



Whole rice in japanese quails' diet

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ABSTRACT. A trial was conducted to evaluate the use of dehulled and unpolished whole rice in Japanese quails' diet. A total of 100 80-days-old Japanese quails (149.07 ± 10 g) were distributed in five treatments: 0% dehulled and unpolished whole rice (control diet based on corn and soybean meal), 20, 40, 60, and 80% of whole rice in replacement of corn; respectively, treatments 1, 2, 3, 4, and 5. Productive performance was evaluated through egg production (%), egg weight (g), body weight (g), egg mass (g), feed conversion per egg mass and feed conversion per dozen eggs. The following variables measured the internal quality of eggs: albumen height (mm), yolk color and percentage, egg white percentage and Haugh units. The external quality of eggs was measured through specific gravity (g cm^{-3}), shell thickness (μm) and shell percentage. Treatment means were analyzed through polynomial regression at 5%. As the level of whole rice was increased in the diets, a significant linear increase in egg production ($p = 0.005$), egg mass ($p = 0.007$), shell thickness ($p = 0.03$) and specific gravity ($p = 0.007$) was observed. Feed conversion per egg mass ($p = 0.006$), feed conversion per dozen eggs ($p = 0.003$) and egg color ($p < 0.0001$), on the other hand, were reduced linearly. The increased utilization of whole rice increased the cost of the diet. In conclusion, the addition of dehulled and unpolished whole rice in partial substitution of corn in Japanese quails' diets increases the egg production and reduces the yolk color.

Keywords: alternative feedstuff, eggs, nutrition, quail production.

Arroz integral na alimentação de codornas japonesas

RESUMO. O objetivo foi estudar a utilização do grão de arroz integral na dieta de codornas japonesas. Foram utilizadas 100 codornas japonesas com peso médio de $149,07 \pm 10$ gramas e 80 dias de idade, distribuídas em cinco tratamentos 0% de arroz integral (dieta controle à base de milho e farelo de soja), 20, 40, 60 e 80% de arroz integral em substituição ao milho. Foi avaliado o desempenho produtivo das aves, através da produção de ovos (%), do peso dos ovos (g), do peso das aves (g), massa de ovos (g), conversão por massa e por dúzia. Nas variáveis de qualidade interna dos ovos foram analisadas a altura de albúmen (mm), cor da gema, porcentagem da gema, porcentagem da clara e unidade Haugh. A qualidade externa dos ovos foi avaliada através da gravidade específica (g cm^{-3}), espessura (μm) e porcentagem da casca. Os dados foram submetidos à análise regressão polinomial a 5% de significância. Conforme aumentou a inclusão de arroz integral na dieta houve um aumento linear da produção de ovos ($p = 0,005$), massa de ovos ($p = 0,007$), da porcentagem da casca ($p = 0,03$) e da gravidade específica ($p = 0,007$), ao contrário da conversão por massa ($p = 0,006$), por dúzia ($p = 0,003$) e da cor da gema ($p < 0,0001$), que reduziram linearmente. O aumento da inclusão de arroz integral aumentou o custo da dieta. Conclui-se que a substituição do milho pelo grão de arroz integral na dieta aumenta a produção de ovos, e reduz a cor da gema de codornas japonesas em postura.

Palavras-chave: alimentos alternativos, ovos, nutrição, coturnicultura.

Introduction

Raising quails is an activity in expansion that has been highlighted each year due to its productive increase, being responsible for the generation of jobs and income in all the levels of the productive chain, mainly because it doesn't need big initial investments, requiring little space in order to set up the raising system, also providing a financial return in short or

medium term. Another reason for such success is its main product, the egg, which is a source of animal protein that has high biologic value, with good acceptance by the consuming market (LEANDRO et al., 2005; TEIXEIRA et al., 2012).

The nutrition of the quails represents one of the productive bottlenecks. In the feeding of these birds, corn consists in the main energetic ingredient that composes the diet, being

responsible for 60 to 70% of the diet cost. Since it is a commodity, its price is subject to the exchange rates variations and market prices, which can cause imbalance in the domestic supply of the input and change the buying strategy of the producers, that try to reduce the costs and increase the profits (MOURA et al., 2010).

In order to meet the demands that are highly dependent on corn, non-conventional ingredients have been searched for its partial or total substitution. According to Krabbe et al. (2012), among the surveyed options, rice (*Oryza sativa* L.) can be a good alternative. However, up to this moment only its derivatives are used, especially broken rice and whole or defatted rice bran. Thus the use of whole grain without bark, since bark has low nutritional value, it becomes an interesting alternative and it allows one to assume that the grain is a potential raw material for animal diets, particularly when the product is found with high supply the market.

Rice grain is characterized as an energy source, showing high contents of carbohydrates and low ones of lipids, and with level of crude protein close to those of the corn. Although it is not known its metabolizable energy for quails, it is possible to estimate the values from the ones of broken rice and rice bran (KRABBE et al., 2012).

Given the exposed, the objective was to evaluate the effect of the substitution of corn by whole rice on the productive performance and eggs quality of Japanese layer quails.

Material and methods

The experiment was conducted at the Poultry Sector of the Laboratory of Animal Science Teaching and Experimentation (LEEZO) of the Federal University of Pelotas, Rio Grande do Sul State.

Were used one hundred Japanese quails (*Coturnix coturnix japonica*), with an average weight of 149.07 ± 10 grams, with 80 days of age, housed in metallic cages, evaluated during three production cycles of 28 days. The quails were distributed into five treatments in a completely randomized design, with levels of 0% of whole rice (control diet based on corn and soybean bran), 20, 40, 60, and 80% of whole rice in substitution to corn, according to Table 1. Diets were formulated to meet the nutritional requirements, in accordance with the recommendations of Silva and Costa (2009), being the diets isocaloric and isoproteic. In order to make the diets become isoenergetic, soybean oil was added with the increase of the substitution of corn by whole rice in the diet. Five replicates were used per treatment, with four birds in each replicate.

Eggs were collected and weighed daily to calculate total production and average weight. The production of eggs was calculated as a percentage by dividing the number of eggs produced by repetition by the number of birds.

Table 1. Composition of the experimental diets.

Ingredients	Corn by whole rice substitution levels (%)				
	0	20	40	60	80
Corn (7.8% CP)	52.45	41.51	30.50	19.40	8.40
Soybean bran (45% CP)	37.30	37.40	37.48	37.71	37.80
Whole rice without bark (8.8% CP)	0.00	10.50	21.00	31.50	42.06
Bone meal	0.00	0.00	0.10	0.10	0.10
Limestone	6.01	5.96	5.92	5.89	5.85
Sodium chloride	0.43	0.43	0.40	0.39	0.38
Soybean oil	0.81	1.20	1.60	2.01	2.41
Vitamin and mineral supplement ⁽¹⁾	3.00	3.00	3.00	3.00	3.00
Calculated composition (%)					
E. Met. (kcal kg ⁻¹)	2,700	2,700	2,700	2,700	2,700
Crude protein	21.0	21.0	21.0	21.0	21.0
Calcium	3.020	3.020	3.020	3.020	3.020
Total phosphorus	0.670	0.670	0.664	0.661	0.659
Digest. phosphorus	0.451	0.450	0.450	0.450	0.450
Total amino acids	0.715	0.712	0.709	0.706	0.704
Digestible methionine	0.368	0.371	0.373	0.376	0.379
Digestible lysine	1.209	1.217	1.225	1.233	1.241
Linoleic acid	1.858	2.551	3.244	3.944	4.642
Crude fiber	3.675	4.817	5.959	7.102	8.244

⁽¹⁾Warranty levels per kilogram of the product: laying nucleus: Vitamin A (UI) 207000; Vitamin D₃ (UI) 43200; Vitamin E (mg) 540; Vitamin K₃ (mg) 51.5; Vitamin B₁ (mg) 40; Vitamin B₂ (mg) 120; Vitamin B₆ (mg) 54; Vitamin B₁₂ (mcg) 430; Niacin (mg) 840; Folic acid (mg) 16.7; Pantothenic acid (mg) 204.6; Choline (mg) 42; Biotin (mg) 1.4; Methionine (g) 11; Manganese (mg) 1485; Zinc (mg) 1535; Iron (mg) 1695; Copper (mg) 244; Iodine (mg) 29; Selenium (mg) 3.2; Bacitracin of zinc (mg) 600; BHT (mg) 700; Calcium (g) 197.5; Cobalt (mg) 5.1; Fluorine (máximo) (mg) 400; Phosphorus (g) 50; Sodium (g) 36.

The calculations of egg mass were obtained by the product of the percentage of eggs produced (bird day⁻¹) and the average egg weight of each parcel as well as feed conversion by egg mass calculations by the ratio of feed intake by birds and produced egg mass (g g⁻¹). Feed conversion per dozen eggs was obtained dividing the amount of feed consumed by birds by produced dozens of eggs (g dozen⁻¹).

In the variables of internal quality of the egg were analyzed albumen height, yolk color, percentage of yolk, albumen percentage and Haugh unit. To determine the albumen height (mm), a specific rule (FHK trademark) was used. The assessment of yolk color was performed using the colorimetric array (DSM). The determination of the percentage of yolk and albumen was performed by weighing the yolk (g) and albumen (g) on a digital scale (Marte, model AS 5500C, with an accuracy of 0.1 g), being the result multiplied by 100 and divided by the weight of the egg. The Haugh unit was obtained from egg weight and albumen height using the formula:

$$UH = 100 \log(H + 7,57 - 1,7 W^{0,37}),$$

where:

$$H = \text{albumen height};$$

W = egg weight.

Regarding external egg quality, the following variables were studied: specific gravity (g cm^{-3}), thickness (mm) and shell percentage (%). For the determination of specific gravity, the eggs were immersed in NaCl solutions with density ranging from 1.050 to 1.098 g cm^{-3} , with interval of 0.004 g cm^{-3} , the eggs being removed as soon as they floated in the solution. Shells were identified, washed and dried at room temperature, in order to later obtain their weight and thickness. To determine the percentage of shell, they were individually weighed on an analytical digital scale (UniBloc, AUY-220, with accuracy of 0.1 mg) and the result obtained was multiplied by 100 and divided by the weight of the egg. Thickness (μm) was measured in the central ring of the shell of each egg, using a manual micrometer (Starret trademark) with 0.01 mm precision.

Feed costs were calculated based on the amount of it consumed, considering daily consumption per bird. The total consumed during the experimental period was multiplied by the cost of the kilogram of the diet. To realize the cost of the diets, the prices of the ingredients used in the formulation were obtained in June 2012.

The economic viability was calculated considering the price of a kilogram of feed consumed (cost) and the average price of a dozen eggs produced (revenue) considering R\$ 0.60 (equivalent to US\$ 0.29) per dozen of quail eggs. The gross income was obtained by subtracting the revenue from the cost.

Data were submitted to analysis of variance (ANOVA) and means were compared by polynomial regression with a significance level of 5%, being used SAS statistical software (SAS, 2002).

Results and discussion

There was no significant effect of the levels of substitution of corn by whole rice ($p > 0.05$) on weight of eggs and birds (Table 2). With respect to egg production, there was a positive linear response with the inclusion of whole rice in the diet, according to the equation $y = 56.84 + 0.12x$. Rice grain showed lower amount of metabolizable energy ($3,218 \text{ kcal kg}^{-1}$) than corn ($3,381 \text{ kcal kg}^{-1}$) (ROSTAGNO et al., 2011). Thus, to make diets isoenergetic soybean oil was added with increase of whole rice inclusion in diet. So, the lipids inclusion was also increased in it, which may have led to an increase in egg production since, according to Costa et al. (2008), testing different levels of soybean oil (1, 2, and 3%) in the diet of laying hens, there was an increase in egg production with the increase of such

levels. According to the authors the increase in production is related to better use of energy by reducing the caloric increment. There was a linear increase in egg mass, probably due to increase in production of eggs. In conversion per mass and per dozen there was a decreasing linear response with increase in substitution of corn by whole rice.

Table 2. Productive performance of quails fed with different levels of whole rice.

Performance	Levels of substitution of corn by whole rice (%)					CV	p*
	0	20	40	60	80		
Eggs production (%)	56.25	58.80	64.10	64.63	66.26	8.32	0.005
Weight of eggs (g)	10.84	10.58	10.81	10.66	10.63	3.28	0.52
Weight of birds (g)	157.29	158.55	159.94	160.31	160.44	5.22	0.54
Mass of eggs (g)	6.04	6.16	6.73	6.86	7.07	8.86	0.007
Conversion per mass (g)	4.98	4.88	4.54	4.37	4.25	8.61	0.006
Conversion per dozen	1.24	1.19	1.11	1.08	1.05	7.97	0.003

p* = significance level by polynomial regression; CV (%) coefficient of variation. Equation adjusted for egg = $56.84 + 0.12x$ ($R^2 = 0.91$). Equation adjusted for egg mass = $6.02 + 0.01x$ ($R^2 = 0.94$). Equation adjusted for conversion per mass = $5.00 - 0.009x$ ($R^2 = 0.96$). Equation adjusted for conversion per dozen = $1.23 - 0.0022x$ ($R^2 = 0.96$).

Furthermore, the addition of oil increases absorption of liposoluble vitamins and the efficiency of energy consumption and reduces the rate of passage of digesta in the gastro-intestinal tract, which allows a better absorption of all nutrients present in the diet (BAIÃO; LARA, 2005).

According to Bertechini (2006), lipids have specific dynamic action and extra caloric value, such as providing and facilitating the absorption of liposoluble vitamins and essential fatty acids. Moreover, they are source of dietary energy with low caloric increment that reduces the speed of passage of food, favoring the functioning of the digestive tract in the aspects of digestion and absorption, possibly being this one of the factors leading to the increase in egg production with rice inclusion in diets.

Moura et al. (2010) found no significant difference in energetic density of diets on egg production of quails. Rabello et al. (2007), evaluating levels of inclusion of soybean oil (0, 1, 2, 3, and 4%) in the diet of laying hens, observed no effect on egg production.

Filardi et al. (2007), testing inclusion levels of 0, 5, 10, and 15% of rice bran in the diet of laying hens, observed no significant effects ($p > 0.05$) in egg weight and egg production. These data corroborate with study by Brum Jr. et al. (2007) that, evaluating levels of inclusion of whole rice bran (0, 12, 24, and 36%) in the diet of laying hens, did not observe effect on egg weight, but production showed a quadratic response, increasing up to the level of 22, 32% of whole rice bran in the diet. Similarly to Filho et al. (2013), testing the inclusion of 0, 5, 10, 15, 20, 25, and 30% of parboiled whole rice bran in the diet

of quails, observed no effect on the egg production and egg weight.

Through regression analysis it was verified a significant decreasing linear response in the color of the egg yolk with the increase of amount of rice in the diet replacing corn (Table 3), following the equation $Y = 3.40 - 0.024x$. Yolk color is directly related to the carotenoids in the diet, which are present in greater amount in corn and absent in rice. Garcia et al. (2012) observed that the reduction in the amount of corn in the diets also caused a decrease in yolk color, attributing this factor to the presence of pigments in corn. However, according to the authors, this problem can be alleviated with the use of pigmenter in the diets. Filho et al. (2013) observed a linear decrease in the color of the yolk of quails fed with levels of 0, 5, 10, 15, 20, 25, and 30% of parboiled whole rice bran.

Table 3. Internal and external quality of eggs of quails fed with whole rice.

Variable	Levels of substitution of corn by whole rice (%)						
	0	20	40	60	80	CV(%)	p*
Albumen height (mm)	4.91	4.78	4.81	4.79	4.71	5.69	0.36
Yolk color	3.30	2.84	2.86	1.34	1.45	16.93	< 0.0001
Yolk percentage (%)	30.15	29.92	30.08	29.79	30.62	3.98	0.67
Albumen percentage (%)	47.02	47.94	48.36	48.31	48.38	2.96	0.18
Haugh unit	90.77	90.86	91.99	90.58	90.05	2.89	0.68
Specific gravity (g cm ⁻³)	1064	1068	1067	1070	1068	0.17	0.007
Shell thickness (µm)	21.17	21.72	21.62	22.49	21.86	2.86	0.23
Shell percentage (%)	7.76	8.05	7.88	8.24	8.14	3.63	0.03

p* = significance level by polynomial regression; CV (%) coefficient of variation. Equation adjusted for yolk color = $3.40 - 0.024x$ ($R^2 = 0.86$); Equation adjusted for specific gravity = $1065.96 + 0.044x$ ($R^2 = 0.52$); Equation adjusted for shell % = $7.82 + 0.004x$ ($R^2 = 0.76$).

The albumen height, yolk percentage, albumen percentage and Haugh unit were not affected by the substitution of corn by whole rice in the diet ($p > 0.05$), according to Table 3 Rice inclusion did not affect the variables of internal egg quality, as it is influenced by the daily protein intake, aiming to ensure the requirements in amino acids (PINTO et al., 2002). Thus, as the diets were isoproteic, quails ingested the daily amount of protein required, not affecting the variables of internal egg quality.

Shell thickness was not affected ($p > 0.05$) by the substitution of corn by whole rice in the diet (Table 3). The specific gravity increased linearly as increased the level of rice in the diet to the 80% level of inclusion, according to the equation $y = 1065.96 + 0.044x$. Similarly, the percentage of shell also linearly increased with the increase of levels of whole rice in diet of quails, which can be determined by equation $y = 7.82 + 0.005x$.

Specific gravity is a measurement that evaluates the density of the egg, being directly related to the thickness of the shell. Thus, deficiency of calcium and vitamin D₃, as well as improper relation

between Ca and P, are factors which interfere to the decrease of specific gravity (ROSA; ÁVILA, 2000). According to Krabbe et al. (2012), whole rice grain has 0.05% Ca, while corn has 0.03% of the mineral (ROSTAGNO et al., 2011). Furthermore, the increased harnessing of vitamin D₃ can be related to the higher level of oil added with the inclusion of rice, for isoenergetic diets. Thus, the increased availability of Ca, with the inclusion of the rice in the diet, leads consequently to a higher concentration of such mineral, since it is found in higher availability in rice than in corn, leading to an increase in specific egg gravity and making shell heavier, due to the greater amount of Ca deposited. As consequence, the shell will have a greater shelf life, because the pores are smaller, reducing the chance of contamination in the egg.

The cost of the diet (Table 4) had an increase as increased the levels of inclusion of rice, possibly due to the increase of oil levels in the diet, since the market value of soybean oil is one of the largest contributor to rising costs of the diet. Even with this increase in price, due to the increased production of eggs, in dozens, it is compensatory economically its use in the diet, because gross income had higher averages with the inclusion of rice. Bonato et al. (2004) using whole rice bran in the diet and supplementing with enzymes, obtained a better economic performance. These results demonstrate the importance of alternative foods for the economy of poultry production.

Table 4. Economic viability of quails fed with different levels of whole rice.

Viability	Levels of substitution of corn by whole rice (%)				
	0	20	40	60	80
Diet cost (R\$ kg ⁻¹)	0.91	0.93	0.94	0.96	0.97
Consumed diet cost (R\$)	2.31	2.34	2.38	2.42	2.46
Egg production (dozen)	3.67	4.05	4.26	4.44	5.00
Cost (R\$ kg ⁻¹ dozen ⁻¹)	0.69	0.62	0.59	0.57	0.50
Revenue (egg dozen R\$ at sale)	2.20	2.43	2.56	2.66	3.00
Gross income (quail 84 ⁻¹ days)	1.52	1.81	1.96	2.09	2.50

Conclusion

Whole rice can replace corn, in a diet based on corn, soybean bran and soybean oil, up to 80%, especially at times when the relation between price of raw materials is favorable to rice, because even with the increase of diet price, we observed a higher egg production, economically compensating its use in the diet, without harm to external quality. Due to the reduction in yolk color, we recommend the use of pigmenters in the diets with rice.

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