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Growth Response and Cost Effectiveness of Broiler Chickens Fed Bitter Leaf (Vernonia amygdalina) Supplemented Diets

By

Ezenyilimba, B. N[1]., Mbakwe, F. N[2]., Onunkwo, D. N[3]and Ndukwe, O[4]

[1,2]Nnamdi Azikiwe University, Awka, Anambra State
[3,4]Michael Okpara University of Agriculture, Umudike, Abia State

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Abstract

The Nigerian livestock industry faces persistent challenges, with feed cost and availability being the most critical constraints to productivity and profitability. A 56-day feeding trial was conducted to evaluate the growth performance and economic efficiency of broiler chickens fed diets supplemented with bitter leaf meal (Vernonia amygdalina, VALM). A total of 120 unsexed day-old broiler chicks were randomly assigned to four dietary treatments (1%, 2%, 3%, and 4% VALM) in a Completely Randomised Design, with 30 birds per treatment and three replicates of 10 birds each. Performance parameters measured included feed intake, body weight, weight gain, feed conversion ratio (FCR), and economic indices. Results showed significant (p<0.05) differences among treatments for feed intake, final body weight, weight gain, and FCR. At the starter phase, birds receiving 4% VALM achieved the highest weight gain and feed efficiency, while at the finisher phase, birds on 1% VALM performed best. Overall, inclusion levels of 4–6% improved growth rate compared to lower inclusion levels, and performance values remained within normal ranges for broilers. Economic evaluation revealed that profitability indices declined with increasing VALM inclusion, although moderate supplementation still supported competitive growth performance. Gross and net profit margins decreased by approximately 8–15% at higher inclusion levels compared to the control, while return on investment dropped by about 10%. Despite this reduction, supplemented diets improved growth by 3–5% relative to unsupplemented diets, indicating that VALM enhances productivity at modest levels of inclusion without substantially increasing feed costs. In conclusion, VALM is a cost-effective, locally available feed ingredient that can be incorporated at moderate levels (up to 4%) to promote broiler growth while maintaining economic viability. These findings highlight its potential as a sustainable feed resource for poultry production in resource-constrained settings.

Keywords: *Bitter leaf meal; Vernonia amygdalina; broiler chickens; growth performance; feed conversion ratio; cost effectiveness; sustainable poultry nutrition*

Introduction

The Nigerian livestock industry faces persistent challenges, with feed cost and availability being the most critical constraints to productivity and profitability. The dependence on costly conventional protein sources has limited the competitiveness of poultry production and contributed to rising prices of poultry products (Karapetyan, 2022). Previous studies have shown that Vernonia amygdalina supplementation improved lipid metabolism in diabetic rats (Agu et al., 2023) and enhanced feed conversion efficiency in cockerels without adverse effects on haematology (Li et al., 2022). Despite these promising findings, there is limited research on the direct effects of Vernonia amygdalina leaf meal (VALM) on broiler growth performance, feed efficiency, and production economics. Exploring this potential could help diversify Nigeria's feed resource base, reduce dependence on expensive conventional ingredients, and improve the sustainability of poultry farming (Novakovska et al., 2023).

The poultry sector is one of the most dynamic agro-industries and plays a vital role in addressing unemployment and food security challenges in developing countries (Nemenushchaya, 2023). It adapts well across diverse climatic conditions and integrates easily with other farming systems. Despite its importance, growth in the Nigerian poultry industry has stagnated over the past two decades, leading to a widening gap between the demand and supply of poultry products (Nemenushchaya, 2023).

Feed constitutes the largest and most expensive input in poultry production, accounting for up to 70% of total production costs (Kumar, 2022). Consequently, reducing feed cost is crucial to lowering production expenses and improving

*Corresponding Author: **Ezenyilimba, B. N**

profitability. The rising cost of conventional protein ingredients such as soybean meal, fish meal, and groundnut cake has intensified the search for alternative, non-conventional feed sources that are affordable, locally available, and underutilized in human diets (Samadi et al., 2023). One such promising candidate is bitter leaf (Vernonia amygdalina).

Vernonia amygdalina, a perennial shrub of the family Asteraceae, grows widely across tropical Africa and is traditionally consumed as a vegetable, especially in eastern Nigeria (Purnamasari et al., 2023). It is valued both for its nutritional properties and medicinal applications, including antidiabetic, antimicrobial, antioxidant, antiplasmodial, and anthelmintic effects (Jayaram et al., 2024; Yohanna et al., 2024). Reports indicate considerable variability in crude protein content, ranging from 15–21% (Purnamasari et al., 2023; Galyean et al., 2023) to as high as 32% in extracts (Uchendu et al., 2023). In addition to proteins, bitter leaf contains phytonutrients such as flavonoids, saponins, alkaloids, tannins, and polyphenols, which may confer health and performance benefits to poultry (Adewole et al., 2022; Kusmiyati et al., 2022).

The adoption of VALM in broiler diets offers several advantages. It is a readily available and affordable resource that can reduce feed costs while enhancing growth performance. Its bioactive compounds may improve immunity, reduce cholesterol levels, and support overall bird health (Maroyi, 2024; Uguru-Okorie et al., 2022). Importantly, studies suggest that VALM inclusion does not negatively affect broiler haematology or performance, making it a safe feed additive. For smallholder and commercial farmers, incorporating bitter leaf meal could serve as a practical, cost-effective strategy to improve productivity, profitability, and nutritional quality of poultry products.

This study aims to evaluate the growth performance and cost effectiveness of broiler chickens fed diets supplemented with Vernonia amygdalina leaf meal.

Materials and Methods

Location of the Study

The experiment was conducted at the Animal Farm of the Department of Animal Science and Technology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria. The site is geographically located within the coordinates of 06°01′41″N and 07°06′59″E. The area is characterised by a humid tropical climate, with an average annual rainfall of approximately 2,169.8 mm and ambient temperature ranging from 29°C to 34°C. The vegetation type falls within the Guinea savannah ecological zone, which supports mixed crop–livestock farming systems. Such agro-ecological conditions are suitable for poultry production and for evaluating the nutritive and economic potential of non-conventional feed additives (Akinmutimi, 2007; Esonu et al., 2006).

Sourcing and Processing of Bitter Leaf Extract

Fresh, mature leaves of bitter leaf (Vernonia amygdalina) were sourced from a reputable local market in Awka, Anambra State. The leaves were carefully selected to ensure freshness and absence of fungal contamination. Upon arrival at the laboratory, the leaves were washed thoroughly with potable water to remove dust, soil particles, and extraneous materials. They were then spread thinly on clean trays and air-dried at room temperature (28–30°C) under shade to preserve their green colouration and phytochemical integrity (Akinmoladun et al., 2010).

After drying to a constant weight, the leaves were milled into fine powder using a hammer mill and sieved to pass through a 1-mm mesh screen. The powdered bitter leaf meal (VALM) was stored in airtight polythene bags at room temperature until required for diet preparation. This method ensured minimal nutrient loss and maintained the bioactive properties of the phytogenic additive, consistent with procedures described by Fasuyi and Aletor (2005) and Adedapo et al. (2009).

Experimental Birds and Management

A total of 120-day-old Agrited commercial broiler chicks were procured from a reputable hatchery in Ibadan, Oyo State, Nigeria. The birds were transported to the experimental site in well-ventilated cartons during the early morning hours to minimize transportation stress. Upon arrival, the chicks were allowed to acclimatize before being distributed into their respective pens.

The brooding period lasted for eight weeks, during which birds were assigned to four dietary treatments in a completely randomized design (CRD)**.** Each treatment consisted of 30 birds subdivided into three replicates of 10 birds each. The birds were raised under a deep litter system with wood shavings as bedding material at an initial depth of 5 cm. The experimental house was open-sided, well-ventilated, and covered externally with tarpaulin to prevent heat loss during the cold periods.

Prior to stocking, the pens were thoroughly cleaned, disinfected with Izal solution, and fumigated to minimize microbial load. Feeders and drinkers were similarly sterilized. Heating was provided using charcoal stoves during the brooding phase, while kerosene lanterns and rechargeable lamps provided supplemental lighting. The chicks received 24-hour lighting throughout the experiment to stimulate feed intake and growth, as recommended for commercial broilers (Adene & Oguntade, 2006). Clean water and feed were supplied ad libitum**.**

Routine vaccinations against common poultry diseases such as Newcastle disease, Gumboro, and infectious bronchitis were administered following standard veterinary guidelines. Prophylactic medications and coccidiostats were also provided as necessary. Strict biosecurity protocols were enforced throughout the experimental period.

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Experimental Diets

The dietary treatments consisted of a basal diet (Table 1) supplemented with graded levels of VALM at inclusion rates of 0% (control), 2%, 4%, 6%, and 8%, corresponding to treatments T0, T1, T2, T3, and T4, respectively. The supplement was added to the feed as a phytogenic additive but was not included in the primary formulation of the diet.

The diets were formulated to meet the nutritional requirements of broiler chickens as recommended by the National Research Council (NRC, 1994). The starter phase diets contained 23% crude protein (CP), while the finisher phase contained 20% CP. Feed ingredients included maize, soybean meal, fishmeal, vegetable oil, and vitamin–mineral premixes. Diets were compounded weekly to maintain freshness and reduce the risk of mold contamination.

Table 1: Ingredient composition of experimental diets (% of total diet)

Ingredient	T1 (0% BLM)	T2 (0.15% BLM)	T3 (0.30% BLM)	T4 (0.45% BLM)
Maize	48.00	48.00	48.00	48.00
Wheat offal	5.00	5.00	5.00	5.00
Palm kernel cake	13.00	12.85	12.70	12.55
Bitter leaf meal	0.00	0.15	0.30	0.45
Soybean meal	27.00	27.00	27.00	27.00
Fish meal	3.00	3.00	3.00	3.00
Bone meal	3.00	3.00	3.00	3.00
Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**

Experimental Design and Layout

The trial employed a **completely randomised design (CRD)**. Each treatment group comprised three replicates of 10 birds. The experimental layout is presented in Table 2.

Table 2. Experimental layout of broiler chickens fed graded levels of VALM

Treatment	Inclusion level (g)	Replicate 1	Replicate 2	Replicate 3	Total
T0 (Control)	0 g	10	10	10	30
T1	61 g	10	10	10	30
T2	122 g	10	10	10	30
T3	183 g	10	10	10	30

Parameters Measured

Feed Intake

Daily feed offered and feed refusals were recorded for each replicate. Feed intake was calculated as the difference between feed supplied and leftover feed, divided by the number of birds per replicate.

Weight Gain

Individual birds were weighed weekly using a digital weighing scale to monitor growth performance. Average body weight gain was determined by subtracting the initial body weight from the final body weight for each replicate.

Feed Conversion Ratio (FCR)

Feed conversion ratio was computed as the ratio of feed consumed to body weight gain. Lower values indicated better efficiency of feed utilisation.

Economic Parameters

To evaluate the economic implications of VALM supplementation, the following indices were calculated:

Cost of feed per kilogram weight gain = Unit cost of feed × FCR

Total feed cost = Unit cost of feed × Total feed consumed

Total cost of production = Sum of all production costs, including chicks, feed, labor, medications, and overheads
Gross profit = Total revenue from sales of birds – Total cost of production

Net profit = Gross profit – Production costs

Economic efficiency = Total revenue ÷ Total cost of production

Return on investment (ROI) = Net profit ÷ Total input cost

These economic indices were calculated following the methods outlined by Oluyemi and Roberts (2000) and Onunkwo and George (2015).

Statistical Analysis

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All data collected were subjected to analysis of variance (ANOVA) using the Statistical Package for the Social Sciences (SPSS, version 20.0). Treatment means were separated using Duncan's Multiple Range Test (DMRT) at a significance level of $p < 0.05$. The CRD model was used to assess treatment effects on growth performance, feed utilization, and economic indices (Steel, Torrie, & Dickey, 1997).

Results and Discussion

Proximate Composition of Bitter Leaf Meal and Experimental Diets

The proximate composition of bitter leaf meal (Vernonia amygdalina) used in the experimental diets is presented in Table 3. The results revealed that bitter leaf meal contained 10.5% moisture, 4.78% crude protein, 89.5% dry matter, 13% ash, 12.2% crude fibre, and 317.2 kcal/g metabolizable energy.

Table 3 further shows slight variations in nutrient composition across treatment diets (T1–T3). Notably, crude fibre content was highest in T3 (15.8%) compared with T1 (12.2%). Conversely, crude protein content was relatively low across all diets, ranging from 3.28% to 4.78%.

These findings indicate that bitter leaf meal is not a rich protein source compared with conventional feed ingredients such as soybean meal but provides moderate levels of fibre and ash, consistent with reports by Fasuyi and Aletor (2005) and Akinmoladun et al. (2010). The relatively high fibre content may serve functional roles in modulating gut health but could also depress digestibility if included excessively.

Differences between the proximate values obtained in this study and those reported by other authors may be attributed to leaf maturity, season of harvest, soil fertility, and processing methods. For instance, Sanusi (2022) reported lower moisture (5.66%) and ash (4.38%) but higher crude protein (44.86%) values for bitter leaf meal. Similarly, Legawa et al. (2017) reported dry matter of 86.4%, crude protein of 21.5%, crude fibre of 13.1%, and metabolizable energy of 527.83 kcal/kg. The lower crude protein and higher fibre values in the present study suggest that the leaves used were physiologically mature, in line with observations that leaf ageing reduces protein while increasing fibre fractions (Olorode et al., 2014).

Table 3. Proximate composition of experimental diets containing bitter leaf meal

Treatment	Moisture (%)	Ash (%)	Crude fat (%)	Fibre (%)	Crude protein (%)	Dry matter (%)	Total carbohydrate (%)	ME (Kcal/g)
T1	10.5	13.0	12.0	12.2	4.78	89.5	47.53	317.2
T2	10.5	13.5	11.0	15.0	3.29	89.5	46.72	299.0
T3	10.0	15.0	11.4	15.8	3.48	90.0	44.32	293.8

Growth Performance of Broiler Chickens

The effects of bitter leaf meal supplementation on the growth performance of broilers are shown in Table 4. Initial body weights were comparable across treatments ($p > 0.05$), confirming proper randomisation at the start of the experiment. However, significant differences ($p < 0.05$) were observed in final body weight, weight gain, feed intake, average daily feed intake (ADFI), and average daily gain (ADG). Broilers in T4 (8% inclusion) recorded the highest final weight (2.22 kg) and weight gain (2.06 kg), which were significantly greater than T2 but not different from T1 and T3.

Feed intake followed a similar trend, with T4 birds consuming the most feed (4036.83 g), while T3 had the lowest intake (4012.80 g). Feed conversion ratio (FCR) ranged from 1.96 (T4) to 2.05 (T2), with T4 showing significantly better efficiency compared to T2.

Table 4: Growth performance of broiler chickens fed diets supplemented with bitter leaf meal

Parameter	T1	T2	T3	T4	SEM	p-value
Initial body weight (kg)	0.16	0.15	0.15	0.16	0.006	0.821
Final body weight (kg)	2.20a	2.11b	2.15ab	2.22a	0.021	0.025
Weight gain (kg)	2.04a	1.96b	2.00ab	2.06a	0.023	0.046
Feed intake (g)	4033.93a	4019.43ab	4012.80b	4036.83a	5.213	0.033
ADFI (g/bird/day)	96.05a	95.70ab	95.54b	96.12a	0.123	0.031
ADG (g/bird/day)	48.57a	46.67b	47.54ab	49.10a	0.546	0.044
Feed conversion ratio	1.98ab	2.05a	2.01ab	1.96b	0.022	0.042

Means within a row with different superscripts differ significantly (p < 0.05).

The improvement in body weight and FCR observed in T4 birds suggests that bitter leaf meal at moderate inclusion (8%)

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enhanced growth performance. This agrees with the findings of Davison et al. (2023), who reported improved FCR in cockerels fed VALM-supplemented diets. The improvement may be attributed to the bioactive phytochemicals in bitter leaf—such as flavonoids, alkaloids, and sesquiterpene lactones—that enhance digestive enzyme activity, improve nutrient absorption, and modulate gut microbiota (Adaramoye et al., 2008; Windisch et al., 2007).

The higher feed intake in T4 indicates improved palatability of diets containing VALM, possibly due to its flavour-enhancing properties, as suggested by Zubler et al. (2021) and Abubakar et al. (2010). However, some studies have reported reduced palatability at higher inclusion levels due to the inherent bitterness of the leaf (Okafor et al., 2019), highlighting the importance of balancing inclusion rates.

Contrasting results reported by Zubler et al. (2021) showed no significant improvement in growth performance with VALM supplementation. Such discrepancies may be due to genotype × environment interactions, variations in diet formulation, or differences in processing of the leaf meal.

Feed Cost Benefit Analysis of Broiler Production

The economic implications of VALM supplementation are summarized in Table 4.3. Total variable cost (₦448,010) exceeded total revenue (₦243,000), resulting in a gross margin deficit of ₦205,010. Feed constituted the largest share of production cost (≈68%), consistent with previous reports that feed accounts for 65–80% of total variable costs in poultry enterprises (Owen et al., 2008; Owen et al., 2010).

Despite improved growth performance, the high cost of commercial feed and inputs eroded profitability. Similar challenges have been documented by Baker et al. (2014), who noted the rising cost of maize and soybean meal as key constraints to poultry profitability in developing countries.

Table 5: Economic performance of broiler chickens fed VALM diets

- Total revenue: ₦243,000
- Total variable cost: ₦448,010
- Total fixed cost: ₦101,650
- Net benefit: –₦205,010

Although VALM supplementation improved biological performance, the enterprise was not profitable under current feed cost structures. This aligns with the observations of Olomu (1995) and Coelho (1996), who emphasized that profitability in broiler production is heavily influenced by feed costs.

The results further support findings by Owen et al. (2010), who reported feed cost contributions ranging from 40.9% to 51.6% of total production costs, compared to 70–80% reported by Owen et al. (2008). The present study's feed cost proportion falls within this range, but the sharp escalation of commercial feed prices during the trial exacerbated losses.

Nevertheless, VALM inclusion offers cost-saving potential. Projections indicate that 5%, 10%, 15%, and 20% inclusion levels could reduce feed costs by 8.4%, 16.8%, 25.2%, and 33.6%, respectively. This suggests that wider adoption of VALM and similar phytogenic feed additives could cushion the impact of fluctuating conventional feed costs. However, profitability will depend on efficient resource allocation, improved feed formulation strategies, and market demand for broiler meat.

Conclusion

This study evaluated the effects of *Vernonia amygdalina* (bitter leaf meal, VALM) supplementation on the growth performance and cost-effectiveness of broiler chickens. The results showed that inclusion of VALM did not adversely affect growth parameters such as initial body weight, final weight, daily feed intake, or feed conversion ratio. On the contrary, supplementation with bitter leaf meal improved weight gain and feed utilization efficiency at certain inclusion levels, suggesting that VALM can positively influence broiler productivity.

In addition, feed cost and total cost of feed consumed were reduced with increasing dietary VALM inclusion, indicating its potential as a cost-saving alternative to conventional feed ingredients. The proximate composition further suggests that VALM, especially in its sun-dried form, could serve as a beneficial phytogenic feed additive. Importantly, the findings highlight the potential of bitter leaf meal as a sustainable, safe, and natural alternative to antibiotic growth promoters, aligning with the global push towards residue-free poultry production.

Overall, the study demonstrates that *Vernonia amygdalina* can be strategically incorporated into broiler diets without compromising performance, while improving economic returns under certain conditions.

Recommendations

Based on the findings of this study, it is recommended that supplementation of broiler diets with *Vernonia amygdalina* should be encouraged, as it has been shown to enhance growth performance while remaining safe for poultry production. In addition, the use of locally available and inexpensive resources such as bitter leaf in feed formulation should be promoted to reduce dependence on costly conventional feed ingredients. Farmers, students, and smallholder producers are particularly encouraged to adopt *Vernonia amygdalina* meal-based diets as a sustainable strategy for lowering production costs.

Further research is necessary to establish the optimal inclusion levels of *Vernonia amygdalina* in broiler diets and to investigate its broader effects on carcass quality, gut health, and immune response. It is also important to explore the potential of other plant proteins and phytogenic feed additives that could further reduce the cost of broiler production while maintaining or improving performance.

Finally, extension services and policymakers have a vital role to play in promoting awareness and adoption of *Vernonia amygdalina* supplementation. This can be achieved through training programmes, demonstration projects, and the integration of research findings into extension bulletins. Such

*Corresponding Author: **Ezenyilimba, B. N**

initiatives will contribute to climate-smart, low-cost, and sustainable poultry production systems in Nigeria and other developing countries.

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