sustainable alternative feed resource for improving poultry production, especially in areas where the plant is readily available. Based on the results, it is recommended that supplementation be scaled for practical applications, but not exceed 4.5% of the birds' live weight to ensure optimal efficiency and safety.

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NOVELTY STATEMENTS

This research work could be the first one to feed poultry water hyacinth for seeking the novelty in poultry sciences.

AUTHOR'S CONTRIBUTIONS

Nguyen Van Thu: Idea, research design, statistical analysis and revisions. Nguyen Thi Kim Dong: Implementing the Exp, analyzing nutrients and writing manuscript.

Conflict of Interest

The authors have declared no conflict of interest.

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