Global Scientific and Academic Research Journal of Multidisciplinary Studies
ISSN: 2583-4088 (Online)
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journals-gsarjms-home/

Growth Response and Feed Cost Benefit of Starter Noiler Chickens to Dietary Anazyme-Forte Phytase Supplementation

By

Onunkwo, D. N[1]., Nwogu, R. K[2]., Ezeoke, F. C[3]., Ndukwe, O[4]., Okoye, L. E[5] and Okocha, N. L[6]

[1,4,6]Michael Okpara University of Agriculture, Umudike, Abia State
[2]University of Agriculture and Environmental Sciences, Umuagwo, Imo State
[3,5]Chukwuemeka Odumegwu Ojukwu University, Igbariam, Anambra State

Article History

Received: 01/09/2025
Accepted: 04/09/2025
Published: 06/09/2025

Vol – 4 Issue –9

PP: - 26-32

Abstract

A feeding trial was conducted to evaluate the growth response and feed cost benefit of dietary phytase enzyme supplementation in starter Noiler chickens. A total of 180 noiler chicks were used in a 21-day experiment. The chicks were brooded under controlled heat and light conditions, with temperature adjusted according to ambient changes and chick behaviour. After one week, birds were randomly allotted to five iso-nitrogenous (21.50% CP) and iso-caloric (2977.40 kcal/kg ME) diets containing 0 g/100 kg (T1), 10 g/100 kg (T2), 15 g/100 kg (T3), 20 g/100 kg (T4), and 25 g/100 kg (T5) of a commercial phytase preparation in a completely randomized design (CRD). Feed and water were supplied ad libitum. Data were collected on feed intake, weight gain, feed conversion ratio (FCR), protein efficiency ratio, and cost indices. Results showed that daily feed intake and protein intake were not significantly ($P > 0.05$) affected by phytase supplementation. However, final live weight, daily weight gain, total weight gain, and protein efficiency ratio differed significantly ($P < 0.05$), with birds on T1 (control) recording the highest values, which were comparable to T2 and T3 but superior to T5. Feed conversion ratio was significantly improved ($P < 0.05$) in T1 (2.02) compared with T5 (2.58), while T2 and T3 maintained intermediate values. Mortality was lowest (0%) in T5. Feed cost per kilogram and daily feed cost per bird were significantly lower ($P < 0.05$) in T1 and T2 compared with T5. In conclusion, phytase enzyme supplementation up to 20 g/100 kg diet supports comparable growth performance and favourable feed cost efficiency in starter Noiler chickens.

***Keywords**: Phytase enzyme, feed cost efficiency, Noiler chickens, growth performance, feed conversion ratio, protein efficiency, dietary supplementation, starter phase*

Introduction

Poultry production remains one of the fastest-growing and most sustainable means of providing high-quality animal protein for the increasing human population, particularly in developing countries such as Nigeria (Ravindran, 2013). Among the poultry species, chickens are the most widely reared due to their relatively short production cycle, rapid growth, and high feed conversion efficiency. In recent years, the introduction of *Noiler chickens*, a dual-purpose breed with a desirable growth rate and adaptability, has gained increasing attention in Nigeria and other parts of Africa. Noilers combine the hardiness of indigenous chickens with the growth performance of commercial noilers, making them well-suited for both smallholder and commercial poultry production systems (Ahiwe et al., 2018). However, maximising their productivity, particularly during the starter phase, requires efficient feed formulation strategies that optimise nutrient utilisation and reduce production costs.

Feed accounts for 60–75% of the total cost of poultry production, making it the single most important factor influencing profitability (Leeson & Summers, 2001; Ravindran, 2013). The starter phase is particularly critical, as nutrient intake during this period determines subsequent growth performance, feed conversion efficiency, and health status of the birds. Despite advances in feed formulation, a major challenge in poultry nutrition is the presence of anti-nutritional factors such as phytate in plant-based feed ingredients (Dibner & Buttin, 2002). Phytate, the primary storage form of phosphorus in cereals and legumes, is poorly digested by poultry because they lack sufficient endogenous phytase to hydrolyze phytate-bound phosphorus (Ravindran, 2013; Ricke, 2003). As a result, significant amounts of dietary

*Corresponding Author: **Onunkwo, D. N**

phosphorus remain unavailable, leading to inefficient nutrient utilization, increased feed costs due to the need for inorganic phosphorus supplementation, and heightened environmental concerns from phosphorus excretion (Dibner & Richards, 2005).

In addition to limiting phosphorus availability, phytate forms complexes with proteins, starch, and essential minerals such as calcium, zinc, and iron, thereby reducing their digestibility and absorption (McDowell, 2000; Windisch et al., 2008). This antinutritional effect not only depresses growth performance but also contributes to higher feed conversion ratios and greater production costs. Consequently, nutritional strategies that improve the hydrolysis of phytate and enhance nutrient bioavailability are of significant importance in modern poultry production (Ravindran, 2013).

One of the most effective approaches to overcoming the limitations of phytate is the dietary supplementation of exogenous phytase enzymes. Phytase catalyses the hydrolysis of phytate, releasing phosphorus and other bound nutrients for absorption (Dibner & Buttin, 2002; Abdel-Fattah et al., 2008). Numerous studies have demonstrated that phytase supplementation improves growth performance, nutrient digestibility, and feed efficiency in noilers and layers (Adil et al., 2010; Moghadam et al., 2006; Hernández et al., 2006). Beyond improving phosphorus utilization, phytase also reduces the environmental impact of poultry production by lowering phosphorus excretion (Ricke, 2003; Haque et al., 2010).

In Nigeria, the growing adoption of commercial phytase products such as Anazyme-Forte offers a promising solution to address nutrient waste and high feed costs in noiler chicken production. Anazyme-Forte is a commercially available phytase preparation specifically designed to enhance phytate hydrolysis in poultry diets. While phytase supplementation has been extensively studied in commercial noilers (Patten & Waldroup, 1988; Islam et al., 2012), there is still limited information on its effects on noiler chickens, particularly during the starter phase, where nutrient demand is high and the foundation for subsequent growth is established. Moreover, while performance benefits have been widely reported, there is a paucity of information on the economic implications, especially in terms of feed cost per unit of weight gain, which is a key determinant of profitability for smallholder and medium-scale farmers.

Cost-benefit evaluation is an essential component of feed additive research, as the ultimate goal of any supplementation is not only to improve growth performance but also to reduce production costs and increase profitability (Castanon, 2007; Mellor, 2009). The rising cost of inorganic phosphorus and synthetic amino acids in Nigeria underscores the need for alternative feed technologies such as phytase that can improve nutrient utilization at a reduced cost. Evaluating the feed cost per kilogram of body weight gain provides a more practical assessment of economic efficiency than growth performance alone (Rahmani & Speer, 2005).

Given these considerations, it is imperative to investigate the growth response and feed cost benefit of starter noiler chickens supplemented with dietary Anazyme-Forte phytase. The study is expected to provide relevant insights into the optimal inclusion level of phytase for noilers, while also highlighting the cost implications of supplementation. Such findings will be of practical importance to poultry farmers, nutritionists, and feed manufacturers in Nigeria and other developing countries where production efficiency is constrained by high feed costs and limited access to expensive feed inputs.

Therefore, the objective of this research was to evaluate the influence of different inclusion levels of Anazyme-Forte phytase enzyme in the diet of starter noiler chickens on growth performance, feed utilisation, and feed cost per unit of body weight gain. It is anticipated that this study will contribute to developing cost-effective feeding strategies for sustainable noiler chicken production.

Materials and Methods

Location of the Experiment

The experiment was conducted at the Poultry Unit of the University Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The farm is located in the humid rainforest zone of southeastern Nigeria, characterised by an annual rainfall of about 2000 mm, a relative humidity range of 70–80%, and an average annual temperature of 27°C (Nwosu et al., 2014). The climatic conditions of Umudike are favourable for poultry production, although temperature fluctuations and humidity can affect the growth and health of noilers if not properly managed (Oluyemi & Roberts, 2000).

Procurement of Experimental Materials

Day-old noiler chicks were procured from Ibadan, Oyo State, Nigeria. All feed ingredients used in compounding the experimental diets (maize, soybean meal, palm kernel cake (PKC), bone meal, lysine, methionine, vitamin–mineral premix, and salt) were purchased from JOCAN AGRO LIMITED Feed Mill, Umuahia, Abia State. The phytase enzyme (Anazyme-Forte®) was supplied by Mid-Century Agro-Allied Ventures Ltd., Lagos. Anazyme-Forte® is a commercial phytase preparation manufactured by Versha Group of Companies, India, and specifically formulated for poultry diets to enhance nutrient release from phytate-bound complexes.

Experimental Diets

Five iso-caloric (2,977.40 kcal/kg metabolizable energy [ME]) and iso-nitrogenous (21.50% crude protein [CP]) experimental diets were formulated for starter noilers. The basal diet was composed of maize, soybean meal, PKC, bone meal, lysine, methionine, vitamin premix, and salt. The diets were supplemented with Anazyme-Forte® phytase enzyme at five inclusion levels: 0 g/100 kg (control), 10 g/100 kg, 15 g/100 kg, 20 g/100 kg, and 25 g/100 kg.

The percentage compositions of the diets are presented in Table 1. The diets met the minimum nutrient requirements for noiler starter chickens as recommended by the National Research Council (NRC, 1994). The vitamin-mineral premix supplied essential vitamins and minerals in line with established poultry feeding standards (Leeson & Summers, 2001).

Table 1: Percentage Composition of Starter Noiler Diets Supplemented with Phytase Enzyme

Ingredients (%)	T1 (0g/100 kg)	T2 (10g/100 kg)	T3 (15g/100 kg)	T4 (20g/100 kg)	T5 (25g/100 kg)
Maize	55.20	55.20	55.20	55.20	55.20
Soybean meal	34.00	34.00	34.00	34.00	34.00
PKC	7.00	7.00	7.00	7.00	7.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.10	0.10	0.10	0.10	0.10
Vitamin premix*	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Crude protein (%)	21.50	21.50	21.50	21.50	21.50
ME (kcal/kg)	2977.40	2977.40	2977.40	2977.40	2977.40

*Premix supplied per kg diet: Vitamin A 15,000 IU; Vitamin D3 13,000 IU; Thiamine 2 mg; Riboflavin 6 mg; Pyridoxine 4 mg; Cobalamin 0.05 g; Biotin 0.08 mg; Choline chloride 0.05 g; Mn 0.096 g; Zn 0.06 g; Fe 0.024 g; Cu 0.06 g; I 0.014 g; Se 0.024 mg; Co 0.024 mg; Antioxidant 0.125 g.

Experimental Animals and Brooding Management

One hundred and eighty (180) day-old Noiler chicks were used for the experiment. The poultry house was thoroughly cleaned and disinfected before the arrival of the chicks to minimise microbial load and reduce the risk of disease outbreaks (Sonaiya & Swan, 2004). The floor was covered with wood shavings as litter material.

Brooding lasted for one week using kerosene stoves, lamps, electric bulbs, and charcoal pots as heat sources. The brooding temperature was gradually reduced based on chicks' behavioural response, such as huddling (indicating cold stress) or panting and dispersing (indicating heat stress), following the guidelines of Oluyemi and Roberts (2000). During the first week, birds were provided with commercial starter feed and clean drinking water ad libitum.

Vaccinations were administered according to a standard poultry health program (Table 2). In addition, prophylaxis against coccidiosis was given at two weeks of age using Embazin-Forte®.

Table 2: Vaccination Schedule for Noiler Chicks

Age	Vaccine	Route
Day-old	Newcastle Disease (NCD)	Intraocular
14 days	Infectious Bursal Disease (IBDV)	Drinking water
21 days	Lasota (NCD booster)	Drinking water

Experimental Design and Rearing Management

After brooding, the chicks were randomly allotted to five dietary treatments in a completely randomised design (CRD). Each treatment had three replicates with 12 birds per replicate, giving 36 birds per treatment. The birds were housed in deep litter pens, provided with clean feeders and drinkers, and given feed and water ad libitum throughout the 21-day experimental period. Routine litter management, such as replacing wet wood shavings with dry ones, was practised to ensure hygiene and reduce ammonia buildup (Adene & Oguntade, 2006).

Data Collection

Data were collected on feed intake, body weight, weight gain, feed conversion ratio (FCR), protein intake, protein efficiency ratio (PER), and feed cost parameters.

Initial body weight: Birds were weighed after one week of brooding before dietary treatments began.

Feed intake: Daily feed intake was measured as the difference between feed offered and feed refused.

Body weight gain: Determined as final live weight minus initial live weight.

Average daily gain (ADG): Calculated as weight gain divided by experimental days (21).

Feed conversion ratio (FCR): Feed intake ÷ weight gain.

Protein intake: (% CP in diet × feed consumed)/100.

Protein efficiency ratio (PER): Weight gain ÷ protein intake.

Feed cost per bird: Total feed consumed × cost/kg feed.

Daily feed cost per bird: Total feed cost ÷ 21 days.

Cost per kg weight gain: FCR × cost/kg feed.

These indices follow standard poultry nutrition evaluation protocols (AOAC, 2005; NRC, 1994).

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using the General Linear Model procedure for a completely randomised design, as described by Steel and Torrie (1980). Significant treatment means were separated using Duncan's New Multiple Range Test (Duncan, 1955). Statistical significance was declared at $p < 0.05$.

Results and Discussion

Proximate Composition of Experimental Diets

The proximate composition of the experimental diets is presented in Table 3. The dry matter (DM) contents ranged from 92.12% to 93.22%, indicating that the diets were well-dried and within the acceptable moisture levels for poultry feeds. Adequate DM ensures stability, prevents microbial spoilage, and promotes longer shelf-life (Akinmutimi et al., 2006).

The ether extract (EE) content varied among treatments, with diet T2 (10 g/100 kg phytase enzyme) showing the highest value (9.84%), while the other diets ranged between 4.37% and 4.93%. Increased EE in T2 suggests improved lipid retention and nutrient stability. Phytase supplementation is known to positively influence nutrient utilization, particularly fat metabolism, by releasing bound minerals that facilitate enzyme activation (Cowieson et al., 2006).

The crude fibre (CF) content decreased with increasing phytase inclusion, from 5.82% in the control to 3.82% in T5. This reduction is in line with reports that phytase enhances fibre degradation by releasing bound nutrients and improving feed digestibility (Onyango et al., 2005).

Crude protein (CP) levels were highest in the control (23.54%) and dropped in the phytase-supplemented diets, with the lowest (20.15%) observed in T3. This apparent decline may be due to a dilution effect from enzyme supplementation or variation in nitrogen utilization. Although protein is critical for growth, phytase has been reported to improve amino acid availability and nitrogen retention, reducing the requirement for higher dietary CP (Selle & Ravindran, 2007).

Metabolizable energy (ME) was highest in T2 (368.93 kcal/g) compared to the control (330.25 kcal/g). The increased energy values with enzyme supplementation corroborate earlier findings that phytase improves carbohydrate utilization by releasing trapped phosphorus and other minerals required for energy metabolism (Shirley & Edwards, 2003).

Ash content ranged widely, from 9.70% in the control to 3.09% in T3, before increasing again in T4 (7.41%) and T5 (11.00%). The variations may reflect differences in mineral retention as influenced by enzyme activity. Nitrogen-free extract (NFE), an indicator of soluble carbohydrates, was highest in T3 (59.95%) and lowest in the control (49.19%), suggesting better carbohydrate digestibility at moderate enzyme inclusion levels.

Overall, the proximate composition indicates that phytase supplementation altered nutrient distribution in the diets. Similar trends have been reported by Cabahug et al. (1999), who observed improved nutrient utilization in poultry diets supplemented with phytase.

Table 4.1: Proximate composition of experimental diets (T_1-T_5)

Parameters	T1	T2	T3	T4	T5
DM (%)	92.62	93.22	92.12	92.71	92.67
EE (%)	4.37	9.84	4.87	4.93	4.93
CF (%)	5.82	5.74	4.06	4.10	3.82
CP (%)	23.54	20.46	20.15	20.44	20.63
Energy cal/g	330.25	368.93	348.23	349.45	336.21
Ash (%)	9.70	3.40	3.09	7.41	11.00
NFE (%)	49.19	53.78	59.95	55.83	52.29

DM: Dry matter, EE: Ether extract, CF: Crude fibre, CP: Crude protein, NFE: Nitrogen free extract

Performance of Starter Noiler Chickens

Table 4 summarises the performance parameters of starter noiler chickens (SBCs) fed diets supplemented with varying levels of phytase enzyme.

Body Weight and Weight Gain

The initial live weights of birds did not differ significantly ($P > 0.05$) among treatments, reflecting effective randomization and uniformity of the experimental chicks. However, the final live weight, total weight gain, and daily weight gain differed significantly ($P < 0.05$). Birds in T1 (control) recorded the highest final weight (726 g) and total gain (600 g), while T5 (25 g/100 kg enzyme) had the lowest values (627.67 g and 501 g, respectively).

These findings suggest that excessive phytase supplementation negatively influenced growth. This contrasts with the results of Saima et al. (2009), who reported significant improvements in body weight gain of noilers when fed phytase-supplemented, low-phosphorus diets. A likely explanation is that the phosphorus levels in the basal diets of this study were already adequate, primarily due to the inclusion of bone meal, which is highly bioavailable (Olomu, 1995). Therefore, additional phytase may not have conferred significant benefits and could have interfered with nutrient utilization.

Feed Intake and Feed Conversion Ratio (FCR)

Daily feed intake and total feed intake were statistically similar across treatments ($P > 0.05$), indicating that phytase supplementation did not significantly affect appetite or feed consumption. This finding agrees with Onyango et al. (2005), who reported no significant differences in feed intake with phytase inclusion.

The feed conversion ratio (FCR), however, differed significantly ($P < 0.05$). Birds in T1 had the best FCR (2.20), while T5 recorded the poorest (2.58). Poorer FCR in T5 indicates less efficient conversion of feed to body weight at higher enzyme inclusion. In contrast, studies by Shirley and Edwards (2003) and Cowieson et al. (2006) demonstrated improved FCR with phytase, particularly in diets deficient in non-phytate phosphorus. Again, the sufficiency of phosphorus in the basal diets likely masked the beneficial effects of phytase in the present study.

Protein Utilization

Protein efficiency ratio (PER) followed a similar trend, being highest in T1 (2.11) and lowest in T5 (1.80). The lower PER in high phytase diets suggests reduced efficiency of protein utilization. Phytase is known to enhance amino acid digestibility in phosphorus-deficient diets (Selle & Ravindran, 2007), but the presence of adequate bone meal phosphorus in this study likely limited the additional benefits.

Mortality Rate

Mortality rates differed significantly (P < 0.05), with the highest mortality recorded in T3 and T4 (5.56%) compared to the control (2.28%) and T5 (0%). Mortality in phytase-treated groups may have been influenced by unmeasured factors such as gut health or pathogenic challenges, though overall mortality rates were within acceptable limits for experimental poultry production (Sonaiya & Swan, 2004).

Table 4: The performance of noiler starter chickens fed diets supplemented with enzyme at different levels

Parameters	T_1	T_2	T_3	T_4	T_5	
	0g/100kg	10/100kg	15g/100kg	20g/100kg	25g/100kg	SEM
Initial live weight (g)	126.00	12.67	121.67	123.33	126.00	1.54
Final live weight (g)	726.00^{a}	700.33^{ab}	699.00^{ab}	671.00^{ab}	627.67^{b}	12.30
Total weight gain (g)	600.00^{a}	578.67^{ab}	577.33^{ab}	577.33^{ab}	501.00^{b}	12.30
Daily weight gain (g)	28.57^{a}	27.56^{ab}	27.49^{ab}	26.08^{ab}	23.89^{b}	0.63
Total feed intake (g)	1319.67	1315.33	1322.33	1301.33	1293.00	12.95
Daily feed intake (g)	62.75	62.64	62.97	61.57	61.57	0.62
FCR	2.20^{b}	2.28^{ab}	2.31^{ab}	2.38^{ab}	2.58^{a}	0.50
Daily protein intake (g)	13.49	13.47	13.54	13.32	13.24	0.13
PER	2.11^{a}	2.05^{ab}	2.05^{ab}	1.96^{b}	1.80^{b}	0.04
Mortality (%)	2.28$_{b}$	2.28	5.56^{a}	5.56^{a}	0^{c}	0.09

^{a,b,c} means in the same row with different superscripts are significantly different (P<0.05) SEM; Standard Error Mean, FCR: Feed Conversion Ratio, PER: Protein Efficiency Ratio

Feed Cost Benefit Analysis

The Feed Cost Benefit Analysis (Table 5) revealed that total feed intake, feed cost per bird, and daily feed cost per bird did not differ significantly (P > 0.05) among treatments. However, cost/kg feed and cost/kg weight gain differed (P < 0.05).

T1 (control) had the lowest cost/kg weight gain (215.31 ₦), while T5 (25 g/100 kg enzyme) had the highest (256.02 ₦). This indicates that increasing phytase supplementation beyond 20 g/100 kg reduced economic efficiency, likely due to the absence of corresponding improvements in growth performance. Similar results were observed by Saima et al. (2009), who reported that while phytase increased feed cost due to enzyme addition, it reduced cost/kg weight gain when diets were phosphorus-deficient.

The findings from this study suggest that phytase supplementation is not cost-effective when dietary phosphorus is sufficient. However, in scenarios where phosphorus sources are limited or expensive, phytase may serve as a viable alternative by reducing dependence on mineral phosphorus sources and mitigating environmental phosphorus excretion (Adeola & Cowieson, 2011).

Table 5: Economics of production of SBCs supplemented with phytase in their diets

Parameters	T_1	T_2	T_3	T_4	T_5	
	0g/100kg	10/100kg	15g/100kg	20g/100kg	25g/100kg	SEM
Cost/kg of feed (N)	98.74^{b}	99.34^{b}	99.64^{ab}	99.94-ab	100.24^{a}	0.14
Total feed intake (g/b)	1319.67	1315.33	1322.33	1301.33	1293.00	12.95
Total feed cost/bird (N)	129.08	129.44	130.53	128.85	128.41	1.26
Daily feed cost/bird (N)	6.21	6.22	6.27	6.19	6.17	0.04
Cost/kg weight gain (N)	215.31^{b}	224.27^{b}	228.18^{ab}	235.34^{ab}	256.02^{a}	5.10

[a,b,c] means in the same row with different superscripts are significantly different ($P<0.05$) SEM; Standard Error Mean,

The overall results indicate that phytase supplementation in starter noiler chicken diets containing adequate bone meal phosphorus did not significantly enhance growth performance or economic efficiency. While proximate composition analyses showed some variations in nutrient distribution, these did not translate into consistent performance improvements.

Several studies have emphasized that the primary role of phytase is to liberate phosphorus bound in phytate complexes, thereby improving phosphorus bioavailability, growth, and feed efficiency (Selle & Ravindran, 2007; Cowieson et al., 2006). The lack of positive response in the current study underscores the importance of diet formulation context. When diets are already sufficient in available phosphorus, phytase benefits may be minimal or even counterproductive, as excessive supplementation can disrupt nutrient balance.

Moreover, the economic analysis highlights that phytase supplementation adds to feed costs without providing proportional returns under phosphorus-sufficient conditions. This aligns with the conclusion of Cabahug et al. (1999), who stressed that phytase efficacy is diet-dependent and most pronounced in phosphorus-deficient diets.

Nonetheless, phytase remains valuable in poultry nutrition. Beyond phosphorus release, it improves amino acid digestibility, energy utilization, and mineral retention (Selle & Ravindran, 2007). Future research should therefore focus on formulating diets with reduced non-phytate phosphorus levels and testing phytase under such conditions in noiler chickens. This approach would allow for a more accurate assessment of its potential to enhance productivity and reduce feed costs.

Conclusion and Recommendation

The findings of this study demonstrated that dietary supplementation of Anazyme-Forte® phytase enzyme up to 20 g/100 kg in the diets of starter noiler chickens did not result in significant improvements in growth performance, feed utilisation, or protein efficiency ratio when compared with the control diet. Although some numerical variations were observed across treatments, the absence of statistically significant differences suggests that the phosphorus content of the basal diet was sufficient to meet the nutritional requirements of the birds without the need for enzyme supplementation. This aligns with the understanding that phytase supplementation yields optimal benefits when basal diets are formulated with reduced available phosphorus levels (Selle & Ravindran, 2007; Adeola & Cowieson, 2011).

Therefore, while phytase inclusion at the tested levels did not negatively impact bird performance, its cost-effectiveness in diets already adequate in phosphorus remains questionable. However, the potential of phytase to improve phosphorus utilisation, reduce feed cost, and mitigate environmental phosphorus excretion under conditions of low dietary phosphorus warrants further investigation.

Recommendations

1. **Dietary Phosphorus Adjustment**: Future studies should formulate starter noiler diets with deliberately reduced levels of available phosphorus. This will allow clearer assessment of phytase efficacy in enhancing phosphorus release from phytate-bound sources, thereby improving bird performance and nutrient utilisation.
2. **Higher Inclusion Levels**: Trials involving higher inclusion levels of phytase (beyond 25 g/100 kg) should be conducted to determine the threshold at which the enzyme maximally enhances growth performance and feed efficiency in noiler chickens.
3. **Economic Evaluation**: Comprehensive cost–benefit analyses, including feed cost per unit of weight gain under low-phosphorus conditions, should be performed to establish the economic feasibility of phytase supplementation.
4. **Nutrient Utilisation and Environmental Benefits**: Beyond growth performance, future research should examine the effects of phytase supplementation on phosphorus and nitrogen retention, mineral bioavailability, and reduction in nutrient excretion, thereby contributing to environmentally sustainable poultry production.
5. **Comparative Enzyme Studies**: It is recommended that phytase be evaluated alongside other exogenous enzymes (e.g., xylanase, protease) in multi-enzyme systems, as synergistic effects may further enhance nutrient utilisation in noiler chicken diets.

References

1. Abdel-Fattah, S. A., El-Sanhoury, M. H., El-Mednay, N. M., & Abdel-Azeem, F. (2008). Thyroid activity, some blood constituents, organs morphology and performance of noiler chicks fed supplemental organic acids. *International Journal of Poultry Science, 7*(3), 215–222.
2. Adeola, O., & Cowieson, A. J. (2011). Board-invited review: Opportunities and challenges in using exogenous enzymes to improve non-ruminant animal production. *Journal of Animal Science, 89*(10), 3189–3218. https://doi.org/10.2527/jas.2010-3715
3. Adene, D. F., & Oguntade, A. E. (2006). *The structure and importance of the commercial and village poultry industry in Nigeria.* FAO.
4. Adil, S., Banday, T., Bhat, G. A., Mir, M. S., & Rehman, M. (2010). Effect of dietary supplementation of organic acids on performance, intestinal histomorphology, and serum biochemistry of noiler chicken. *Veterinary Medicine International, 2010,* 479485. https://doi.org/10.4061/2010/479485
5. Ahiwe, E. U., Omede, A. A., Abdallh, M. B., Iji, P. A., & Graham, H. (2018). Water intake in poultry: A review. *World's Poultry Science Journal, 74*(3),

409–426. https://doi.org/10.1017/S0043933918000370
6. Akinmutimi, A. H., Ojewola, G. S., & Etuk, E. B. (2006). Response of noiler chicks fed raw and cooked pigeon pea seed meal diets. *International Journal of Poultry Science, 5*(7), 622–625.
7. AOAC. (2005). *Official methods of analysis* (18th ed.). Association of Official Analytical Chemists.
8. Cabahug, S., Ravindran, V., Bryden, W. L., & Selle, P. H. (1999). Response of noiler chickens to microbial phytase supplementation as influenced by dietary phytic acid and non-phytate phosphorus levels. *IUBMB Life, 48*(5), 449–455. https://doi.org/10.1080/15216549900201373
9. Castanon, J. I. R. (2007). History of the use of antibiotic as growth promoters in European poultry feeds. *Poultry Science, 86*(11), 2466–2471.
10. Cowieson, A. J., Acamovic, T., & Bedford, M. R. (2006). Phytate and microbial phytase: Implications for protein utilization by poultry. *Poultry Science, 85*(5), 878–885. https://doi.org/10.1093/ps/85.5.878
11. Dibner, J. J., & Buttin, P. (2002). Use of organic acids as a model to study the impact of gut microflora on nutrition and metabolism. *Journal of Applied Poultry Research, 11*(4), 453–463. https://doi.org/10.1093/japr/11.4.453
12. Dibner, J. J., & Richards, J. D. (2005). Antibiotic growth promoters in agriculture: History and mode of action. *Poultry Science, 84*(4), 634–643.
13. Duncan, D. B. (1955). Multiple range and multiple F tests. *Biometrics, 11*(1), 1–42.
14. Haque, M. N., Chowdhury, R., Islam, K. M. S., & Akbar, M. A. (2010). Propionic acid is an alternative to antibiotics in poultry diet. *Bangladesh Journal of Animal Science, 39*(1–2), 115–122.
15. Hernández, F., Madrid, J., García, V., Orengo, J., & Megías, M. D. (2006). Influence of two plant extracts on noilers performance, digestibility, and digestive organ size. *Poultry Science, 85*(9), 1690–1696. https://doi.org/10.1093/ps/85.9.1690
16. Islam, M. W., Rahman, M. M., Kabir, S. M. L., & Kamruzzaman, S. M. (2012). Effect of citric acid supplementation on the performance of noiler chicken. *Bangladesh Journal of Animal Science, 41*(1), 56–61. https://doi.org/10.3329/bjas.v41i1.11977
17. Leeson, S., & Summers, J. D. (2001). *Nutrition of the chicken* (4th ed.). University Books.
18. McDowell, L. R. (2000). *Vitamins in animal and human nutrition* (2nd ed.). Iowa State University Press.
19. Mellor, S. (2009). Alternatives to antibiotic growth promoters. *Pig Progress, 25*(10), 6–9.
20. Moghadam, H. N., Jahanian, R., & Alizadeh-Ghamsari, A. (2006). Effect of citric acid supplementation on growth performance, serum biochemistry, and immune responses in noilers. *International Journal of Poultry Science, 5*(12), 1162–1170. https://doi.org/10.3923/ijps.2006.1162.1170
21. National Research Council (NRC). (1994). *Nutrient requirements of poultry* (9th rev. ed.). National Academy Press.
22. Nwosu, C. V., Ezeokeke, C. T., & Ogbonna, J. U. (2014). Climatic conditions and poultry production in southeastern Nigeria. *Nigerian Journal of Animal Science, 16*(2), 45–53.
23. Olomu, J. M. (1995). *Monogastric animal nutrition: Principles and practice.* Jachem Publications.
24. Oluyemi, J. A., & Roberts, F. A. (2000). *Poultry production in warm wet climates* (2nd ed.). Spectrum Books.
25. Onyango, E. M., Bedford, M. R., & Adeola, O. (2005). Efficacy of supplemental phytase in noiler diets without inorganic phosphorus supplementation. *British Poultry Science, 46*(6), 665–672. https://doi.org/10.1080/00071660500395436
26. Patten, J. D., & Waldroup, P. W. (1988). Use of organic acids in noiler diets. *Poultry Science, 67*(8), 1178–1182. https://doi.org/10.3382/ps.0671178
27. Rahmani, H. R., & Speer, W. (2005). Natural additives influence the performance and health of poultry. *International Journal of Poultry Science, 4*(9), 713–717.
28. Ravindran, V. (2013). Poultry feed availability and nutrition in developing countries. In *Poultry Development Review* (pp. 60–63). FAO.
29. Ricke, S. C. (2003). Perspectives on the use of organic acids and short chain fatty acids as antimicrobials. *Poultry Science, 82*(4), 632–639.
30. Saima, H., Nadeem, A., Rehman, H., & Akram, M. (2009). Effect of phytase supplementation on growth performance, phosphorus and nitrogen retention in noilers fed diets with low available phosphorus. *Journal of Animal and Plant Sciences, 19*(1), 39–43.
31. Selle, P. H., & Ravindran, V. (2007). Microbial phytase in poultry nutrition. *Animal Feed Science and Technology, 135*(1–2), 1–41. https://doi.org/10.1016/j.anifeedsci.2006.06.010
32. Shirley, R. B., & Edwards, H. M. (2003). Graded levels of phytase past industry standards improves noiler performance. *Poultry Science, 82*(4), 671–680. https://doi.org/10.1093/ps/82.4.671
33. Sonaiya, E. B., & Swan, S. E. J. (2004). *Small-scale poultry production: Technical guide.* FAO.
34. Steel, R. G. D., & Torrie, J. H. (1980). *Principles and procedures of statistics: A biometrical approach* (2nd ed.). McGraw-Hill.
35. Windisch, W., Schedle, K., Plitzner, C., & Kroismayr, A. (2008). Use of phytogenic products as feed additives for swine and poultry. *Journal of Animal Science, 86*(14_suppl), E140–E148.

*Corresponding Author: **Onunkwo, D. N**