Inclusion of broken rice in meat-quail diets at different ages

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ABSTRACT. The aim of this study was to evaluate the inclusion of 50% broken rice (BR) in diets for meat quail from 1 to 35 days old, starting at different ages. A total of 875 mixed quail were allocated to five treatments in a completely randomized design with five replicates of 35 birds. The treatments consisted of a maize- and soybean meal-based control diet and four other similar diets in which the inclusion of 50% BR was started at different ages, namely, 1st, 8th, 15th and 22nd days. Feed intake, weight gain, feed conversion and mortality rate were evaluated weekly. At 35 days, 10 quail per plot were weighed and selected to be slaughtered for evaluations of live weight, carcass yield and gizzard yield. Lastly, a study of economic viability was carried out. No significant difference (p > 0.05) was detected for the performance parameters, live weight or carcass yield, but a higher gizzard yield was found (p < 0.05) in the treatment without BR. The inclusion of BR from the first day of life provided better economic viability. Diets with a maximum inclusion of 50% BR can be formulated for meat quail at any age.

Keywords: alternative feedstuff; carcass; production performance.

Introduction

Feeding accounts for the costliest production factor in quail farming. The energy component is the second factor that most elevates the cost of a diet, only after protein. In this respect, numerous alternative feedstuffs have been the object of study to ensure effective animal nutrition with satisfactory performance, at a low cost.

Rice is a food of high energy value. The processing of rice generates a waste called 'broken rice', whose chemical composition is similar that of the polished grain and which has the potential to replace (fully or partially) maize in the diet of quail (Filgueira et al., 2014).

Studies on the use of broken rice for laying and meat quail in different stages are reported in the literature, all of which tested different replacement levels. However, there is no information on the sudden replacement of maize with broken rice at a certain bird age, considering that, in practice, the producer may apply this type of substitution whenever the price of maize rises. Maize and broken rice have relative differences in their chemical composition that may reflect on the intestinal physiology of animals and, consequently, on their production performance.

The aim of this study was to evaluate the inclusion of broken rice to replace maize, starting at different ages, in diets for meat quail from 1 to 35 days of age on production performance, carcass yield, gizzard yield and economic viability.

Material and methods

The experiment was carried out on a quail farm located in Sítio Bom Jardim, countryside of Arapiraca, Alagoas State, Brazil. During the experimental period, the average temperature (minimum and maximum) and relative humidity (minimum and maximum) were 24.3 and 29.4°C and 50.32 and 73.48%, respectively.

The experiment involved 875 o-day-old mixed European quail (*Coturnix coturnix*) born on the very farm. The quail were allocated to five treatments in a completely randomized design with five replicates of 35 birds. The birds were housed in a masonry shed with a colonial-style roof lined with

canvas and one side with a grid and curtain. Galvanized-steel cages measuring $0.7 \times 1.0 \times 0.3$ m were used, providing a density of 50 birds m^{-2}. The cage floor was covered with disinfected rice straw. Circular tray-type feeders were used up to 14 days and trough-type feeders thereafter. Pressure-type drinkers with a capacity of 1 L were used until the 7th day and then replaced by nipple drinkers as the birds adapted.

Water and feed were available *ad libitum*. Heating was provided by two 100-W incandescent lamps per cage until the 21st day. The lighting program consisted of 24h and ventilation was controlled by curtain management.

A nutritional plane with two isoenergetic and isoproteic diets was adopted. The diets were formulated according to the nutritional recommendations for the starter (1 to 21 days) and grower (22 to 35 days) phases of meat quail as established by Silva and Costa (2009). Two types of diet were prepared per phase: one with maize as the main energy ingredient and the other with 50% broken rice (BR) replacing maize (Table 1). The broken rice was acquired from a rice processing industry in the state of Alagoas, Brazil. The chemical composition of the ingredients was applied to the diet formulation program in accordance with Rostagno et al. (2011) (Table 2).

Four ages were evaluated for the start of supply of feed with the inclusion of 50% BR replacing maize, namely, 1st, 8th, 15th and 22nd day. Therefore, the treatments were as follows: Diet without BR; Diet with 50% BR from the 1st day; Diet with 50% BR from the 8th day; Diet with 50% BR from the 15th day; and Diet with 50% BR from the 22nd day.

Table 1. Centesimal composition of the ingredients of the experimental diets.

Ingredient	1 to 21 days of age		22 to 35 days of age	
	Without BR*	50% BR	Without BR	50% BR
Soybean meal 45%	48.000	46.953	39.603	39.251
Maize 7.88%	45.296	22.855	54.058	27.020
Broken rice	-	22.855	-	27.020
Soybean oil	3.261	3.640	3.750	3.950
Limestone	1.267	1.245	1.043	1.017
Dicalcium phosphate	0.936	0.969	0.752	0.783
Common salt	0.381	0.381	0.331	0.331
DL-methionine	0.374	0.452	0.200	0.284
L-threonine	0.171	0.251	0.013	0.095
L-lysine HCL	0.064	0.152	0.000	0.000
Vit-starter poultry[1]	0.100	0.100	-	-
Vit-grower poultry[2]	-	-	0.100	0.100
Min-poultry[3]	0.050	0.050	0.050	0.050
Choline chloride	0.040	0.040	0.040	0.040
Sodium monensin	0.030	0.030	0.030	0.030
Zinc bacitracin	0.030	0.030	0.030	0.030
Total	100,000	100,000	100,000	100.,000
Cost kg^{-1}	1.756	1.727	1.650	1.605

*BR = broken rice. [1]Vitamin premix (starter) - provides per kg of diet: vit. B9 (min.) - 750 mg kg^{-1}, vit. B5 (min.) - 12 g kg^{-1}, BHT (min.) - 1,000 mg kg^{-1}, biotin (min.) - 25 mg kg^{-1}, niacin (min.) - 35 g kg^{-1}, vit. A (min.) - 8,000,000 IU kg^{-1}, vit. B1 (min.) - 1,500 mg kg^{-1}, vit. B12 (min.) - 12,000 mcg kg^{-1}, vit. B2 (min.) - 5,000 mg kg^{-1}, vit. B6 (min) - 2,000 mg kg^{-1}, vit. D3 (min.) - 2,000,000 IU kg^{-1}, vit. E (min.) - 15,000 IU kg^{-1}, vit. K3 (min.) - 1,800 mg kg^{-1}. [2]Vitamin and mineral premix (grower) - provides per kg of diet: vit. B9 (min.) - 150 mg, vit. B5 (min.) - 2,500 mg, BHT (min.) - 1,000 mg kg^{-1}, biotin (min.) - 2.5 mg kg^{-1}, copper (min.) - 5,000 mg kg^{-1}, choline (min.) - 90 g kg^{-1}, iron (min.) - 25 g kg^{-1}, iodine (min.) - 500 mg kg^{-1}, manganese (min.) - 35 g kg^{-1}, niacin (min.) - 7,500 mg kg^{-1}, selenium (min.) - 150 mg kg^{-1}, vit. A (min.) - 2,000,000 IU kg^{-1}, vit. B1 (min.) - 50 mg kg^{-1}, vit. B12 (min.) - 2,500 mcg kg^{-1}, vit. B2 (min.) - 1,200 mg kg^{-1}, vit. B6 (min.) - 50 mg kg^{-1}, vit. D3 (min.) - 500,000 IU kg^{-1}, vit. E (min.) - 4,000 IU kg^{-1}, vit. K3 (min.) - 400 mg kg^{-1}, zinc (min.) - 30 g kg^{-1}. [3]Mineral premix - provides per kg of diet: copper (min.) - 20 g kg^{-1}, iron (min.) - 96 g kg^{-1}, iodine (min.) - 1,400 mg kg^{-1}, manganese (min.) - 156 g kg^{-1}, selenium (min.) - 500 mg kg^{-1}, zinc (min.) - 110 g kg^{-1}.

The feed provided was stored in plastic buckets, which were identified by treatment and replicate to control feed intake. The birds and the orts in the feeders and buckets were weighed weekly and values were recorded for later calculations of feed intake, weight gain and feed conversion. Mortality was recorded daily to calculate production viability and to correct feed intake, as recommended by Sakomura and Rostagno (2006).

The quail were weighed at 35 days of age. Ten birds per experimental unit, with a maximum weight variation of 5% in relation to the average weight of the respective plot, were selected to be slaughtered, following the standard procedures (stunning, bleeding and plucking), as recommended by Decree n. 9,013 (Decreto n. 9.013, 2017).

Table 2. Calculated composition of the experimental diets.

Nutrient	1 to 21 days of age		22 to 35 days of age	
	Without BR*	50% BR	Without BR	50% BR
Met. energy (Kcal kg^{-1})	2,900,000	2,900,000	3,050,000	3,050,000
Crude protein (%)	25.000	25.000	22.175	22.178
Crude fiber (%)	3.328	3.049	3.034	2.708
Fat (%)	5.280	5.086	6.021	5.537
Available phosphorus (%)	0.320	0.320	0.270	0.270
Calcium (%)	0.850	0.850	0.700	0.700
Chloride (%)	0.270	0.274	0.249	0.244
Sodium (%)	0.170	0.170	0.150	0.150
Magnesium (%)	0.197	0.173	0.177	0.152
Potassium (%)	1.010	0.969	0.881	0.848
Dig. lysine (%)	1.370	1.370	1.120	1.060
Dig. methionine (%)	0.698	0.736	0.494	0.534
Dig. met. + cyst. (%)	1.040	1.040	0.800	0.800
Dig. tryptophan (%)	0.301	0.284	0.257	0.241
Dig. arginine (%)	1.675	1.566	1.438	1.336
Dig. phenylalanine (%)	1.200	1.101	1.047	0.948
Dig. phenyl. + tyr. (%)	2.053	1.884	1.791	1.621
Dig. histidine (%)	0.632	0.573	0.557	0.496
Dig. isoleucine (%)	1.030	1.020	0.890	0.894
Dig. leucine (%)	1.938	1.703	1.750	1.495
Dig. threonine (%)	1.040	1.040	0.780	0.780
Dig. valine (%)	1.095	1.000	0.959	0.862

Weight was measured using a scale with 5-g precision. The yields as a percentage of the eviscerated carcass, without head and feet, were calculated based on live weight at slaughter. Each bird's gizzard was separated for later weighing, and the values were calculated based on the weight of the eviscerated carcass. For this analysis, an analytical scale with 0.001-g precision was used. The cost of the diets was calculated based on the price of the ingredients purchased by the farm to determine the best economic viability.

The best cost-benefit ratio between the treatments was found based on the weighted average cost of each diet. The feed conversion ratio of each treatment was multiplied by the average cost of the diet consumed during the entire experimental period, where the lowest obtained value was considered to provide the best economic viability.

The variables were subjected to analysis of variance using SAEG statistical software (Sistema para Análise Estatística e Genéticas [SAEG], 2007). In case of significance, the Student Newman Keuls (SNK) means test was applied at the 5% probability level.

Results and discussion

The temperatures recorded inside the shed did not exceed the minimum (15°C) or maximum (32 °C) critical limits. Therefore, the birds spent most of the day in the thermal comfort zone, which, for adult birds, is between 5 and 30°C. Accordingly, their performance was not adversely affected by unfavorable thermal conditions (Albino and Barreto, 2003).

No difference was detected between treatments for performance variables in the starter (1 to 21 days) and grower (22 to 35 days) phases or during the entire experimental period (1 to 35 days of age) with the inclusion of 50% BR from the 1st day of life (Table 3).

These results corroborate those described by Filgueira et al. (2014), who evaluated the inclusion of BR at levels of up to 100% for meat quail from 7 to 49 days of age and found no significant differences in production performance. Additionally, Pereira et al. (2016) tested the BR levels of 0, 25, 50, 75 and 100% for Japanese quail from 64 to 148 days of age and did not observe a significant effect on production performance.

Because feed intake can be regulated according to the energy content of the diet, the lack of differences for this variable was because the diets were isoenergetic. Although BR has a lower metabolizable energy level for birds than maize (3,279 and 3,381 kcal kg^{-1}, respectively), this difference was offset with the inclusion of oil in the diets, which was aimed at increasing the metabolizable energy of the diet containing BR. According to Filgueira et al. (2014), weight gain reflects the intake and absorption of nutrients from the

feed. Thus, because feed intake was the same between the treatments, nutrient absorption was apparently also similar, which explains the absence of differences in weight gain.

Table 3. Average performance of meat quail fed diets including 50% broken rice replacing maize, starting at different ages.

Age	1 to 21 days							
	Age at 50% BR inclusion[3]							
Variable	Without BR	1st day	8th day	15th day	22nd day	CV[7] (%)	SEM[8]	P[1]
FI[4] (g)	237.00	226.80	238.60	229.20	218.80	9.43	0.02	0.62 ns[2]
WG[5] (g)	117.50	121.40	128.60	113.20	117.4	8.01	0.01	0.17 ns
FC[6]	2.02	1.87	1.86	2.03	1.86	9.12	0.18	0.35 ns
Age	22 to 35 days							
	Age at 50% BR inclusion							
Variable	Without BR	1st day	8th day	15th day	22nd day	CV (%)	SEM	P
FI (g)	331.25	333.40	332.20	302.20	323.00	8.76	0.03	0.41 ns
WG (g)	94.75	96.20	85.40	84.20	91.80	13.28	0.01	0.44 ns
FC	3.52	3.47	4.00	3.59	3.54	11.55	0.43	0.30 ns
Age	1 to 35 days							
	Age at 50% BR inclusion							
Variable	Without BR	1st day	8th day	15th day	22nd day	CV (%)	SEM	P
FI (g)	568.25	560.20	570.40	531.60	554.74	7.46	0.04	0.61 ns
WG (g)	212.25	217.40	215.20	197.40	206.00	8.69	0.01	0.46 ns
FC	2.69	2.58	2.66	2.69	2.70	3.49	0.10	0.28 ns

P[1] = probability at the 5% significance level (SNK test); ns[2]= non-significant difference; BR[3] = broken rice; FI[4] = feed intake; WG[5] = weight gain; FC[6] = feed conversion; CV[7] = coefficient of variation; SEM[8] = standard error of the mean.

The current performance results differ from those reported by Ashour, Reda and Alagawany (2015), who evaluated maize-to-broken rice replacement levels up to 50% in diets for Japanese quail from 1 to 35 days old and obtained better feed conversion at the 30% level.

González-Alvarado, Jiménez-Moreno, Lázaro and Mateos (2007) investigated broilers from 1 to 21 days of age and observed better performance when the birds were fed a diet containing polished white rice as the main energy component, compared with those fed a diet containing maize as a primary energy source. The authors attributed this effect to the higher starch level present in rice compared with maize.

Cancherini et al. (2008) evaluated broilers and found no significant differences following the inclusions of 22.5 and 7.5% BR during the starter and grower phases, respectively, on production performance. Similar results were observed by Brum Júnior et al. (2007), who included BR at the levels of 0, 20 and 40% replacing maize in diets for broilers in the starter, grower and finisher phases.

Broken rice has characteristics related to the fraction that corresponds to carbohydrates that can improve the digestive and absorptive capacities of the birds' gastrointestinal tract. This effect can be attributed to the lower non-starch polysaccharide content and the size of the starch granules of BR (3 to 8 µm) compared with maize (3 to 23 µm), as well as the possible superiority in amylopectin content of BR (González-Alvarado et al., 2007). As a consequence, the nutrients present in BR may be better utilized in relation to those of maize, which reflected in the better production performance of the quail fed the diets containing BR. Nonetheless, the differences between maize and BR did not result in changes in the production performance of the animals evaluated in the present study.

No significance was observed for live weight or carcass yield (Table 4). These results are in line with those observed by Filgueira et al. (2014), who described no significant differences in carcass yield in 7-to-49-day-old meat quail fed diets with levels of up to 100% BR replacing corn. However, in a study with Japanese quail from 1 to 35 days, Ashour et al. (2015) described no significant differences in carcass yield.

Table 4. Live weight, carcass yield and gizzard yield of meat quail fed diets containing 50% inclusion of broken rice replacing maize and slaughtered at 35 days of age.

	Age at 50% BR inclusion[3]							
Variable	Without BR	1st day	8th day	15th day	22nd day	CV[7] (%)	SEM[8]	P[1]
LW[4] (g)	221.21	226.60	223.70	206.04	218.09	8.43	0.02	0.47 ns[2]
CY[5] (%)	69.68	67.70	70.41	67.78	68.82	9.31	6.40	0.16 ns
GY[6] (%)	1.86 a	1.65 b	1.65 b	1.69 b	1.67 b	13.41	0.22	0.00 *

P[1] = probability at the 5% significance level (SNK test); * = different letters in the row indicate a significant difference between treatments; ns[2] = non-significant difference; BR[3] = broken rice; LW[4] = live weight; CY[5] = carcass yield; GY[6] = gizzard yield; CV[7] = coefficient of variation; SEM[8] = standard error of the mean.

According to Freitas, Fuentes, Santos Júnior, Guerreiro, and Espínola (2006), it seems unlikely that carcass yield is influenced by the inclusion of alternative feedstuffs when the dietary levels are properly evaluated. These authors stated that under- or overestimating the net energy may induce changes in the energy:protein ratio that would result in differences in carcass traits.

The age at which BR was included in the diet influenced gizzard yield, with the highest values obtained in the treatment without BR inclusion. This result may have been due to the greater degradability of rice compared with maize, lower crude fiber content and higher levels of rapidly digested starch (Rostagno et al., 2011).

It can be inferred that the treatments including 50% BR provided a higher starch content in the diets, which may not have conferred sufficient mechanical friction for the gizzard to further develop, since it is an organ with abundant muscle tissue whose development depends on stimuli that the fiber deficiency of BR does not induce.

In terms of economic viability, the treatments with 50% BR inclusion for the longest time were those which provided the lowest diet cost, since the price of BR acquired by the farm was 23.07% lower than that of grain maize, at the time of the study (Table 5).

Table 5. Feed conversion, diet cost and total production cost from 1 to 35 days of age.

Variable	Age at 50% BR inclusion				
	Without BR	1st day	8th day	15th day	22nd day
Feed conversion (kg kg⁻¹)	2.69	2.58	2.66	2.69	2.70
Diet cost (BRL kg⁻¹)	1.69	1.65	1.65	1.66	1.67
Total cost (BRL kg⁻¹ live weight)	4.56	4.27	4.41	4.47	4.50

BRL - Brazilian real.

The period that showed the best economic viability for the inclusion of 50% BR was from the 1st to the 35th day of life, as it provided a reduction of BRL 0.29 in the total cost (kg of diet kg⁻¹ live weight) compared with the treatment without BR.

Conclusion

Diets containing a maximum broken rice inclusion level of 50% can be formulated for meat quail at any age without losses to production performance, carcass yield or economic viability.

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