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Leveraging rice bran as an alternative feed ingredient: Effects on growth performance, carcass traits, and economic efficiency of Japanese quail (*Coturnix japonica*)

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A B S T R A C T

The study was conducted to evaluate the potential use of rice bran (RB) as a partial substitute for conventional feed in the diet of Japanese quails (*Coturnix japonica*). A total of 240 unsexed, 2-week-old quails were randomly assigned to one of four dietary treatments (0%, 10%, 20% and 30%) in a completely randomized design, with six replicates per treatment and ten birds per replicate. Growth performance parameters, including feed intake, body weight gain, average daily gain (ADG), and feed conversion ratio (FCR), were recorded weekly. At the end of the experiment, two birds per replicate, closest to the mean cage weight, were selected for carcass evaluation. Results showed rice bran inclusion did not significantly ($P > 0.05$) influence final body weight, body weight gain, ADG, total feed intake, ADFI, and FCR. Nonetheless, at the starter phase, BW ($P = 0.0193$), BWG ($P = 0.0146$), TFI and ADFI ($P = 0.0010$), and FCR ($P = 0.0075$) were significantly affected by dietary treatments. From the results, the RB_20 diet recorded the highest BW (143.33 g), BWG (90.83 g), and ADG (4.33 g/day), significantly outperforming the RB_30 group, which exhibited the lowest growth performance. Feed intake parameters showed a similar trend, with RB_20 significantly increasing ADFI (21.22 g/day) and TFI (445.50 g), while RB_0 recorded the lowest values. Conversely, FCR was adversely affected at higher inclusion levels, with RB_10 and RB_20 showing significantly higher FCR values than RB_0, whereas RB_30 exhibited intermediate efficiency. Carcass weight (95–102 g), thigh muscle yield (21.33–23.00 g), and wing weight (5.67–8.33 g) were also not significantly ($P > 0.05$) affected by dietary RB levels. Compared with the other treatment diets, the economic analysis showed that 30% RB inclusion resulted in the lowest feed cost (GH₵ 5.58). In summary, growth performance was optimized at 20% RB inclusion, suggesting improved nutrient utilization at moderate inclusion levels. Furthermore, increasing RB inclusion up to 30% in Japanese quail diets did not adversely affect growth performance or carcass traits, while significantly reducing feed costs. These findings highlight the potential of rice bran as a cost-effective alternative feed ingredient.

Keywords: Feed cost, Rice bran, Growth performance, Carcass traits, Japanese quail

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Introduction

Poultry production is the largest contributor to the global meat supply, primarily due to its rapid growth, short maturity period, and efficient feed conversion (Zampiga *et al.*, 2021). Among poultry species, the Japanese quail (*Coturnix japonica*) has gained attention as a profitable alternative to chickens due to its rapid growth, early maturity, high egg production, and low production costs (Silva *et al.*, 2009; Lukanov *et al.*, 2018). Quails typically reach maturity within 6–7 weeks, produce up to 300 eggs annually, and thrive under intensive rearing systems, making them an attractive option for small, medium- and large-scale producers (Arunrao *et al.*, 2023; Roy's Farms, 2023).

Research indicates that feed costs remain a major constraint, accounting for approximately 70% of the total variable production cost in poultry systems (Oladokun and Johnson, 2012; Wongnaa and Awunyo-Vitor, 2023). This has encouraged the exploration of agro-industrial by-products such as rice bran and wheat bran as alternative feed ingredients. Previous research has shown that incorporating wheat bran into broiler diets does not compromise growth performance, regardless of the level of multi-enzyme supplementation (Idan, 2019; Idan *et al.*, 2023). Although rice bran is a nutrient-dense milling by-product, abundant in protein, fat, and antioxidants (Reema *et al.*, 2021; Tan *et al.*, 2023), two major challenges limit its application in poultry nutrition: high fiber content (which is poorly digested in monogastric animals) and rapid lipid oxidation. While several studies have evaluated rice bran in broilers, layers, and pigs (Ersin *et al.*, 2006; Tran *et al.*, 2016; Attia *et al.*, 2023), there is a paucity of information on its utilization and impacts in Japanese quails.

Therefore, the present study sought to evaluate the effects of increasing levels of rice bran on growth performance, carcass traits, and economic viability in Japanese quails.

Materials and Methods

Experimental site

The experiment was conducted at the Poultry Section of the Department of Animal Science, Kwame Nkrumah University of Science and Technology (KNUST), Ghana. The department lies at approximately 6.67°N latitude and 1.57°W longitude. The mean annual temperature is approximately 25.9°C, with annual rainfall averaging 1,100-1,500 mm. Relative humidity remains high throughout the year, averaging 84% in the morning and about 60% in the afternoon. These climatic conditions create a favorable environment for livestock and poultry research activities within the university.

Dietary treatment and experimental design

Dietary treatments were assigned using a Completely Randomized Design (CRD). Four treatments were defined by replacing portions of the basal diet with rice bran at 0%, 10%, 20%, and 30%, with each treatment replicated six times. The details of the treatments are as follows; RB_0 = Control diet with no rice bran, RB_10 = Diet formulated with 10% rice bran, RB_20 = Diet formulated with 20% rice bran and RB_30 = Diet formulated with 30% rice bran

Feed formulation

For both the starter and grow-finisher phases, the basal diet was modified by increasing the rice bran (RB) level, resulting in four experimental diets. All diets were formulated to be isocaloric and isonitrogenous. All the feeds were formulated at the Feed Manufacturing Centre in the Department of Animal Science, KNUST. Before mixing, the corn was ground using a hammermill (Kingdom Engineering Co. Ltd, Accra, Ghana). All dry ingredients, together with liquid fat (palm oil), were then blended in a 2-ton vertical mixer for 20 minutes. During the mixing process, samples of the complete feed were taken and kept in a freezer for subsequent chemical analysis. After mixing, the complete feeds were packaged, well labelled by treatment, and transported to the experimental site.

Table 1. Ingredient composition of starter, grower-to-finisher diets.

Ingredient (kg)	Treatment Diets			
Starter Diet	RB_0	RB_10	RB_20	RB_30
Maize	61.65	53.75	43.75	32.45
Soybean Meal	20.00	25.00	25.00	25.00
Fish Meal	8.00	5.00	5.00	5.00
Wheat Bran	6.00	0.00	0.00	0.00
Rice Bran	0.00	10.00	20.00	30.00
Soybean Oil	0.50	1.50	1.50	3.00
Dicalcium Phosphate	1.20	1.50	1.50	1.30
Oyster Shell	0.80	1.20	1.20	1.20
L-Lysine	1.00	1.00	1.00	1.00

DL-Methionine	0.50	0.50	0.50	0.50
Vitamin-Mineral Premix	0.25	0.25	0.25	0.25
Salt	0.10	0.30	0.30	0.30
Calculated Nutrient Composition				
Crude Protein	23.80	23.83	23.92	23.89
Crude Fiber	3.15	3.68	4.05	4.29
ME (Kcal/kg)	2949.7	2948.6	2941.9	2940.6
Grower – Finisher Diet				
Maize	57.80	53.55	44.75	35.70
SBM	24.05	24.30	22.50	21.45
Fish Meal	8.00	8.00	8.00	8.00
Wheat Bran	7.00	1.00	1.00	0.00
Rice Bran	0.00	10.00	20.00	30.00
Soy Oil	0.10	0.30	0.90	2.00
Dicalcium Phosphate	1.20	1.20	1.20	1.20
Oyster Shell	0.50	0.50	0.50	0.50
L-Lysine	0.50	0.50	0.50	0.50
DL-Methionine	0.50	0.30	0.30	0.30
Vitamin-Mineral Premix	0.25	0.25	0.25	0.25
Salt	0.10	0.10	0.10	0.10
Calculated Nutrient Composition				
Crude Protein %	21.076	21.181	21.027	21.026
Crude Fiber	3.398	3.778	4.525	5.212
ME, Kcal/kg	3,053.2	3,045.7	3,040.6	3,039.9

Birds and bird husbandry

The feeding trial, spanning from 14 to 54 days of age, was conducted in two phases: starter (days 14 – 35) and grower-finisher (days 29 – 54). A total of two hundred and forty (240) two-week-old straight-run Japanese quails were procured from a local hatchery in Ejisu-Besease in the Ashanti Region of Ghana for the study. Birds with similar body weights were randomly allocated to 24 cages with 10 birds per cage. Fresh wood shavings were used as litter, and each cage was equipped with a plastic feeder and drinker. Paper boxes were placed beneath the cages to collect droppings and prevent contamination between units. Feed and water were provided *ad libitum* throughout the study.

Data collection

Growth performance measurement

Body weight (BW) and feed consumption were recorded for each cage every week by weighing the birds and the remaining feed in the feeders. The BW of the quails and feed disappearance were used to calculate total feed intake, final body weight, body weight gain, average daily gain (ADG), and average daily feed intake (ADFI). Mortality was recorded daily, and the BW of any dead birds was included in the total cage weight and used to adjust feed intake data, thereby ensuring accurate calculation of the feed conversion ratio (FCR).

Carcass characteristics measurement

At the end of the trial, two birds per replicate with body weights close to the cage average were selected and humanely slaughtered for carcass evaluation. Parameters measured included defeathered weight, thigh muscle yield, edible organ weights, and intestinal weight and length.

Economic analysis

For economic viability, feed costs were estimated using market ingredient prices (as of May 8, 2024) and their corresponding dietary proportions. The total feed cost was calculated by multiplying the ingredient cost by the total feed intake per treatment, and the feed cost per kilogram of gain was determined as described by Frempong *et al.* (2019).

Statistical analysis

The experimental data were analyzed using one-way analysis of variance (ANOVA) with the GLIMMIX procedure of SAS 9.4M8 (SAS Institute, 2023). The statistical model accounted for the effects of rice bran inclusion levels on growth performance and carcass characteristics of Japanese quails. When significant differences were detected ($P < 0.05$), means were separated using

Tukey's pairwise comparison test. The statistical model used was:

$Y_{ijk} = \mu + \alpha_i + e_{ijk}$

where:

Y_{ijk} = observed value of the dependent variable,

μ = overall mean,

α_i = fixed effect of inclusion levels of rice bran (i = 1, 2, 3)

e_{ijk} = random error term assumed to be normally distributed with mean zero and constant variance.

Results

Growth performance

The effects of rice bran inclusion on the growth performance of starter and grower-finisher Japanese quails are shown in Tables 2 and 3. Based on the results, the initial body weight (IBW) of quail chicks did not differ significantly (P > 0.05) among dietary treatment groups. In the starter phase, rice bran inclusion significantly influenced growth performance. Total feed intake (TFI), body weight (BW), average daily feed intake (ADFI), average daily gain (ADG), and feed conversion ratio (FCR) were all influenced by rice bran inclusion. Quails fed RB_20 had the highest final BW (143.33 g), which was significantly (P < 0.05) greater than that of quails fed RB_30 (131.67 g). The BWs of the RB_0 (135.83 g) and RB_10 (137.50 g) groups were intermediate and not statistically different from those of the RB_20 or RB_30 groups. A similar pattern was observed for BWG, ADG, TFI, and ADFI. The RB_20 group recorded the highest BWG (90.83 g) and ADG (4.33 g/bird/day), which were significantly higher (P < 0.05) than the RB_30 group (79.17 g and 3.77 g/bird/day, respectively). ADFI of the RB_20 group was the highest (21.22 g/bird/day), similar to that of the RB_10 group (20.20 g/bird/day), and significantly higher (P < 0.05) than those of the RB_0 (17.07 g/bird/day) and RB_30 (17.82 g/bird/day) groups. The control group had the lowest ADFI. A similar pattern was observed for total feed intake (TFI), with the RB_20 group consuming the most feed (445.50 g) during the starter period. For the FCR, the most efficient was observed in the control group (2.64), which was significantly better (P < 0.05) than the RB_10 (3.09) and RB_20 (3.11) groups. The FCR of the RB_30 group (2.85) was intermediate and not significantly different from the control or the higher-inclusion groups (RB_10 and RB_20).

Table 2. Effects of rice bran on growth performance of starter Japanese quail.

Growth Parameters (g)	Treatment Diets					
	RB_0	RB_10	RB_20	RB_30	SEM	P-Value
IBW	54.17	52.50	52.50	52.50	2.1731	0.8292
BW	135.83^{ab}	137.50^{ab}	143.33^{a}	131.67^{b}	3.3541	0.0193
BWG	84.17^{ab}	85.00^{ab}	90.83^{a}	79.17^{b}	3.1950	0.0146
ADG	4.01^{ab}	4.05^{ab}	4.33^{a}	3.77^{b}	0.1081	0.0146
ADFI	17.07^{c}	20.20^{ab}	21.22^{a}	17.82^{bc}	0.6855	0.0010
TFI	358.33^{c}	424.17^{ab}	445.50^{a}	374.17^{bc}	20.3644	0.0010
FCR	2.64^{b}	3.09^{a}	3.11^{a}	2.85^{ab}	0.1365	0.0075

[abc]Means within a row with different superscripts are significantly different at (P < 0.05). RB_0 = Control dirt (no RB); RB_10 (10% RB inclusion); RB_20 (20% RB inclusion); RB_30 (30% RB inclusion); IBW = Initial Body Weight; BW = Body Weight at the end of starter phase; BWG = Body Weight Gain; TFI = Total Feed Intake; ADFI = Average Daily Feed Intake; ADG = Average Daily Gain; SEM = Standard error of the means.

For the grower-to-finisher phase, no significant (P < 0.05) differences were observed among treatments for any growth performance parameters, indicating that the earlier effects did not persist.

Carcass traits

The results on carcass characteristics, evaluated at the end of the study, are presented in Table 4. Results showed no significant differences (P > 0.05) among the dietary treatments for any of the carcass parameters measured. This indicates that incremental inclusion of rice bran up to 30% of the diet had no measurable effect on the yield of valuable carcass components, such as breast, thighs, and wings, or on the overall dressing percentage. The uniformity in carcass traits across all groups suggests that the energy and nutrient intake were sufficient to support standard muscle and skeletal development, irrespective of the fiber level introduced by rice bran.

Table 3. Effects of rice bran on the growth performance of grower-to-finisher Japanese quail.

Growth Parameters (g)	Treatment Diets					
	RB_0	RB_10	RB_20	RB_30	SEM	P-Value
FBW	168.00	170.92	165.33	153.92	7.4546	0.1475
BWG	116.33	118.42	112.83	101.42	8.5490	0.2272
ADG	4.16	4.23	4.03	3.62	0.3048	0.2201
ADFI	24.73	28.51	28.63	27.17	1.9249	0.1849
TFI	692.50	798.33	801.67	760.83	53.9019	0.1851
FCR	4.13	4.66	4.85	4.98	0.3181	0.0675

[abc]Means within a column with different superscripts are significantly different at (P < 0.05). RB_0 = control group; RB_10 = 10% rice bran inclusion; RB_20 = 20% rice bran inclusion; RB_30 = 30% rice bran inclusion. IBW = Initial Body Weight; FBW = Final Body Weight; BWG = Body Weight Gain; TFI = Total Feed Intake; ADFI = Average Daily Feed Intake; ADG = Average Daily Gain; SEM = Standard error of the mean.

Table 4. The Effects of increasing levels of rice bran on the carcass traits of quails.

Carcass traits (g)	Treatment Diets					
	RB_0	RB_10	RB_20	RB_30	SEM	P-Value
Leg	4.67	4.33	2.33	3.67	1.2472	0.3201
Lung	1.13	1.34	1.09	0.99	0.1604	0.2433
Neck	8.67	6.67	4.33	7.67	2.4267	0.3799
L. intestine	2.67	2.33	2.33	2.67	0.4714	0.8018
Spleen	0.37	0.16	0.05	0.07	0.2131	0.4588
Thigh	22.33	21.33	23.00	21.33	1.9149	0.7812
Wings	7.67	5.67	8.33	6.67	2.66	0.7663
Shank	2.37	2.33	2.60	2.57	0.2273	0.5692
S. intestine	6.67	4.33	7.33	5.33	1.0274	0.0729
Proventriculus	0.54	0.37	0.61	0.60	0.1281	0.3112
Carcass weight	95.00	102.00	100.00	95.00	7.9451	0.7231

[abc]Means within a column with different superscripts are significantly different at (P < 0.05). RB_0 = control group; RB_10 = 10% rice bran inclusion; RB_20 = 20% rice bran inclusion; RB_30 = 30% rice bran inclusion. SEM = Standard error of the means.

Economic viability

The impact of dietary rice bran inclusion on production economics is presented in Table 5. A reduction in the feed cost per kg was observed with progressive RB inclusion, declining from ₵6.26 in the RB_0 diet to ₵5.58 in the RB_30 diet. However, the key metric of economic efficiency, the feed cost per unit of weight gain, was most favorable for the control diet (RB_0) at GH₵21.19/kg. This result indicates that the compromised feed conversion ratios and growth rates associated with higher rice bran levels negated the initial savings in feed ingredient costs, rendering the control formulation the most economically viable strategy under the present experimental conditions.

Table 5. Economic viability analysis of using rice bran as an ingredient in starter-to-finisher quail diet (0-7 weeks).

Parameters	Treatment Diets			
	RB_0	RB_10	RB_20	RB_30
Total feed intake (g)	1049.82	1222.17	1247.17	1135.00
Feed cost (₵) per kg	6.26	6.14	5.83	5.58
Cost of feed per gain (₵/kg)	21.19	23.80	23.20	21.85

*Total feed intake = the addition of total feed intake for each treatment from the starter to the finisher phase. Feed cost = (total feed cost for two phase/2)/100 kg; Cost of feed per gain = (FCR for each treatment at starter and grower to finisher phase/2) *feed cost per kg*

Discussion

The present study demonstrated a phase-dependent response of Japanese quail to dietary rice bran, revealing a trade-off between growth stimulation and feed efficiency. During the starter phase, birds fed 20% rice bran had higher body weight and weight gain, primarily due to increased feed intake, indicating good palatability and a favorable nutrient profile (Aljuobori *et al.*, 2017). Similar early growth responses have been reported by Attia *et al.* (2023). However, this advantage was accompanied by poorer feed conversion ratios in the RB_10 and RB_20 groups, reflecting reduced nutrient utilization due to the high fiber content and antinutritional factors, such as phytic acid, in rice bran (Saeed *et al.*, 2019). At 30% inclusion, both feed intake and growth declined, suggesting that excessive fiber reduced dietary digestibility and voluntary feed intake.

The lack of significant differences during the grower–finisher phase indicates that quails adapted to the dietary fiber as their digestive capacity and cecal microbial activity increased with age (Sharma *et al.*, 2020). This adaptation eliminated both the early growth advantage observed at 20% inclusion and the depression seen at higher levels, resulting in comparable final performance across treatments. Similar findings have been reported in broilers and quails by Varzaru *et al.* (2020) and Yakubu *et al.* (2024). Other studies (Wu *et al.*, 2019; Sun *et al.*, 2016) have reported inconsistent outcomes, with variations attributed to differences in rice bran species, processing methods, energy content, and phytate levels.

Carcass characteristics were not affected by dietary treatments, consistent with similar final body weights and with previous reports (Attia *et al.*, 2023; Varzaru *et al.*, 2020). This indicates that rice bran can be included in quail diets without adversely affecting carcass yield at market age.

Although rice bran reduced the feed cost per kilogram, the control diet remained economically superior due to its better feed conversion efficiency. This confirms that lower feed costs do not necessarily translate into lower production costs. Nevertheless, studies such as Nguyen *et al.* (2022) show that enzyme supplementation can alleviate the anti-nutritive effects of fiber and improve the economic value of rice bran-based diets. Therefore, the full nutritional and economic potential of rice bran for quail feeding may be realized through appropriate processing or the inclusion of enzymes.

In conclusion, the inclusion of rice bran in quail diets yielded positive outcomes. The 20% level improved feed intake and early growth, while birds later adapted and maintained growth comparable to the control. This underscores the potential of rice bran as a practical and nutritious alternative feed resource for quails. Further research on enzyme supplementation, particularly phytase and xylanase, may improve nutrient availability and maximize the feeding value of rice bran in poultry diets.

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