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Effects of replacing maize, with rice milling waste with or without enzyme supplementation, on performance and nutrient digestibility of broiler chickens

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Abstract: The escalating cost of conventional feed ingredients, such as maize, commonly used as the primary energy source, has intensified the search for cost-effective alternatives in broiler production. Rice milling waste (RMW), an abundant agro-industrial by-product, presents a promising substitute. This study evaluated the effects of replacing maize with RMW, with or without enzyme supplementation, on the growth performance and nutrient digestibility of broiler chickens. A total of 280 one-day-old Arbor Acre broiler chicks were randomly assigned to seven dietary treatments in a completely randomized design, each with four replicates of 10 birds. Treatment 1 served as the control (0% RMW), while Treatments 2, 4, and 6 involved 20%, 30%, and 40% maize replacement with RMW without enzyme supplementation, respectively. Treatments 3, 5, and 7 had the same replacement levels but were supplemented with enzymes. The trial lasted for 7 weeks. Proximate analysis of RMW showed 3.62% crude protein, 39.74% crude fibre, 16.57% nitrogen-free extract, 1.87% crude fat, and 89.76% dry matter. Dietary treatments significantly ($p < 0.05$) influenced final body weight, weight gain, feed intake, feed conversion ratio, and feed cost efficiency. Birds fed enzyme-supplemented RMW diets (Treatments 3, 5, and 7) showed improved performance compared to their unsupplemented counterparts. It was concluded that RMW can replace maize up to 40% in broiler diets when enzymes are added.

Keywords: rice milling waste; performance characteristics; enzyme; broiler chickens

INTRODUCTION

Broiler chickens, widely reared for meat production, play a crucial role in global animal protein supply due to their rapid growth rate, efficient feed conversion, and short production cycle. As the demand for poultry meat continues to rise, the economic viability of broiler production hinges largely on the cost and availability of quality feed, which accounts for approximately 70–80% of total production expenses (Olukosi et al., 2008). Efficient feed formulation, therefore, remains a central concern in commercial poultry operations. To sustain high performance, broiler

diets must be rich in energy, protein, and readily digestible nutrients, all of which are traditionally provided by conventional feed ingredients such as maize. Maize is the predominant cereal grain used in poultry diets, valued for its high energy content and palatability. It can contribute up to 60% of total dietary inclusion in broiler rations, mainly as a source of metabolizable energy. However, increasing competition for maize between the feed industry, human consumption, and bio-fuel production has led to soaring prices and supply instability (Mateos et al., 2012). This situation has compelled nutritionists and feed formulators to explore cost-effective and locally available

alternatives that can replace maize partially or wholly without compromising bird performance.

Rice milling waste (RMW), a by-product of rice processing, has emerged as a promising substitute for maize in poultry diets. It comprises a heterogeneous mixture of rice bran, broken grains, husks, and fine particles. Nutrient composition varies based on the milling method and the proportion of each component, but RMW generally contains moderate levels of protein and energy along with high fiber content. Onabanjo et al., (2021) reported that RMW contains approximately 89.84% dry matter, 10.80% crude protein, 24.09% crude fiber, and 15.08% ash, with a gross energy of 3,789 kcal/kg. These values suggest that RMW could serve as a viable feed ingredient, especially in regions where rice processing is prevalent, and maize is expensive. Other researchers have also reported similar proximate compositions. Oladunjoye et al. (2014) documented values of 91.1% dry matter, 7.3% crude protein, 18.0% crude fiber, and 1.8% ether extract in rice milling by-products. Poultry lack endogenous enzymes to degrade non-starch polysaccharides (NSPs) and lignocellulosic materials and inclusion beyond certain levels depresses feed efficiency and nutrient digestibility (Ani et al., 2013). As a result, RMW inclusion beyond certain levels could depress feed efficiency and nutrient digestibility.

To mitigate the limitations associated with high-fiber feed ingredients, enzyme supplementation has become an effective nutritional strategy in broiler production. Exogenous enzymes, such as cellulase, xylanase, amylase, and protease improve nutrient availability by degrading complex carbohydrates and anti-nutritional factors in fibrous feedstuffs. Numerous studies have highlighted the benefits of enzyme use in poultry diets, particularly those incorporating alternative feed ingredients like RMW (Ani et al., 2013; Esiegwu and Okonkwo, 2019).

Ani et al. (2013) observed that broilers fed diets containing 20% RMW, with Roxazyme G2® enzyme showed improved feed conversion efficiency and weight gain compared to non-supplemented counterparts. Similarly, Esiegwu and Okonkwo (2019) reported that broilers receiv-

ing Maxigrain® enzyme at 150 g/ton with 15% RMW inclusion had better feed utilization and reduced mortality. These findings demonstrate that enzyme supplementation enhances the feeding value of RMW, making it more suitable for broiler nutrition.

Given the rising cost of maize, the availability of rice milling waste, and the growing accessibility of commercial enzyme blends, the strategic replacement of maize with enzyme-supplemented RMW presents a viable solution for sustainable and cost-effective broiler production. This study, therefore, seeks to evaluate the maize replacement value of rice milling waste with or without enzyme supplementation in the diets of broiler chickens, focusing on growth performance and nutrient digestibility.

MATERIALS AND METHOD

Experimental site/Location

This experiment was carried out at the Poultry Production and Research unit, Teaching and Research Farm of the Ladoke Akintola University of Technology, Ogbomosho, situated in the derived savanna zone of Southwest of Nigeria, and lies on latitude 8°8' 31.7940"N of the Equator, and longitude 4°14'42.6696"E of the Greenwich Meridian.

Experimental animals and management

A total of two-hundred-and-eighty-day-old Arbor Acres broiler chicks were used for the experiment. The birds were weighed at the commencement of the experiment and randomly distributed into seven treatments, each with four replicates, after weighing and each replicate had ten (10) birds, making a total of forty birds per treatment. The birds were managed intensively in a deep litter housing system. Each replicate was housed in pen measuring 130cm x 97cm x 186cm. All necessary vaccinations and medications were administered appropriately. The birds were offered feed and water at the starter phase for 21 days and the finisher phase for 28 days *ad libitum* throughout the experiment which lasted for 49 days.

Test ingredients:

Rice milling waste was obtained from a Rice milling factory at Owode area, Ogbomoso, Oyo state. Enzyme was procured from a very reputable vendor in Lagos state.

Enzyme profile:

ENZYME 1:

Name; phytase

Form; granular

Usage; to improve growth, weight gain and performance

Recommended rate of inclusion; 5g/100kg
ENZYME 2:

Name; Yiduozyme compound enzyme

Form; granular

Usage; to improve growth, weight gain and performance

Recommended rate of inclusion; 5g/100kg

Experimental design:

Seven experimental layouts were designed as follows:

Diet 1- Control diet without enzyme (basal diet).

Table 1. Composition of starter diets (g/100g)

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7
Maize	52.00	41.60	41.60	36.40	36.40	31.20	31.20
Soy oil	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Soybean	33.00	33.00	33.00	33.00	33.00	33.00	33.00
Wheat offal	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Rice Milling Waste	0.00	10.40	10.40	15.60	15.60	20.80	20.80
Enzyme	-	-	+	-	+	-	+
Fish meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Dicalcium Phosphate	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
*Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
<i>Nutrient analysis</i>							
ME (kcal/kg)	3117.10	2889.34	2889.34	2775.46	2775.46	2661.58	2661.58
Crude protein (%)	21.55	21.03	21.03	20.77	20.77	20.51	20.51
Ether extract (%)	3.55	4.04	4.04	4.33	4.33	4.59	4.59
Crude fibre (%)	4.16	7.90	7.90	9.77	9.77	11.64	11.64
Lysine (%)	1.40	1.38	1.38	1.36	1.36	1.35	1.35
Methionine (%)	0.63	0.61	0.61	0.60	0.60	0.60	0.60
Calcium (%)	1.59	1.58	1.58	1.58	1.58	1.58	1.58
Phosphorus (%)	0.872	0.80	0.80	0.78	0.78	0.77	0.77
Cost /kg of feed (#/kg)	338.11	318.33	333.33	308.15	322.65	299.56	314.56

*Vitamin premix per kg of diet: vitamin A, 12,000IU; vitamin D3, 2500IU; vitamin E, 30IU; vitamin K, 2.0mg; vitamin B1, 2.25mg; vitamin B2, 6.0mg; vitamin B6, 4.5mg; vitamin B12, 0.015mg; Niacin 40mg; Panthetonic acid 15mg; Folic acid 1.5mg; Biotin 0.05mg; Chlorine chloride 300mg; Manganese 80mg; Zinc 50mg; Iron 20mg; Copper 5.0mg; Iodine 1.0mg; selenium 0.2mg; Cobalt 0.5mg; Antioxidant 125mg.

Source: Akinola et al., 2025

Diet 2- 20% maize of basal diet replaced, with rice milling waste without enzyme supplementation.

Diet 3- 20% maize of basal diet replaced, with rice milling waste with enzyme supplementation.

Diet 4- 30% maize of basal diet replaced, with rice milling waste without enzyme supplementation.

Diet 5- 30% maize of basal diet replaced, with rice milling waste with enzyme supplementation.

Diet 6- 40% maize of basal diet replaced, with rice milling waste without enzyme supplementation.

Diet 7- 40% maize of basal diet replaced, with rice milling waste with enzyme supplementation.

Experimental diets

The gross composition of the experimental diets is presented in Tables 1 and 2.

Data collection

Data were obtained from the following parameters:

Growth performance characteristics: The performance of broiler chicken was measured by using the following parameters.

Table 2. Composition of finisher diets (g/100g)

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7
Maize	51.00	40.80	40.80	35.70	35.70	30.60	30.60
Soy oil	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Soybean	29.50	29.50	29.50	29.50	29.50	29.50	29.50
Wheat offal	9.50	9.50	9.50	9.50	9.50	9.50	9.50
Rice Milling Waste	0.00	10.20	10.20	15.30	15.30	20.40	20.40
Enzyme	-	-	+	-	+	-	+
Fish meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Dicalcium Phosphate	2.00	2.00	2.00	2.0	2.00	2.00	2.00
Limestone	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
*Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
<i>Nutrient analysis</i>							
ME (kcal/kg)	3070.10	2847.47	2847.47	2735.78	2735.78	2624.09	2661.58
Crude protein (%)	20.76	20.25	20.25	19.99	19.99	19.74	19.74
Ether extract (%)	3.54	4.05	4.05	4.31	4.31	4.56	4.56
Crude fibre (%)	4.29	7.95	7.95	9.79	9.79	11.62	11.62
Lysine (%)	1.34	1.32	1.32	1.31	1.31	1.30	1.30
Methionine (%)	0.62	0.60	0.60	0.59	0.59	0.59	0.59
Calcium (%)	1.58	1.58	1.58	1.58	1.58	1.58	1.58
Phosphorus (%)	0.81	0.79	0.79	0.77	0.77	0.76	0.76
Cost/kg of feed (#/kg)	328.81	309.21	323.71	299.43	313.92	289.63	304.13

*Vitamin premix per kg of diet: vitamin A, 12,000IU; vitamin D3, 2500IU; vitamin E, 30IU; vitamin K, 2.0mg; vitamin B1, 2.25mg; vitamin B2, 6.0mg; vitamin B6, 4.5mg; vitamin B12, 0.015mg; Niacin 40mg; Panthetonic acid 15mg; Folic acid 1.5mg; Biotin 0.05mg; Chlorine chloride 300mg; Manganese 80mg; Zinc 50mg; Iron 20mg; Copper 5.0mg; Iodine 1.0mg; selenium 0.2mg; Cobalt 0.5mg; Antioxidant 125mg.

Source: Akinola et al., 2025

i. Total Feed Intake: the feed intake was calculated by deducting the left-over feed from feed offered and then divided by the number of birds.

$$\text{Total feed intake} = \frac{(\text{feed offered} - \text{leftover feed})}{\text{Number of birds}}$$

ii. Total Weight Gain: This was calculated by subtracting the initial weight from the final weight.

$$\text{Total weight gain} = \text{final weight} - \text{initial weight}$$

iii. Daily Weight Gain: This was calculated as total weight gain in a week divided by the number of days

$$\text{Daily weight gain} = \frac{\text{Total weight gain in a week}}{7 \text{ days}}$$

iv. Feed Conversion Ratio: This was derived by dividing the total feed consumed by the total weight gain of the birds.

$$\text{Feed to gain ratio} = \frac{\text{total feed intake}}{\text{total weight gain}}$$

v. Feed Cost per Kg: The feed cost was calculated by dividing the total feed cost by quantities of feed formulated.

$$\text{Feed cost} = \frac{\text{Total feed cost}}{\text{Quantity of feed}}$$

vi. Feed Cost per Kg Weight gain: This was done by multiplying the feed cost per Kg and the feed to gain ratio.

$$\text{Feed Cost per Kg Weight gain} = \text{feed cost} \times \text{feed to gain ratio}$$

vii. Daily Feed Intake: This was done by dividing the total feed intake by the number of days.

$$\text{Daily feed intake} = \frac{\text{Total feed intake}}{\text{Number of days}}$$

Digestibility trial: At the 49th day of experiment, four (4) birds were selected randomly from each treatment and transferred to the metabolic cages for digestibility study. The birds were acclimatized for four days after which data on daily feed intake and excreted faeces was collected daily for three days. The faeces were collected into aluminium foil and oven dried at 60 °C for 8 days and sub-samples were taken for proximate analysis.

Proximate and statistical analyses

Rice milling waste, experimental diets and dried faecal samples was analysed for proximate composition using the procedure of AOAC (2023).

Data were analyzed using one – way analysis of variance (ANOVA) of the General Linear Model of SAS (2000) software. Means were separated using Duncan Multiple Range Test of the same statistical package (Duncan, 2010).

RESULTS AND DISCUSSION

The growth of broiler chickens fed diet containing varying rice milling waste, supplemented with or without enzyme at starter phase is presented in Table 3. Initial body weights were similar ($p > 0.05$) across all treatments, indicating uniformity of the experimental birds at the start. However, significant ($p < 0.05$) differences were observed in final weight, total weight gain, daily weight gain, feed intake, and feed conversion ratio (FCR). Birds fed the control diet (T1) and those on 20% RMW + enzyme (T3) recorded the highest ($p < 0.05$) final weights and total weight gains, while the lowest values were observed in birds fed 40% RMW (T6). Enzyme supplementation improved growth performance at each inclusion level, as seen in the superior body weight gain in birds on enzyme-supplementation (T3, T5, T7) compared with birds on the non-supplemented treatments. (T2, T4, T6). Feed intake was highest ($p < 0.05$) in birds fed 20% and 40% RMW with enzyme (T3 and T7), but lowest in control and 20% RMW (T1, T2). Feed cost per kilogram of feed (₺/kg) was lowest ($p < 0.05$) in T6 (₺299.56) and highest in T1 (₺388.11), showing that RMW inclusion reduced feed cost. However, the best feed-to-gain ratio (1.11) was recorded for the control group, followed closely by enzyme-supplemented RMW diets (T3 and T5), while the poorest (1.42) was in 40% RMW + enzyme (T7).

The improved final weight and weight gain of birds fed 20% RMW + enzyme (T3) compared to those on higher inclusion levels, suggest that

Table 3. Growth performance of broiler chicks fed diets containing rice milling waste, supplemented with or without enzyme at starter phase

Parameters	T1	T2	T3	T4	T5	T6	T7	SEM	P-value
Initial weight(g)	46.35	46.93	46.63	46.10	45.58	45.53	45.68	0.18	0.09
Final weight (g)	620.55 ^a	589.51 ^b	619.25 ^a	559.03 ^c	585.38 ^b	543.25 ^d	571.30 ^c	5.20	0.01
Total weight gain (g)	574.20 ^a	524.63 ^b	570.58 ^a	512.93 ^c	539.80 ^b	497.73 ^d	525.63 ^b	5.19	0.01
Daily weight gain (g)	27.34 ^a	25.84 ^{ab}	27.12 ^a	24.43 ^c	25.70 ^{ab}	23.70 ^d	25.03 ^a	0.25	0.02
Total feed intake (g)	618.48 ^c	622.27 ^c	733.59 ^a	670.53 ^b	649.45 ^b	644.53 ^b	741.45 ^a	4.42	0.03
Daily feed intake (g)	29.45 ^c	29.63 ^c	34.93 ^a	31.93 ^b	30.93 ^b	31.64 ^b	35.31 ^a	0.21	0.01
FC/KG (₺)	388.11 ^a	318.33 ^d	333.33 ^b	308.15 ^e	322.65 ^c	299.5f	314.56 ^d	0.75	0.02
FCR	1.11 ^d	1.18 ^c	1.33 ^{ab}	1.33 ^{ab}	1.25 ^c	1.36 ^a	1.42 ^a	0.01	0.01
FC/KG(WG) (₺)	374.44 ^b	376.40 ^b	422.80 ^a	408.38 ^b	401.89 ^b	408.51 ^b	446.47 ^a	4.63	0.02

^{abcdef} Means within each row with different superscripts are significantly different ($p < 0.05$)

T1: Control, T2: 20% rice milling waste, T3: 20% rice milling waste + enzymes, T4: 30% rice milling waste, T5: 30% rice milling waste + enzymes, T6: 40% rice milling waste, T7: 40% rice milling waste + enzyme.

SEM: Standard Error of Mean. FC/KG= Feed cost/kg, FCR= Feed conversion ratio, FC/KG(WG)= Feed cost/kg (weight gain).

Source: Akinola et al., 2025

moderate replacement of maize with RMW, when combined with exogenous enzymes, can sustain efficient nutrient utilization during the starter phase. The reduction in growth at higher inclusion levels ($\geq 30\%$) may be attributed to increased crude fibre and lignocellulosic content in RMW, which can limit nutrient digestibility and energy availability (Olusiyi and Wafar, 2017; Onabanjo et al., 2021). The positive response to enzyme supplementation agrees with earlier findings that exogenous enzymes such as xylanase, cellulase, and phytase improve nutrient release from fibrous feed ingredients by hydrolyzing non-starch polysaccharides (NSPs) and phytate complexes (Olukosi et al., 2008; Choct, 2015). Enzymes enhanced metabolizable energy and amino acid availability, promoting better feed efficiency in T3 and T5 compared with un-supplemented RMW diets. Feed intake increased with RMW inclusion, possibly due to the bulkier nature of fibrous feed materials which stimulate good motility and appetite (Bodie and Micciche, 2019). However, the highest intake in T7 (40% RMW + enzyme) did not correspond to proportional weight gain, indicating reduced nutrient conversion efficiency at higher fiber levels. This finding is consistent with

the report of Zhang et al. (2021), who observed reduced energy utilization in broilers as rice bran inclusion increased beyond optimal levels. The decreased feed cost per kilogram in RMW-based diets indicates the economic advantage of incorporating RMW as a partial maize substitute. Despite the lower feed cost, performance was best maintained at 20% RMW + enzyme (T3), suggesting this level achieves a balance between cost savings and growth efficiency. Similar cost-benefit outcomes were reported by Onabanjo et al., (2021) and Afolayan et al., (2020), who noted that agro-industrial by-products supplemented with enzymes can reduce feeding costs without impairing productivity.

The growth of broiler fed diet containing varying rice milling waste, supplemented with or without enzyme at finisher phase, is presented in Table 4. Initial body weight did not differ significantly among treatments ($p > 0.05$). Final body weight differed significantly ($p < 0.05$). The control group T1 recorded a final weight of 1530.45 g, which was comparable to the enzyme-supplemented 20% and 40% groups T3 (1580.83 g) and T7 (1562.55 g), and higher than the unsupplemented high-RMW treatments T 4 (1359.77 g)

Table 4. Growth performance of broiler chickens fed diets containing rice milling waste, supplemented with or without enzyme at finisher phase

Parameters	T1	T2	T3	T4	T5	T6	T7	SEM	P-value
Initial weight (g)	618.75	587.84	611.98	557.72	588.53	541.83	581.08	12.57	0.07
Final weight (g)	1530.45 ^a	1414.09 ^b	1580.83 ^a	1359.77 ^c	1437.08 ^b	1375.00 ^c	1562.55 ^a	28.47	0.04
Total weight gain (g)	911.70 ^b	826.26 ^d	968.86 ^a	802.05 ^c	848.55 ^c	833.18 ^d	981.47 ^a	30.10	0.02
Daily weight gain (g)	43.41 ^b	39.35 ^d	46.14 ^a	38.19 ^c	40.41 ^c	39.68 ^d	46.74 ^a	1.53	0.04
Total feed intake (g)	2549.78 ^d	2552.92 ^d	3108.38 ^a	2607.89 ^c	2410.12 ^c	2696.18 ^c	2986.78 ^b	41.04	0.04
Daily feed intake (g)	121.42 ^d	121.58 ^d	148.02 ^a	124.19 ^c	114.77 ^c	128.39 ^c	142.23 ^b	1.95	0.03
Feed Cost/KG of feed (₦)	328.81	309.21	323.71	299.43	313.92	289.63	304.13	0.02	0.06
FCR	3.12 ^d	3.26 ^c	3.31 ^b	3.39 ^b	2.96 ^e	3.53 ^a	3.09 ^e	0.14	0.02
Feed Cost/ KG of Wight Gain (₦)	1025.15 ^b	1007.81 ^c	1070.75 ^a	1015.77 ^c	929.86 ^c	1021.52 ^b	939.72 ^c	42.62	0.04
Mortality (%)	0.00 ^c	0.00 ^c	0.29 ^a	0.10 ^c	0.05 ^d	0.15 ^b	0.12 ^c	0.05	0.02

^{abcd} Means within rows with different superscript differ significantly ($p < 0.05$).

T1: Control, T2: 20% rice milling waste, T3: 20% rice milling waste + enzymes, T4: 30% rice milling waste, T5: 30% rice milling waste + enzymes, T6: 40% rice milling waste, T7: 40% rice milling waste + enzyme.

SEM: Standard Error of Mean. FC/KG= Feed cost/kg, FCR= Feed conversion ratio, FC/KG(WG): Feed cost/kg (weight gain).

Source: Akinola et al., 2025

and T6 (1375.00 g). Total weight gain followed the same pattern: T1(911.70 g), while T3 (968.86 g) and T7 (981.47 g) showed the greatest gains; the lowest gains occurred in T4 (802.05 g) and T6 (833.18 g) ($p < 0.05$). Daily weight gain differed ($p < 0.05$), with T1 (43.41 g/day), T3 (46.14 g/day) and T7 (46.74 g/day) at the upper range, and T4 (38.19 g/day) at the lower range. Total feed intake varied ($p < 0.05$): T1 consumed (2549.78 g), while the highest intake was T3 (3108.38 g) and the lowest T5 = (2410.12 g). Daily feed intake mirrored totals T1 (121.42 g/day). Feed conversion ratio (FCR) differed significantly ($p < 0.05$). The control (T1) had FCR (3.12), intermediate to the best value T5 (2.96) and the poorest T6 (3.53). Feed cost per kg gain also varied ($p < 0.05$): T1 (₦1025.15), compared with T5 (₦929.86) and T7 (₦939.72). Mortality was low overall, but significantly different among treatments ($p < 0.05$): T1 and T2 (0.00%), highest in T3 (0.29%).

The control diet performed satisfactorily, providing a baseline for comparing RMW treat-

ments. Enzyme supplementation in RMW diets improved growth performance, demonstrating enhanced nutrient digestibility and absorption. Birds receiving enzyme-treated RMW diets achieved performance comparable to or exceeding that of the control diet, suggesting that enzymes effectively reduce the anti-nutritional effects of fiber and phytate (Giacobbo et al., 2021; Fortes et al., 2024). High RMW inclusion without enzyme negatively affected growth and feed efficiency, confirming that untreated RMW can limit nutrient availability (Bodie and Micciche, 2019; Olayemi et al., 2020). The improved feed conversion in moderate RMW diets with enzyme indicates more efficient utilization of feed nutrients and better biological performance compared with unsupplemented high-RMW diets (Radhi et al., 2023). Economically, enzyme supplementation with RMW reduced feed cost per unit of weight gain relative to the control diet, highlighting the potential for cost-effective poultry production using locally available feed resources (Shuvo et al.,

2022). Mortality remained low, indicating that inclusion of RMW, especially when enzyme-supplemented, is safe for broilers.

Table 5 shows the nutrient digestibility of broiler chickens fed diet containing varying rice milling waste, supplemented with or without enzyme.

Dry matter (DM) digestibility differed significantly ($P < 0.05$) among treatments, with the highest value (96.39%) recorded in birds fed 30% RMW without enzyme (T4) and the lowest (94.22%) in those, fed 40% RMW without enzyme (T6). Crude protein (CP) digestibility showed no significant difference ($P > 0.05$) among treatments, with values ranging from 97.43% to 98.34%. Crude fat digestibility differed significantly ($P < 0.05$), being highest in T4 (98.70%) and lowest in T6 (97.72%). Crude fibre digestibility also showed significant variation ($P < 0.05$), with the highest value (92.02%) in T4 and the lowest (86.37%) in T6. Similarly, ash digestibility was highest in T4 (93.31%) and lowest in T6 (88.65%). Gross energy (GE) digestibility varied ($P < 0.05$), ranging from 98.03% (T6) to 98.77% (T4). Metabolizable energy (ME) was significantly higher in T5 (100.46 kcal/kg) than in other treatments. Nitrogen-free extract (NFE) digestibility was also significantly affected ($P < 0.05$), with the highest value (95.42%) recorded in T4 and the lowest (92.74%) in T6.

The results demonstrate that the nutrient digestibility of broiler chickens fed diets containing RMW was significantly influenced by both the level of inclusion and enzyme supplementation. The superior digestibility values observed at 30% RMW inclusion (T4 and T5) suggest that this level provided an optimal balance between nutrient density and fibre content, allowing better digestion and absorption of nutrients. Moderate inclusion of fibrous feed ingredients has been reported to stimulate gizzard development and enzyme secretion, improving nutrient utilization (Choct, 2015; Alabi et al., 2019).

The lack of significant differences in crude protein digestibility across treatments indicates that RMW inclusion, up to 40%, did not drastically impair protein digestion. This aligns with the findings of Olukosi et al., (2008), who observed that enzyme supplementation improves protein and energy utilization without necessarily altering apparent CP digestibility when alternative feed ingredients are used. The improved digestibility of dry matter, crude fat, and energy in the 30% RMW diets could be attributed to enhanced nutrient accessibility, possibly due to reduced anti-nutritional effects at moderate inclusion levels (Kolade et al., 2023).

Enzyme supplementation (T3, T5, T7) further improved nutrient digestibility, particularly for ME

Table 5. Nutrient digestibility of broiler chickens fed diets containing rice milling waste, supplemented with or without enzyme

Parameters	T1	T2	T3	T4	T5	T6	T7	SEM	P-value
Dry Matter (%)	94.44 ^{bc}	95.92 ^{ab}	94.65 ^{bc}	96.39 ^a	95.77 ^{ab}	94.22 ^c	95.55 ^{abc}	0.22	0.03
Crude Protein (%)	97.71	98.25	97.62	98.34	98.11	97.43	97.55	0.12	0.27
Crude Fat (%)	97.99 ^{ab}	98.60 ^{ab}	97.98 ^{ab}	98.70 ^a	98.45 ^{ab}	97.72 ^c	98.41 ^{ab}	0.10	0.03
Crude Fibre (%)	87.26 ^{bc}	90.42 ^{ab}	87.61 ^{bc}	92.02 ^a	89.97 ^{ab}	86.37 ^c	89.10 ^{abc}	0.52	0.02
Ash (%)	89.73 ^{bc}	92.55 ^{ab}	90.38 ^{bc}	93.31 ^a	91.65 ^{abc}	88.65 ^c	91.69 ^{abc}	0.42	0.03
G. E(kcal/kg)	98.14 ^{ab}	98.62 ^{bc}	98.25 ^{abc}	98.77 ^a	98.55 ^{abc}	98.03 ^c	98.49 ^{abc}	0.08	0.04
ME (kcal/kg)	99.99 ^b	99.99 ^b	99.99 ^b	99.99 ^b	100.46 ^a	99.99 ^b	100.02 ^b	0.05	0.02
NFE (%)	92.89 ^{bc}	94.77 ^{ab}	93.25 ^{bc}	95.42 ^a	94.64 ^{ab}	92.74 ^c	94.34 ^{abc}	0.28	0.03

^{abcd} Means within rows with different superscript differ significantly ($p < 0.05$).

T1: Control, T2: 20% rice milling waste, T3: 20% rice milling waste + enzymes, T4: 30% rice milling waste, T5: 30% rice milling waste + enzymes, T6: 40% rice milling waste, T7: 40% rice milling waste + enzyme. SEM: Standard Error of Mean.

Source: Akinola et al., 2025

and GE, confirming previous reports that exogenous enzymes such as xylanase, cellulase, and phytase degrade non-starch polysaccharides (NSPs), reduce intestinal viscosity, and release encapsulated nutrients (Kim et al., 2021). These enzymes hydrolyze cell wall components, allowing better access of endogenous enzymes to starch and protein fractions (Ravindran et al., 2019). Consequently, birds fed enzyme-supplemented RMW diets (especially T5) achieved higher metabolizable energy values than birds on non-supplemented diet treatment, indicating more efficient nutrient conversion. Conversely, digestibility parameters declined significantly in treatments containing 40% RMW (T6 and T7), implying that excessive fibre and lignin fractions in RMW limit nutrient accessibility and enzyme-substrate interaction. Abubakar et al., (2024) similarly reported that high levels of rice by-products, such as rice husk, decreased nutrient digestibility due to elevated cellulose and hemicellulose contents. The reduction in digestibility at high RMW inclusion corroborates the findings of Elbaz et al., (2023), who reported that excessive fibrous feedstuffs may exceed the enzymatic degradation capacity of broilers, even in enzyme-supplemented diets. The improved digestibility recorded in 30% RMW diets, particularly with enzyme inclusion, supports the feasibility of partial maize replacement with RMW in broiler diets. (Kolade et al., 2023; Alabi et al., 2019).

CONCLUSION

Rice milling waste can effectively replace part of the maize in broiler diets when supplemented with enzymes. Birds fed 40% inclusion level of rice milling waste at the finisher phase, with enzyme supplementation had better performance when compared with other treatments. Rice milling waste can therefore replace maize up to 40% of control with enzyme supplementation, thus having a significant effect on performance.

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