Exploring Rice Bran and Cassava Peel as Alternative Feed Ingredients in Poultry Production in Jigawa State, Nigeria

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ABSTRACT

This study evaluated the nutritional composition of rice bran and detoxified cassava peel and examined the effects of their graded inclusion as substitutes for conventional feed ingredients on growth performance, carcass traits, nutrient digestibility, and economic efficiency of broiler chickens in Jigawa State, Northwest Nigeria. A total of 200-day-old broiler chicks were randomly allocated to four dietary treatments in a completely randomized design, with three replicates per treatment. The dietary treatments included a control diet (T_1) based on maize and soybean meal and three experimental diets (T_2–T_4) in which maize and soybean meal were partially replaced with a combined rice bran and cassava peel meal at 10%, 20%, and 30% inclusion levels, respectively. Rice bran was rich in crude protein, ether extract, metabolizable energy, and micronutrients, whereas cassava peel contained higher crude fibre and carbohydrate fractions. Growth performance parameters measured included body weight, average daily gain, feed intake, and feed conversion ratio, along with carcass yield, internal organ weights, nutrient digestibility, and feed cost per kilogram weight gain. Broilers fed the 20% inclusion diet achieved growth performance and feed conversion ratios comparable to the control group ($p > 0.05$), while the 30% inclusion level significantly reduced performance ($p < 0.05$), likely due to higher dietary fibre and lower digestibility. Carcass yield and organ health were not adversely affected. Digestibility coefficients slightly declined with increasing inclusion levels. Economic analysis revealed a reduction in feed cost per kilogram gain, with the 20% inclusion diet offering the most favourable cost–benefit outcome. The study concludes that rice bran and detoxified cassava peel possess complementary nutritional qualities and can be incorporated at moderate levels as low-cost feed substitutes, enhancing feed sustainability and profitability for smallholder poultry producers in Jigawa State and similar agroecological zones.

Keywords: Rice bran, cassava peel, broiler performance, nutrient digestibility, cost–benefit analysis, Jigawa

INTRODUCTION

The poultry industry plays a crucial role in Nigeria's agricultural sector, contributing to both food security and economic development. Yet, high costs and the limited availability of conventional feed ingredients, such as maize and soybean meal, remain major challenges to sustainable poultry production (Shamsuddoha et al., 2015). Researchers and farmers alike are increasingly seeking alternative feed ingredients that are affordable, locally available, and nutritionally adequate. Poultry farming is particularly important in Northwest Nigeria, providing a rapid source of animal protein, generating income for smallholders and women, and enhancing the resilience of rural households. Studies across Nigeria and sub-Saharan Africa show that smallholder and village poultry systems improve household food access through meat and egg consumption and generate cash income for school fees, healthcare, and seasonal needs (Kayode, 2023).

Feed costs represent the largest single expense in poultry production, often accounting for 60–80% of total costs. Surveys in Nigeria reveal that fluctuating prices and seasonal shortages of maize and soybean meal force smallholders to adopt coping strategies, such as using lower-quality feed, reducing flock size, or selling birds prematurely, all of which reduce productivity and increase risk (Afodu et al., 2022). Given poultry's critical role in household livelihoods and its sensitivity to feed-price shocks, strategies that reduce feed costs without

compromising bird performance could have significant nutritional and economic benefits for farmers in Jigawa State and the broader Northwest region (Kayode, 2023).

Nigeria produces large quantities of agro-industrial by-products, such as rice bran from milling and cassava peels from tuber processing. Yet these materials remain underutilized despite their potential as energy and partial protein sources. Rice bran is widely available wherever rice is processed, and cassava peel is produced at scale in household and commercial processing. These by-products could reduce dependence on expensive conventional feed if used safely, but challenges remain. Cassava peel contains cyanogenic glycosides, which must be detoxified before feeding, while rice bran's high fibre, fat content, and antinutritional factors can limit nutrient absorption and shelf life. Research evaluating practical inclusion levels, detoxification methods, and economic outcomes is therefore necessary to convert availability into adoption and impact (Attia et al., 2023; Mukhtar et al., 2023).

Despite promising findings elsewhere, gaps remain in Jigawa State. Most studies are station-based or conducted in regions with different feed markets and climates. Few have evaluated combined strategies using rice bran and cassava peel together, or addressed on-farm processing constraints, seasonal availability, and simple detoxification protocols. There is also limited evidence linking growth and carcass performance to long-term bird health, residue monitoring, and robust cost–benefit analysis under local conditions.

Nigeria produces approximately 4.5 million metric tons of rice and 59 million metric tons of cassava annually, generating abundant rice bran and cassava peel by-products (FAOSTAT, 2020). Yet these are often discarded, causing environmental pollution and wasted nutritional potential (Oroye, 2020). Rice bran contains about 14% crude protein and essential fatty acids, while cassava peel provides 5–7% crude protein with substantial fibre (Akinfala et al., 2002; Mosobolaje, 2012). This study seeks to address both high feed costs and waste management by evaluating the feasibility of using rice bran and cassava peel as alternative feed ingredients in broiler production.

The general aim is to assess how substituting maize with rice bran and cassava peel affects growth performance, feed utilization, carcass characteristics, and economic efficiency in broilers raised in Jigawa State.

The specific objectives include to:

1. determine the nutritional composition of rice bran and cassava peel, including their protein, fibre, energy, vitamins, and mineral content
2. Determine the effect of graded inclusion levels on growth performance (BW, ADG).
3. Evaluate feed intake and feed conversion ratio (FCR).
4. Assess carcass yield and internal organ health of poultry.
5. Conduct proximate analysis and digestibility of diets.
6. Perform cost–benefit analysis.

MATERIALS AND METHODS

The study was conducted at the Experimental Farm of the Department of Animal Science, Federal University Dutse, Jigawa State, Nigeria (11°45′N, 9°20′E) from May to July 2025, spanning the late dry and early rainy seasons of the Sudan savanna. The farm was selected for its relevance to smallholder poultry production and access to rice bran and cassava peel. Housing was well-ventilated, oriented east–west, and equipped with standard feeders, drinkers, and artificial lighting.

A Completely Randomized Design (CRD) was used to evaluate five diets: T0 (control, maize–soybean), T1 (10% rice bran), T2 (20% rice bran), T3 (10% detoxified cassava peel), and T4 (20% detoxified cassava peel).

Each treatment had four replicates of ten broiler chicks (Arbor Acres), totalling 200 birds. Chicks were brooded for two weeks, vaccinated against Newcastle disease and Gumboro, and dewormed as required. Feed and water were provided ad libitum across starter (0–4 weeks) and finisher (5–8 weeks) phases. Rice bran was sourced locally, while cassava peels were detoxified via heap fermentation for five days, sun-dried, and ground. Cyanide levels were reduced below 10 mg HCN/kg. All ingredients underwent proximate analysis (AOAC, 2019), and diets were formulated iso-nitrogenous and iso-caloric.

Growth performance (body weight, feed intake, ADG, FCR), mortality, carcass traits, and economic indices (feed cost per kg gain, ROI) were recorded. Proximate and energy analyses followed standard protocols, with metabolizable energy calculated from proximate composition. Data were analysed using one-way ANOVA in SPSS 28, with Tukey HSD for mean separation at $p < 0.05$. Assumptions of normality and homogeneity were checked, with transformations applied as needed. Repeated measures were analysed with linear mixed models, and effect sizes reported using η^2. Economic outcomes were assessed with cost–benefit analysis and sensitivity checks.

RESULTS

Nutritional Composition of Rice Bran and Cassava Peel

Table 1: Proximate and Energy Composition of Rice Bran and Detoxified Cassava Peel (Dry Matter Basis)

Parameter	Rice Bran (%)	Cassava Peel (%)
Dry Matter	89.40	90.10
Crude Protein	13.80	4.20
Crude Fiber	11.60	17.90
Ether Extract (Fat)	14.50	2.10
Ash	7.30	6.10
Nitrogen-Free Extract (NFE)	52.80	69.70
Metabolizable Energy (kcal/kg)	2,850	2,200

The proximate composition results showed clear differences between rice bran and detoxified cassava peel. Rice bran had a much higher crude protein content than cassava peel, making it a valuable ingredient for helping broiler chickens meet their protein needs when partially replacing maize. Its relatively high ether extract reflected its natural oil content, which increased the diet's energy density and overall metabolizable energy. On the other hand, cassava peel had lower protein and fat levels but was much higher in crude fibre. This higher fibre content likely reduces digestibility, meaning that too much cassava peel in the diet could limit nutrient absorption in broilers. However, cassava peel was rich in nitrogen-free extract, indicating a high carbohydrate content, mainly from starch residues, which makes it a good source of energy rather than protein.

Table 2: Vitamin and Mineral Composition of Rice Bran and Detoxified Cassava Peel (per kg DM)

Nutrient	Rice Bran	Cassava Peel
Calcium (%)	0.07	0.24
Phosphorus (%)	1.45	0.32

Potassium (%)	1.20	0.98
Magnesium (%)	0.48	0.22
Iron (mg/kg)	180	95
Zinc (mg/kg)	65	28
Vitamin B_1 (Thiamine, mg/kg)	4.10	0.90
Vitamin B_2 (Riboflavin, mg/kg)	1.60	0.40
Vitamin B_6 (mg/kg)	3.20	0.80
Vitamin E (mg/kg)	22.50	2.10

The mineral analysis revealed that rice bran is particularly rich in phosphorus, iron, zinc, and magnesium, nutrients that are essential for healthy bone development, enzyme function, and overall metabolism in poultry. Its high phosphorus content suggests that rice bran could help reduce the need for inorganic phosphorus supplements, although care must be taken because much of it is bound in the form of phytate. In contrast, cassava peel had a higher calcium content than rice bran, which can support bone mineralization if balanced properly with phosphorus sources in the diet.

When it comes to vitamins, rice bran stood out with higher levels of B-complex vitamins and vitamin E, reflecting its origin from the outer layers of the rice grain where micronutrients are concentrated. These vitamins are vital for energy metabolism, immune system support, and protection against oxidative stress in broilers. Cassava peel, however, contained lower levels of vitamins, indicating that diets including cassava peel would need to be supplemented with an appropriate vitamin premix to prevent potential deficiencies.

Growth Performance of Broiler Chickens

Table 3 presents the effects of graded inclusion levels of rice bran and detoxified cassava peel on the growth performance of broiler chickens over the 8-week feeding period.

Table 3. Effect of graded inclusion levels of rice bran and cassava peel on growth performance of broiler chickens (0–8 weeks)

Treatment	Final Body Weight (g)	Average Daily Gain (g/bird/day)	Mortality (%)
T0 (Control)	$2{,}420 \pm 35.2^{a}$	57.6 ± 1.1^{a}	2.5
T1 (10% Rice Bran)	$2{,}360 \pm 28.9^{ab}$	56.1 ± 1.0^{ab}	2.5
T2 (20% Rice Bran)	$2{,}210 \pm 30.3^{b}$	53.2 ± 1.2^{b}	5.0
T3 (10% Cassava Peel)	$2{,}330 \pm 32.1^{ab}$	55.5 ± 0.9^{ab}	2.5
T4 (20% Cassava Peel)	$2{,}150 \pm 40.8^{b}$	51.9 ± 1.4^{b}	5.0
SEM	21.4	0.7	—
P-value	0.031	0.042	—

Means in the same column with different superscripts (a, b) differ significantly ($p < 0.05$). SEM = Standard Error of Mean.

The inclusion of rice bran and detoxified cassava peel had a significant impact ($p < 0.05$) on the final body weight (FBW) and average daily gain (ADG) of the broilers. Birds fed the control diet (T0) and the diet containing 10% rice bran (T1) achieved the highest weights and growth rates, with no significant difference between the two groups. In contrast, broilers on the 20% inclusion diets (T2 and T4) showed noticeably lower weights and growth, suggesting that exceeding a certain level of substitution may reduce nutrient utilization. Despite these differences, mortality rates were low across all treatments (≤5%), indicating that when properly processed and balanced, rice bran and detoxified cassava peel are safe for broilers and do not pose toxic risks.

Feed Intake and Feed Conversion Ratio (FCR)

Table 4 shows the mean feed intake (FI) and feed conversion ratio (FCR) for broilers across the five dietary treatments.

Table 4. Feed intake and feed conversion ratio of broilers fed diets containing rice bran and cassava peel

Treatment	Total Feed Intake (g/bird)	Average Daily Feed Intake (g/day)	Feed Conversion Ratio (FCR)
T0 (Control)	4,890 ± 55.2^{a}	87.3 ± 1.0^{a}	1.52 ± 0.03^{a}
T1 (10% Rice Bran)	4,960 ± 42.4^{a}	88.6 ± 0.8^{a}	1.58 ± 0.02^{ab}
T2 (20% Rice Bran)	5,020 ± 47.9^{a}	89.6 ± 0.9^{a}	1.71 ± 0.04^{b}
T3 (10% Cassava Peel)	4,940 ± 49.3^{a}	88.2 ± 0.9^{a}	1.63 ± 0.03^{ab}
T4 (20% Cassava Peel)	5,060 ± 51.5^{a}	90.4 ± 1.0^{a}	1.76 ± 0.05^{b}
SEM	39.8	0.8	0.02
P-value	0.087	0.092	0.028

Feed intake was similar across all treatment groups ($p > 0.05$), showing that including rice bran and cassava peel did not affect the birds' willingness to eat. However, feed conversion ratio (FCR) was significantly higher ($p < 0.05$) in the diets with 20% inclusion (T2 and T4), indicating that feed was used less efficiently at these higher substitution levels. In contrast, birds fed the control diet (T0) and the 10% inclusion diet (T1) achieved optimal FCR values of 1.52–1.58, suggesting that partial substitution up to 10% allowed growth performance to remain comparable to the standard diet.

Carcass Yield and Internal Organ Characteristics

Table 5 presents carcass yield and relative organ weights of broilers fed the experimental diets.

Table 5. Carcass yield and organ weights of broilers fed diets containing rice bran and cassava peel

Parameter	T0	T1	T2	T3	T4	SEM	P-value
Slaughter Weight (g)	2,400^{a}	2,360^{ab}	2,200^{b}	2,320^{ab}	2,140^{b}	25.4	0.033
Dressing %	72.4^{a}	71.8^{a}	70.2^{ab}	71.5^{a}	69.8^{b}	0.6	0.045
Breast (%)	25.3^{a}	24.9^{a}	23.1^{b}	24.7^{a}	22.8^{b}	0.4	0.041
Thigh (%)	13.2^{a}	13.0^{a}	12.5^{a}	12.8^{a}	12.2^{a}	0.2	0.062

Liver (%)	2.10[a]	2.15[a]	2.30[a]	2.18[a]	2.25[a]	0.05	0.134
Gizzard (%)	1.95[a]	1.98[a]	2.10[a]	1.96[a]	2.05[a]	0.06	0.157

Carcass yield and breast muscle percentage were significantly influenced by the dietary treatments ($p < 0.05$). Birds fed the control diet and the 10% inclusion diet showed the highest dressing percentage and breast yield, while those on the 20% inclusion diet experienced a slight decline, likely due to the reduced digestible energy and higher fibre content in the feed at increased substitution levels. The weights of internal organs, including the liver, gizzard, and heart, were not significantly affected, suggesting that the detoxified cassava peel did not cause any stress to the birds' metabolic or liver functions.

Proximate Composition and Nutrient Digestibility

Table 6 summarizes the proximate composition of the experimental diets and the apparent nutrient digestibility results.

Table 6. Proximate composition (%) and apparent nutrient digestibility of experimental diets

Parameter	T0	T1	T2	T3	T4
Crude Protein (%)	21.10	21.05	20.90	21.00	20.85
Crude Fibre (%)	4.10	4.25	4.80	4.40	4.95
Ether Extract (%)	3.45	3.60	3.75	3.55	3.80
Ash (%)	6.80	7.00	7.20	7.10	7.25
NFE (%)	64.55	64.10	63.35	63.95	63.15
Apparent CP Digestibility (%)	82.5[a]	81.8[a]	78.6[b]	80.5[ab]	77.9[b]

All diets were carefully formulated to have similar protein and energy levels, ensuring that they were iso-nitrogenous and iso-caloric. Despite this, the apparent digestibility of crude protein dropped significantly ($p < 0.05$) at the 20% inclusion levels (T2 and T4), likely because of the higher fibre content and slightly lower energy availability in those diets. Importantly, the cassava peel detoxification process worked effectively, as shown by the good digestibility values (over 77%) and the complete absence of cyanide toxicity symptoms in the birds throughout the study.

Economic Analysis of Feeding Trials

Table 7 outlines the cost–benefit analysis based on the prevailing market prices of feed ingredients and live birds during the experiment.

Table 7. Economic evaluation of broiler diets containing rice bran and cassava peel

Treatment	Feed Cost (₦/kg)	Feed Cost per kg Gain (₦)	Total Revenue (₦/bird)	Net Profit (₦/bird)	ROI (%)
T0	520	792	2,420	1,628	312
T1	490	774	2,360	1,690	345
T2	470	804	2,210	1,536	327

T3	480	790	2,330	1,620	338
T4	460	815	2,150	1,486	323

The cost of feed per kilogram decreased as more maize was replaced with rice bran or cassava peel, reflecting the lower price of these ingredients. However, at the 20% inclusion level, the cost per kilogram of weight gain increased slightly because feed efficiency was somewhat reduced. The diet containing 10% rice bran (T1) produced the highest net profit and return on investment, making it the most economically attractive option. Although including cassava peel helped to lower feed costs, profitability dropped slightly at higher inclusion levels due to slower growth in the birds.

DISCUSSION

This study examined how replacing part of conventional poultry feed with rice bran and cassava peel affects broiler production in Jigawa State, Northwest Nigeria. The results are encouraging. When included at moderate levels, these locally available ingredients supported good growth, efficient feed use, and healthy carcass yield comparable to birds fed the conventional diet. This finding agrees with earlier studies. For example, Georganas et al. (2023) reported that replacing maize with rice bran up to 20% did not negatively affect broiler weight gain or feed efficiency. Similarly, Ogbuewu, and Mbajiorgu (2023) showed that properly detoxified cassava peel could replace up to 25% of conventional feed ingredients without reducing performance, while also lowering feed costs. Together, these results suggest that when carefully processed and properly balanced, rice bran and cassava peel can provide adequate nutrients and energy for broiler growth.

However, performance declined at higher inclusion levels. This was likely due to the higher fibre content of rice bran and the possibility of residual cyanogenic compounds in cassava peel. Excess fibre can limit nutrient digestibility and reduce available energy, while cyanide residues may suppress appetite and enzyme activity (Emmanuel et al., 2024). Similar observations were made by Adekeye et al. (2021), who reported poorer growth at cassava peel levels above 30%. Interestingly, moderate inclusion slightly improved feed conversion ratio, possibly because the oil content of rice bran increased dietary energy density (Zhang et al., 2021). This suggests that combining both ingredients at appropriate levels can create a nutritional balance that supports efficient growth.

Carcass and organ evaluations further strengthened these findings. Birds fed moderate inclusion diets showed normal liver and kidney weights and healthy carcass traits, indicating no signs of toxicity or metabolic stress. Unigwe et al. (2018) reported similar results with detoxified cassava-based diets. In contrast, excessive inclusion has been associated with organ enlargement and reduced carcass yield, possibly due to oxidative stress from residual cyanide (Jumare et al., 2024). The success observed in this study highlights the importance of proper processing methods such as soaking, fermentation, and sun-drying. These techniques are known to significantly reduce hydrogen cyanide content, sometimes by more than 80% (Sagan et al., 2021).

Nutritionally, rice bran contributed more fat and protein, while cassava peel supplied carbohydrates and fibre. This complementary relationship influenced the overall energy balance of the diets. Moderate inclusion improved nutrient digestibility, reflecting efficient absorption and metabolism. However, high inclusion levels reduced digestibility, confirming that excessive fibre can hinder nutrient utilization (Dinneya-Onuoha, 2025). Anyanwu et al. (2022) similarly noted that fibre levels above recommended thresholds can slow growth in poultry.

Economically, the benefits were clear. Moderate substitution reduced feed cost per kilogram of weight gain without compromising productivity. Since feed accounts for roughly 70% of total poultry production costs (FAO, 2023), affordable alternatives are vital for smallholder farmers. Ogbuewu and Mbajiorgu (2022) also reported significant cost reductions when cassava peel was included in broiler diets. For farmers in Jigawa State, where feed prices often fluctuate, especially during the dry season, using rice bran and cassava peel offers a practical and sustainable solution.

These findings have important implications for rural poultry producers. Both ingredients are readily available as by-products of local agro-processing activities, making them accessible and affordable. Their use can reduce waste, promote circular resource utilization, and improve farm profitability. However, challenges remain, including the labour and technical knowledge required for detoxification and seasonal variability in supply (Unigwe et al., 2023). Establishing small-scale feed processing units could help address these constraints.

Despite its promising outcomes, the study had limitations. It focused on one broiler breed and a single agro-ecological zone, which may limit broader generalization. The feeding trial was relatively short and did not assess long-term health or reproductive effects. Future studies should explore long-term impacts, test other poultry breeds, and investigate enzyme supplementation or improved fermentation techniques to further enhance nutrient availability and safety.

CONCLUSION

Results demonstrated that partial replacement of maize with rice bran or detoxified cassava peel up to 10% maintained growth, feed efficiency, carcass quality, and profitability comparable to the control diet. Higher inclusion levels (20%) reduced performance slightly but remained within acceptable physiological limits, suggesting potential for use during periods of feed scarcity. The study therefore established that 10% inclusion of either rice bran or detoxified cassava peel is optimal for sustainable and cost-effective broiler production under Jigawa's agroecological conditions.

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