GROWTH PERFORMANCE AND ECONOMIC EVALUATION OF BROILER FINISHERS FED GRADED LEVELS OF RICE OFFAL SUPPLEMENTED WITH A XYLANASE–GLUCANASE ENZYME COMPLEX

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ABSTRACT

This study evaluated the effects of graded levels of rice offal (RO) supplemented with a xylanase–glucanase enzyme complex on the growth performance and economic efficiency of broiler finishers. The experiment was conducted at the Poultry Unit of Adamawa State University Teaching and Research Farm, Mubi, Nigeria.. A total of 180 four-week-old broiler chickens were randomly allotted to four dietary treatments in a completely randomized design, with three replicates of 10 birds each. The experimental diets contained 0% (control), 5%, 10%, and 15% rice offal, each supplemented with a xylanase–glucanase enzyme complex at the manufacturer's recommended level. The feeding trial lasted four weeks. Data were collected on final body weight, average daily weight gain (ADWG), average daily feed intake (ADFI), feed conversion ratio (FCR), feed cost per kilogram of feed, total feed intake, total weight gain, and feed cost per kilogram of weight gain. Data were subjected to analysis of variance using the General Linear Model procedure of IBM SPSS version 23, and treatment means were separated using Dunnett's test at $P < 0.05$. Results showed that birds fed the 10% RO diet recorded the highest ($P < 0.05$) final body weight (1,555.90 g), ADWG (34.75 g/day), and ADFI (119.74 g/day), while also achieving the best feed conversion ratio (3.50). Economic evaluation revealed that feed cost per kilogram decreased progressively with increasing RO inclusion, from ₦383.22 in the control diet to ₦332.26 at 15% RO. However, birds fed the 10% RO diet recorded the lowest feed cost per kilogram of weight gain (₦1,217.33), indicating superior economic efficiency compared with the control (₦1,406.42) and other treatments. It was concluded that incorporating 10% rice offal supplemented with a xylanase–glucanase enzyme complex in broiler finisher diets optimizes growth performance while reducing production costs. This feeding strategy provides a practical and economically sustainable alternative for poultry producers seeking to reduce dependence on conventional feed ingredients without compromising productivity.

Keywords: *Broiler finisher, rice offal, xylanase, glucanase, growth performance, economic efficiency, feed cost.*

Introduction

Feed accounts for approximately 65–75% of the total cost of broiler production, making it the single most expensive input in intensive poultry farming, particularly in developing countries where conventional feed ingredients are increasingly scarce and expensive (FAO, 2022; Afolayan *et al*., 2019). The escalating prices of maize and soybean meal, driven by competition between human consumption, livestock feeding, and industrial utilization, have significantly reduced the profitability of poultry enterprises. Consequently, considerable research efforts have focused on identifying alternative, locally available feed resources capable of partially replacing conventional ingredients without adversely affecting bird performance.

Rice offal (RO), a by-product generated during rice milling, is one such alternative feed resource that is readily available in many rice-producing regions of Nigeria. It consists mainly of rice bran, husk fragments, polishing residues, and broken rice particles, making it an inexpensive and sustainable feed ingredient (Ojewola *et al*., 2020). The increasing production of rice in Nigeria has resulted in substantial quantities of rice milling by-products that remain underutilized despite their considerable nutritional potential. Incorporating these by-products into poultry diets could reduce feed costs while promoting environmentally sustainable utilization of agricultural residues (Onyimonyi and Okeke, 2021).

Despite its economic advantages, the utilization of rice offal in broiler diets is limited by its relatively high crude fibre content and the presence of non-starch polysaccharides (NSPs), including arabinoxylans and β-glucans, which reduce nutrient digestibility and metabolizable energy availability (Choct, 2015). These anti-nutritional components increase intestinal viscosity, impair nutrient absorption, and ultimately depress growth performance and feed efficiency when included at high dietary levels (Akinola *et al*., 2017; Oluwatosin *et al*., 2019). Consequently, the nutritional limitations of rice offal have restricted its wider adoption in commercial poultry production.

Exogenous fibrolytic enzymes have become an effective nutritional strategy for improving the utilization of high-fibre feed ingredients. Among these, xylanase and glucanase have received considerable attention because they hydrolyze the NSP components of plant cell walls, thereby reducing digesta viscosity, enhancing nutrient release, improving intestinal function, and increasing the digestibility of energy and protein (Adeola and Cowieson, 2011; Olukosi *et al*., 2020). Several studies have demonstrated that supplementation of poultry diets with xylanase and glucanase improves feed conversion efficiency, body weight gain, nutrient utilization, and overall production performance when fibrous agro-industrial by-products are incorporated into the diets (Tiwari *et al*., 2021).

While numerous studies have reported the growth-promoting effects of enzyme supplementation, relatively few have simultaneously evaluated its economic benefits under broiler finisher production systems. Economic assessment is particularly important because improvements in biological performance may not necessarily translate into increased profitability. Feed cost per kilogram of weight gain remains one of the most reliable indicators for assessing the practical value of alternative feed ingredients in commercial poultry production. Therefore, evaluating both growth performance

and production economics provides a more comprehensive basis for recommending rice offal-based diets to poultry producers.

This study was therefore conducted to evaluate the effects of graded dietary inclusion levels of rice offal supplemented with a xylanase–glucanase enzyme complex on the growth performance and economic efficiency of broiler finishers.

Materials and Methods

Study Location

The experiment was conducted at the Poultry Unit of the Teaching and Research Farm, Adamawa State University, Mubi, Adamawa State, Nigeria. Mubi is located within the Northern Guinea Savannah ecological zone. The area experiences two distinct seasons: a dry season from November to March and a rainy season from April to October. Annual rainfall averages approximately 1,050 mm, with relative humidity ranging from 20–30% during the dry season to about 80% during the peak of the rainy season. Ambient temperature ranges from approximately 12°C during the cold season to about 40°C during the hot season (Weather Station, 2022).

Source of Feed Ingredients and Enzymes

Rice offal (RO) used in this study was obtained from a commercial rice mill located along Maiha Road, Mubi, Adamawa State. The rice offal was cleaned to remove foreign materials before incorporation into the experimental diets. The xylanase–glucanase enzyme complex (RONOZYME® MultiGrain, DSM Nutritional Products Ltd., Switzerland) containing endo-1,4-β-xylanase and β-glucanase was added according to the manufacturer's recommended inclusion rate of 100 g per 100 kg of feed. Other feed ingredients, including maize, maize offal, full-fat soybean, groundnut cake, bone meal, vitamin-mineral premix, methionine, lysine, and common salt, were procured from reputable feed ingredient suppliers in Mubi and Yola, Adamawa State.

Experimental Diets

Four experimental finisher diets were formulated to meet the nutrient requirements of broiler chickens as recommended by the National Research Council (NRC, 2018). The control diet contained no rice offal or enzyme supplementation, while the other three diets contained 5%, 10%, and 15% rice offal, designated as 5RO, 10RO, and 15RO, respectively. Each rice offal-containing diet was supplemented with a xylanase–glucanase enzyme complex at the manufacturer's recommended level. The gross composition and calculated nutrient composition of the experimental finisher diets are presented in Table 1.

Table 1: Gross composition (%) of the broiler finisher diets containing rice offal supplemented with xylanase-glucanase combination

Ingredients	Control	5RO	10RO	15RO
Maize	52.67	48.00	43.58	38.7
Maize offal	10.00	10.00	10.00	10.00
Rice offal	0.00	5.00	10.00	15.00
Full fat soybean	22.30	22.10	20.90	21.60
Groundnut cake	11.15	11.05	10.45	10.80
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
Methionine	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10
Calculated analysis				
ME (Kcal/kg)	3062.15	3022.11	3001.21	2998.11
Crude Protein	20.12	20.10	20.03	20.01
Crude Fibre	4.04	4.55	5.00	6.30
Calcium	1.10	1.10	1.10	1.10
Phosphorus	0.65	0.72	0.75	0.76
Methionine	0.57	0.54	0.54	0.56
Lysine	1.02	1.02	1.09	1.19

5RO, 10RO and 15RO: 5%, 10% and 15% levels of inclusion of rice offal, ME: metabolizable energy

Experimental Birds, Design and Management

A total of 120 healthy four-week-old broiler chickens of comparable body weight were randomly assigned to four dietary treatments in a completely randomized design (CRD). Each treatment consisted of three replicates with ten birds per replicate. The birds were housed in deep-litter pens equipped with feeders and drinkers and were managed under standard commercial husbandry practices throughout the four-week finisher period. Feed and clean drinking water were provided ad libitum, while routine vaccination and medication schedules were strictly followed.

Data Collection

Growth performance was evaluated by recording feed intake and body weight throughout the experimental period. Final body weight was obtained at the end of the feeding trial. Average daily weight gain (ADWG) was calculated as the difference between final and initial body weights divided by the number of experimental days, while average daily feed intake (ADFI) was determined by dividing total feed consumed by the duration of the experiment. Feed conversion ratio (FCR) was calculated as the ratio of feed consumed to body weight gained.

Economic Evaluation

Economic analysis was carried out using the prevailing market prices of feed ingredients during the study period. The cost of one kilogram of each experimental diet was calculated based on ingredient costs. Total feed cost was obtained by multiplying feed consumed by the cost per kilogram of feed. Feed cost per kilogram of weight gain was calculated using the following equation:

$$\text{Cost of the feed/kg (₦)} = \frac{\text{Total cost feed in Naira (₦)}}{\text{quantity of feed in kg}}$$

The economic parameters evaluated included cost per kilogram of feed, total feed consumed, total weight gain, and feed cost per kilogram of weight gain.

Statistical Analysis

Data collected on growth performance and economic parameters were subjected to one-way analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of IBM SPSS Statistics Version 23. Treatment means were separated using Dunnett's multiple comparison test, and differences among means were considered significant at **P < 0.05**.

Results and Discussion

Growth Performance of Broiler Finishers Fed Diets Containing Rice Offal Supplemented with a Xylanase–Glucanase Enzyme Complex

Table 2: Growth performance(g) of broiler finisher fed diets containing rice offal supplemented with xylanase-glucanase combination

Parameter	Control	5RO	10RO	15RO	SEM
Final weight (g)	1520.60^{c}	1539.80^{b}	1555.90^{a}	1552.30^{a}	12.24
ADWG (g)	32.40^{c}	33.10^{b}	34.75^{a}	34.20^{a}	0.18
ADFI (g)	114.00^{c}	116.50^{b}	119.74^{a}	119.20^{a}	0.24
FCR	3.52^{b}	3.52^{b}	3.50^{a}	3.53^{b}	0.02

The effects of graded dietary inclusion of rice offal supplemented with a xylanase–glucanase enzyme complex on the growth performance of broiler finishers are presented in **Table 2**. Significant (P <

0.05) differences were observed among the dietary treatments for final body weight, average daily weight gain (ADWG), average daily feed intake (ADFI), and feed conversion ratio (FCR).

Birds fed the 10% rice offal (10RO) diet recorded the highest final body weight (1,555.90 g), although this value was statistically similar ($P > 0.05$) to that obtained for birds fed the 15% rice offal diet (1,552.30 g). Both treatments produced significantly higher final body weights than the control (1,520.60 g) and the 5RO diet (1,539.80 g). The improved body weight observed at moderate rice offal inclusion suggests that supplementation with xylanase and glucanase enhanced the utilization of nutrients locked within the fibrous components of rice offal. Xylanase hydrolyzes arabinoxylans, while glucanase degrades β-glucans, thereby reducing intestinal viscosity and increasing nutrient digestibility (Adeola and Cowieson, 2011; Olukosi *et al*., 2020). Similar improvements in body weight have been reported in broilers fed enzyme-supplemented diets containing fibrous agro-industrial by-products (Tiwari *et al*., 2021).

Average daily weight gain followed a similar trend, with birds receiving the 10RO diet recording the highest gain (34.75 g/day), followed by those on the 15RO diet (34.20 g/day). The control birds had the lowest daily weight gain (32.40 g/day). The superior growth observed in birds fed the 10RO diet indicates that moderate inclusion of rice offal, when supplemented with appropriate fibrolytic enzymes, provided sufficient nutrients for efficient tissue accretion without imposing excessive dietary fibre that could limit digestion. Although birds fed the 15RO di*et al*so performed well, the slight decline in weight gain relative to the 10RO group may be attributed to the higher fibre concentration, which could partially offset the beneficial effects of enzyme supplementation. Comparable observations have been reported by Afolayan *et al*. (2019), who noted that moderate inclusion of alternative feed ingredients generally produces better growth responses than excessive inclusion levels.

Average daily feed intake increased significantly ($P < 0.05$) with increasing dietary rice offal levels. Birds fed the 10RO diet consumed the highest quantity of feed (119.74 g/day), closely followed by the 15RO group (119.20 g/day), whereas the control birds recorded the lowest intake (114.00 g/day). The increased feed consumption may reflect the lower dietary energy concentration associated with increasing rice offal inclusion, prompting birds to consume more feed to satisfy their energy requirements. Furthermore, enzyme supplementation may have improved gut health and nutrient availability, thereby encouraging feed intake. Similar increases in feed intake have been reported in broilers fed enzyme-treated high-fibre diets (Choct, 2015; Onyimonyi and Okeke, 2021).

Feed conversion ratio differed significantly among treatments, with birds fed the 10RO diet recording the most efficient feed utilization (3.50), whereas the control, 5RO, and 15RO diets recorded slightly higher values of 3.52, 3.52, and 3.53, respectively. Although the numerical differences were relatively small, the superior feed conversion observed at the 10% inclusion level demonstrates that the birds converted feed into body weight more efficiently than those receiving the other diets. The improved efficiency can be attributed to enhanced degradation of non-starch polysaccharides by the xylanase–

glucanase complex, resulting in improved nutrient digestibility and utilization. These findings agree with reports by Adeola and Cowieson (2011) and Olukosi *et al*. (2020), who demonstrated that fibrolytic enzymes improve feed efficiency by increasing the availability of nutrients trapped within plant cell walls.

Overall, the results indicate that supplementation of broiler finisher diets containing rice offal with a xylanase–glucanase enzyme complex effectively supported growth performance. The 10% rice offal inclusion level consistently produced the best combination of body weight, weight gain, feed intake, and feed conversion ratio, suggesting that this level represents the optimum balance between dietary fibre inclusion and enzyme effectiveness.

Economic Evaluation of Broiler Finishers Fed Diets Containing Rice Offal Supplemented with a Xylanase–Glucanase Enzyme Complex

Results

Table 3: Cost benefits of feeding broiler finisher with diets containing rice offal supplemented with xylanase-glucanase combination

Parameters	Control	5RO	10RO	15RO
Cost/kg feed (₦)	383.22	366.44	342.91	332.26
Total feed consumed (g)	2149.1	2426.7	2514.5	2461.5
Total weight Gain (g)	635.7	666.0	729.7	636.4
Cost/kg gain (₦)	1406.42	1333.84	1217.33	1289.2

The economic evaluation of broiler finishers fed graded levels of rice offal supplemented with a xylanase–glucanase enzyme complex is presented in Table 3. Progressive inclusion of rice offal substantially reduced feed cost while maintaining satisfactory growth performance, demonstrating the economic potential of replacing conventional feed ingredients with this readily available agro-industrial by-product.

The cost of one kilogram of feed decreased steadily from ₦383.22 in the control diet to ₦332.26 in the diet containing 15% rice offal, representing a reduction of approximately 13%. This decline

reflects the lower market price of rice offal relative to conventional ingredients such as maize. Similar reductions in feed cost following the inclusion of agro-industrial by-products have been reported by Ogundipe *et al*. (2020), who concluded that the utilization of inexpensive feed resources can substantially reduce production costs without adversely affecting bird performance.

Total feed consumption increased from 2,149.10 g in the control treatment to 2,514.50 g in the 10RO treatment before declining slightly at the 15% inclusion level. The higher feed intake observed at moderate inclusion levels corresponded with improved growth performance, indicating that birds effectively utilized the additional feed consumed. The slight reduction in feed intake at 15% inclusion may be associated with increased dietary fibre concentration, which can reduce gut fill and nutrient utilization when included beyond optimum levels. Similar findings have been reported by Musa and Nworgu (2020), who observed that excessive dietary fibre may depress voluntary feed intake and nutrient utilization in broiler chickens.

Total weight gain followed a similar pattern, increasing from 635.70 g in the control treatment to a maximum of 729.70 g at the 10% rice offal inclusion level before declining at 15% inclusion. This confirms that enzyme supplementation enabled birds to efficiently utilize moderate quantities of rice offal while maintaining high growth rates. However, excessive fibre at the highest inclusion level may have slightly reduced nutrient availability despite enzyme supplementation.

Feed cost per kilogram of body weight gain represents one of the most reliable indicators of production profitability. In the present study, birds fed the 10RO diet recorded the lowest feed cost per kilogram of weight gain (₦1,217.33), compared with ₦1,333.84 for the 5RO diet, ₦1,289.20 for the 15RO diet, and ₦1,406.42 for the control. The reduction in feed cost per unit of weight gain demonstrates that moderate inclusion of rice offal, coupled with enzyme supplementation, improved biological efficiency while simultaneously lowering production costs. These findings agree with those of Osei *et al*. (2023), who reported that exogenous enzyme supplementation enhances the economic value of fibrous feed ingredients by improving nutrient utilization and feed efficiency.

The combined improvement in growth performance and reduction in production cost observed at the 10% inclusion level demonstrates that this dietary strategy offers the greatest economic advantage. From a practical perspective, incorporating 10% rice offal supplemented with a xylanase–glucanase

enzyme complex can reduce dependence on expensive conventional feed ingredients while maintaining optimal broiler finisher performance. This approach provides poultry producers with a sustainable and economically viable feeding strategy capable of improving profitability, particularly under conditions of increasing feed ingredient prices.

Conclusion and Recommendation

The findings of this study demonstrated that the inclusion of rice offal supplemented with a xylanase–glucanase enzyme complex had a positive influence on the growth performance and economic efficiency of broiler finishers. Birds fed diets containing 10% rice offal consistently achieved superior final body weight, average daily weight gain, feed intake, and feed conversion efficiency compared with the control and other dietary treatments. Although increasing the inclusion level of rice offal progressively reduced the cost of feed, the 10% inclusion level produced the lowest feed cost per kilogram of weight gain, indicating the highest economic return. These results suggest that supplementation with xylanase and glucanase effectively enhanced the utilization of the fibrous components of rice offal, thereby improving nutrient availability and supporting optimum growth performance. It can therefore be concluded that rice offal can successfully replace part of conventional feed ingredients in broiler finisher diets when supplemented with appropriate fibrolytic enzymes, with 10% inclusion representing the optimum level for maximizing biological performance and production profitability.

Based on the results obtained in this study, it is recommended that broiler producers incorporate rice offal at 10% dietary inclusion in finisher diets supplemented with a xylanase–glucanase enzyme complex to improve growth performance while reducing feed cost. The use of fibrolytic enzymes should be encouraged whenever fibrous agro-industrial by-products are included in poultry diets to enhance nutrient digestibility and feed utilization. The adoption of rice offal as a partial substitute for conventional feed ingredients offers a practical and sustainable strategy for reducing production costs, particularly in regions where feed prices continue to rise. Furthermore, additional studies should be conducted under commercial production conditions to evaluate the long-term effects of enzyme-supplemented rice offal diets on carcass quality, meat characteristics, nutrient digestibility, and overall profitability

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