# Parboiled rice whole bran in laying diets for Japanese quails

Ivan Bezerra Quevedo Filho[(1)], Ednardo Rodrigues Freitas[(1)], Thales Marcel Bezerra Filgueira[(1)], Germano Augusto Jerônimo do Nascimento[(1)], Nádia de Melo Braz[(1)], Danilo Rodrigues Fernandes[(1)] and Pedro Henrique Watanabe[(1)]

[(1)]Universidade Federal do Ceará, Centro de Ciências Agrárias, Departamento de Zootecnia, Campus do Pici, Avenida Mister Hull, nº 2.977, Caixa Postal 12.168, CEP 60021-970 Fortaleza, CE, Brazil. E-mail: ivanzootecnia@yahoo.com.br, ednardo@ufc.br, thalesmarcel@gmail.com, germanoaugusto@ufc.br, nadia_zootec@yahoo.com.br, danilo_zoo@hotmail.com, pedrowatanabe@ufc.br

Abstract – The objective of this work was to evaluate the effects of parboiled rice whole bran (PRWB) inclusion in laying diets for Japanese quails, on their performance, egg quality, and economic viability. A total of 448 17-week-old quails were weighed and distributed in a completely randomized design with seven treatments and eight replicates of eight birds each. A control diet (no PRWB) and six diets, containing 5, 10, 15, 20, 25, and 30% of PRWB, were tested. The increasing levels of PRWB did not affected nutrient digestibility coefficient, dietary energy use, feed intake, egg production, egg weight, egg mass, and the economic viability indices. However, there was a linear decrease in egg shell percentage, specific weight, and yolk color. The inclusion of up to 30% PRWB in the diet allows nutrient utilization and performance similar to those obtained by the control group, and it is economically viable.

Index terms: byproduct, economic analysis, egg characteristics, nutrition, quail production, rice bran.

## Farelo integral de arroz parboilizado na ração de postura para codornas japonesas

Resumo – O objetivo deste trabalho foi avaliar os efeitos da inclusão do farelo integral de arroz parboilizado (FIAP) na ração de postura para codornas japonesas sobre seu desempenho, qualidade dos ovos e viabilidade econômica. Um total de 448 codornas, com 17 semanas de idade, foi pesado e distribuído em delineamento inteiramente casualizado, com sete tratamentos e oito repetições, de oito aves cada. Uma dieta controle (sem FIAP) e seis dietas, com 5, 10, 15, 20, 25 e 30% de FIAP, foram testadas. Os níveis crescentes de FIAP não afetaram o coeficiente de digestibilidade dos nutrientes, o aproveitamento da energia das rações, o consumo, a produção, o peso e a massa de ovos, e os índices de viabilidade econômica. Entretanto, observou-se redução linear na percentagem de casca, no peso específico e na cor da gema. A inclusão de até 30% de FIAP na ração possibilita aproveitamento dos nutrientes e desempenho semelhantes aos obtidos pelo grupo-controle e é economicamente viável.

Termos para indexação: subproduto, análise econômica, características de ovos, nutrição, coturnicultura, farelo de arroz.

## Introduction

Rice is one of the most widely grown cereals in the world. It is cultivated for human feeding, and byproducts such as broken rice grains and rice whole bran are obtained from its processing (Lima et al., 2000).

Because of its high oil content, whole rice bran is presented as a good energy source for birds. It can be an alternative to partially substitute corn in diets, since it is produced at a large scale and has low prices. However, according to Schoulten et al. (2003) and Gallinger et al. (2004), the use of whole rice bran in poultry feeding is limited due to the presence of antinutritional factors. Hydrolytic and oxidative rancidity during storage and the high content of fiber, phytates, and enzymatic inhibitor are its most commonly cited factors that may cause damage to digestibility of all nutritive components of the diet.

When evaluating rice bran inclusion levels (0, 12, 24 and 36%) in laying hens diets, Brum Júnior et al. (2007) observed that feed intake and feed conversion had a linear decrease with the inclusion levels. The authors related the observed reduction in feed intake to the presence of antinutritional factors in rice bran. However, according to these authors, the lower cost of rice bran allows an inclusion level of 18.01% in diets, making it a feasible alternative depending on the availability and on the market price of this byproduct.


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Literature on the use of rice bran in diets for quails is scarce. Enke et al. (2008) reported the inclusion of 7% defatted rice bran in diet composition of quails fed fish silage, without any negative effect on their performance. Amoah & Martin (2010) reported the viability of an inclusion of 20% of rice whole bran in diets for Japanese laying quails, since feed intake, egg production, weight and mass of eggs, and feed conversion of birds were similar to those birds fed diets without the inclusion of rice bran.

Differently from the traditional processing, rice grain parboiling is subjected to heat under pressure before being peeled and polished, which results in physical and chemical changes in polished grain and in bran (Dors et al., 2009). The thermal process stabilizes rice bran by lipase inactivation, contributing to the preservation of its nutritional value during storage. It may also inactivate other antinutritional factors with trypsin inhibitors, which would further contribute to a better use of dietary nutrients (Mujahid et al., 2003).

The objective of this work was to evaluate the effect of parboiled rice whole bran inclusion in laying diets on the performance, egg quality, and economic viability of Japanese quails.

## Materials and Methods

The experiment was conducted in the poultry sector of the Animal Science Department, at the Universidade Federal do Ceará (UFC), Fortaleza, CE, Brazil. Four hundred forty eight 17-week-old Japanese quails were used, with 198 g initial average weight. The animals were housed in laying cages (33x23x16 cm) with gutter type feeders, nipple type drinkers, and egg collectors designed for a density of eight eggs per cage.

A completely randomized experimental design was used, with seven treatments and eight replicates of eight birds each. Treatments consisted of seven isonutrient diets (Table 1) with differents levels (5, 10, 15, 20, 25 and 30%) of parboiled rice whole bran (PRWB) and a control diet. Diets were formulated according to nutritional recommendations of the National Research Council (1994), and feed composition followed recommendations of Rostagno et al. (2011). Adequate corrections based in the analyses of the ingredients were carried out in the laboratory of animal nutrition, at UFC's Animal Science Department.

The experiment period lasted 105 days, divided into five 21-day periods during which animals received diets and water ad libitum. A lighting program of 16 hours (natural light + artificial light) was used, with 40 Watts fluorescent light bulbs for artificial illumination.

Temperature and air relative humidity inside the shelter were measured with a maximum and minimum thermometer and a psychrometer, respectively. Data were registered daily, at 8:00 h and 16:00 h. Means for maximum and minimum temperatures, and for air relative humidity values were measured at the end of the experimental period.

The performance variables assessed were: feed intake (g per bird per day), egg production (% per bird per day), egg weight (g), egg mass (g per bird per day), and feed conversion (diet consumption, kg, per egg production, kg). Evaluations were also made for egg quality and egg constituents by assessing: percentage of yolk, albumen, and shell; Haugh unit; specific weight (g $cm^{-3}$); and yolk color.

Egg production was daily recorded in each cage, and production per replicate was calculated at the end of each period. Egg average weight was obtained by dividing the total weight of the collected eggs by the number of laid eggs per replicate, in each period. Weighing was performed once a week on a 0.01g precision electronic scale. Egg mass was calculated by multiplying the number of the produced eggs by the average weight of the egg for each replicate; and feed conversion was calculated by dividing feed intake by egg mass.

Egg quality and egg constituents were evaluated once a week throughout the experimental period. For this purpose, eggs of each replicate were collected and three of them were randomly selected (avoiding broken, cracked and dirty eggs) to be used in the evaluation. Firstly, egg specific weight (SG) was determined with the procedures described by Freitas et al. (2004). Weighing system was set on a precision scale (0.01 g) in order to obtain egg weight in air and in water. Values of egg weight in air and in water were recorded for SG calculation by using the equation: $SG = EW / (WW \times F)$, in which: EW is egg weight in air; WW is egg weight in water; and F is the temperature correction factor.

After determining SG, eggs were broken on a glass surface to determine albumen height, using a depth micrometer. Data of albumen height and egg weight


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were used for calculation of Haugh unit (UH) with the equation UH = 100 log (H + 7.57 - 1.7W$^{0.37}$), in which H is albumen height (mm) and W is egg weight (g).

After determination of albumen height, yolks were separated and weighed on a precision scale (0.01 g), and egg shells were washed and dried for a 48-hour period, after which they were also weighed. Percentages of yolk and shell were obtained by the relationship between the weight of each portion and egg weight, whereas albumen percentage was determined by the following: % albumen = 100 - (% yolk + % shell). Yolk color was obtained by visual comparison using a color fan (Roche pattern).

All excreta produced in the fifth experimental period was collected in order to evaluate the effects of the inclusion levels of PRWB on nutrient digestibility and excreta moisture. Excreta were collected twice a day (at 8:00 h and 16:00 h.) and sent to the laboratory, for drying in a forced ventilation oven at 55ºC for 72 hours. After that, samples were ground in a knife mill, put in bottles, and sent to the laboratory to determine the contents of dry matter (DM), nitrogen (N) and gross energy (GE), according to the methodology described by Silva & Queiroz (2002). Based on laboratory results, excreta moisture (%) and the digestibility coefficients of DM, N, and GW were calculated. Apparent metabolizable energy (AME) and apparent metabolizable energy corrected for nitrogen balance (AMEn) were calculated based on the equations proposed by Matterson et al. (1965).

In order to check the economic viability of PRWB inclusion in the diets, diet cost per kilogram of egg was firstly determined by adapting the equation proposed by Bellaver et al. (1985) as CRI = (Qi × Pi)/Mi, in which: CRI is the diet cost per kilogram of egg, in the i$^{th}$ treatment; Pi is the diet price per kilogram used in the i$^{th}$ treatment; Qi is the amount of feed consumed in the i$^{th}$ treatment; and Mi is egg mass in the i$^{th}$ treatment. Feed costs were determined by considering its composition and prices of the ingredients obtained in January 2011, in the city of Fortaleza. Moreover, index of economic efficiency (IEE) and cost index (CI), proposed by Fialho et al. (1992), were calculated using the equations IEE = (MCei /CTei) × 100, and IC = (CTei / MCei) × 100, in which: MCei is the lowest

**Table 1.** Calculated percentage and nutritional composition of experimental diets.

| Ingredient | Inclusion levels of parboiled rice whole bran (g kg$^{-1}$) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| Corn | 556.0 | 505.3 | 454.3 | 403.2 | 352.4 | 301.5 | 250.0 |
| Soybean meal (45%) | 339.6 | 334.2 | 328.9 | 323.6 | 318.3 | 312.9 | 307.7 |
| Rice bran | 0.0 | 50.0 | 100.0 | 150.0 | 200.0 | 250.0 | 300.0 |
| Soybean oil | 28.8 | 35.2 | 41.8 | 48.4 | 54.9 | 61.4 | 68.3 |
| Limestone | 51.6 | 51.9 | 52.2 | 52.5 | 52.9 | 53.2 | 53.5 |
| Dicalcium phosphate | 15.9 | 15.3 | 14.7 | 14.2 | 13.5 | 12.9 | 12.4 |
| DL-methionine | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Egg laying Puramix(1) | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Salt | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 |
| Total | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| | Calculated nutritional composition | | | | | | |
| Metabolizable energy (kcal kg$^{-1}$) | 2,900 | 2,900 | 2,900 | 2,900 | 2,900 | 2,900 | 2,900 |
| Crude protein (g kg$^{-1}$) | 200.0 | 200.0 | 200.0 | 200.0 | 200.0 | 200.0 | 200.0 |
| Total lysine (g kg$^{-1}$) | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 |
| Total methionine + cystine (g kg$^{-1}$) | 7.7 | 7.7 | 7.7 | 7.7 | 7.7 | 7.7 | 7.7 |
| Total methionine (g kg$^{-1}$) | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| Total threonine (g kg$^{-1}$) | 7.8 | 7.8 | 7.8 | 7.8 | 7.8 | 7.8 | 7.8 |
| Total tryptophan (g kg$^{-1}$) | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Calcium (g kg$^{-1}$) | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| Available phosphorus (g kg$^{-1}$) | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| Sodium (g kg$^{-1}$) | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |

(1)Composition per kg of the product: folic acid, 400 mg; calcium pantothenate, 3,000 mg; antioxidant, 2,000 mg; copper, 2,000 mg; coline, 126,000 mg; iron, 20,000 mg; iodine, 200 mg; manganese, 18,000 mg; methionine, 217,800 mg; niacin, 7,000 mg; pyridoxine, 800 mg; colistin, 1,400 mg; riboflavin, 1,200 mg; selenium, 100 mg; thiamine, 800 mg; vitamin A, 2,000,000 UI; vitamin B12, 1,000 mcg; vitamin D3, 500,000 UI; vitamin E, 1,000 UI; zinc, 14,000 mg; biotin, 10 mg; menadione, 500 mg; zinc bacitracin, 10,000 mg.

feed cost per egg kilogram, found among treatments; and CTei is the cost of the considered i treatment.

Statistical analyses were done using Proc GLM of the statistical program SAS. Data were subjected to analysis of variance according to a completely randomized model, and degrees of freedom related to the levels of PRWB addition, except for the control diet (level zero of addition). They were unfolded into polynomials in order to set the best description curve for data behavior and to determine the best level of PRWB addition. Dunnett test (5%) was used to compare the results obtained with each one of the levels of PRWB addition in comparison to the control diet.

## Results and Discussion

During the experimental period, minimal and maximum temperatures were 25.7±1.27ºC and 29.9±1.36°C, respectively, and air relative humidity was 67.2%.

The coefficients of dry matter digestibility, nitrogen, gross energy, and the values of apparent metabolizable energy and apparent metabolizable energy corrected for nitrogen were not significantly influenced by the PRWB levels (Table 2), compared to the control diet (0% PRWB). Furthermore, the assessed levels of PRWB did not significantly influence quail capacity of using nutrients from the diets. According to Freitas et al. (2006), lipid increasing in the diet may promote an extra-caloric effect, which is an increase of the nutrient availability of other dietary ingredients, and it may promote as well the extra-metabolic effect, which results in energy efficiency improvement due to the increase in the diet net energy.

**Table 2.** Digestibility coefficients for dry matter (DMCD), nitrogen (NDC), and gross energy (GECD); apparent metabolizable energy (AME); and apparent metabolizable nitrogen (AMEn) corrected for nitrogen balance of diets for Japanese quails fed different levels of parboiled rice whole bran (PRWB).

| Levels of PRWB | DMCD | NDC | GECD | AME | AMEn |
|---|---|---|---|---|---|
| (%) | --------------- (%) -------------- | | | -- (kcal kg$^{-1}$ MS) -- | |
| 0 | 78.28 | 47.29 | 82.13 | 3,406 | 3,284 |
| 5 | 78.16 | 48.54 | 82.02 | 3,416 | 3,287 |
| 10 | 76.16 | 43.43 | 81.11 | 3,370 | 3,260 |
| 15 | 77.73 | 47.77 | 82.52 | 3,449 | 3,278 |
| 20 | 76.97 | 49.08 | 82.05 | 3,424 | 3,265 |
| 25 | 77.15 | 50.57 | 80.28 | 3,361 | 3,188 |
| 30 | 75.29 | 49.98 | 81.68 | 3,426 | 3,277 |
| Mean | 77.11 | 48.09 | 81.68 | 3,407 | 3,263 |
| | p values for the analysis of variance | | | | |
| Inclusion levels | 0.66 | 0.88 | 0.27 | 0.88 | 0.68 |
| Linear effect | 0.87 | 0.82 | 0.99 | 0.98 | 0.52 |
| Quadratic effect | 0.69 | 0.55 | 0.92 | 0.98 | 0.61 |
| CV (%) | 3.40 | 8.35 | 2.97 | 2.97 | 2.60 |

Nonetheless, the good performance achieved with the PRWB inclusion may also be attributed to the beneficial effects of thermal processing of parboiled rice, inasmuch as the grain is subjected to heat under pressure before being peeled and polished. This thermal process results in physical and chemical changes in polished grain and in bran (Dors et al., 2009), stabilizing rice bran – which contributes to the preservation of nutritional value during storage, due to the lipase inactivation – and also inactivating other antinutritional factors with trypsin inhibitors, which would contribute to a better use of the dietary nutrients (Mujahid et al., 2003).

Addition of PRWB at levels above 5% did not influence feed intake, egg laying percentage, egg average weight, egg mass, and feed conversion (Table 3).

According to Leeson & Summers (2001), involuntary feed intake by birds, within certain limits, is regulated by energy ingestion; therefore, birds fed diets with higher levels of energy may reduce intake, in comparison to those fed diets with lower energy levels. However, there are other factors that may affect feed intake, as the bird age, environment, production phase, and diet characteristics, such as protein concentration, adequate mineral supply, particle size, density, and presence of fibers and antinutritional factors. Considering that diets were formulated to be isonutrient, and since there was no significant variation in the metabolization of dietary energy, feed intake was actually expected not to vary significantly between treatments.

Diet intake by birds may be altered by adding ingredients that affect palatability or modify the density of the diet. Thus, intake reduction has been frequently reported for laying hens diets with higher levels of rice bran, usually associated with the increased fiber content, which promotes a satiety feeling (Samli et al., 2006; Brum Júnior et al., 2007). However, our results showed that this effect did not occur for quails fed up to 30% PRWB. Rezaei (2006) and Filardi et al. (2007) also observed that the inclusion of whole rice bran (up to 25 and 15%, respectively) did not influence feed intake of laying hens.

Since there were no significant differences in egg production, egg mass, and in feed conversion, the ingestion and the use of dietary nutrients between treatments should be similar.

Effects of PRWB inclusion in the feeding of quails differ from some reported works with commercial laying hens. For instance, Brum Júnior et al. (2007) evaluated increasing levels of common whole Rice bran (0, 12, 24 and 36%) and found that feed intake and feed conversion linearly decreased as bran inclusion increased. Samli et al. (2006) evaluated the levels of 0, 5, 10 and 15%, and found that 15% inclusion promoted a reduction in feed intake, egg production, and egg mass.

Yolk and albumen percentages, as well as the Haugh units, were also not affected by the PRWB inclusion levels (Table 4). However, there was a linear effect of the PRWB levels on shell percentage ($\hat{Y} = 8.07 - 0.01X$, $R^2 = 0.42$), specific weight ($\hat{Y} = 1.068 - 0.0002X$, $R^2 = 0.84$), and yolk color ($\hat{Y} = 6.09 - 0.06X$, $R^2 = 0.95$), which significantly differed from control treatment (Table 4). Shell percentage and values for yolk color reduced with the 10% inclusion of PRWB, reaching minimal values with 30% inclusion. However, for specific weight, reduction only occurred with 20% inclusion.

The worsening in shell quality, associated to the smaller proportion of shell and to the worse specific weight with increasing PRWB levels in the diet, could be attributed to the alleged presence of antinutritional factors in this ingredient (Islam et al., 2010;

**Table 3.** Performance of laying Japanese quails fed different levels of parboiled rice whole bran (PRWB).

| Level of PRWB (%) | Feed intake (g per bird per day) | Egg production (% per bird per day) | Egg weight (g) | Egg mass (g per bird per day) | Feed conversion (g $g^{-1}$) |
|---|---|---|---|---|---|
| 0 | 25.33 | 92.35 | 11.48 | 10.61 | 2.39 |
| 5 | 25.27 | 95.39 | 11.54 | 11.01 | 2.31 |
| 10 | 24.80 | 88.97 | 11.42 | 10.16 | 2.45 |
| 15 | 23.33 | 94.19 | 11.55 | 10.88 | 2.15 |
| 20 | 23.43 | 92.02 | 11.40 | 10.49 | 2.24 |
| 25 | 23.52 | 88.12 | 11.40 | 10.05 | 2.36 |
| 30 | 23.71 | 92.51 | 11.41 | 10.55 | 2.25 |
| Mean | 24.18 | 91.94 | 11.45 | 10.53 | 2.31 |
| | | | p values for the analysis of variance | | |
| Inclusion levels | 0.10 | 0.21 | 0.30 | 0.13 | 0.57 |
| Linear effect | 0.06 | 0.20 | 0.73 | 0.20 | 0.57 |
| Quadratic effect | 0.10 | 0.30 | 0.90 | 0.32 | 0.63 |
| CV (%) | 7.42 | 5.35 | 2.53 | 6.13 | 9.88 |

**Table 4.** Egg components and egg quality of Japanese quails fed different levels of parboiled rice whole bran (PRWB).

| Levels of PRWB | Yolk | Albumen | Shell | Haugh | Specific weight | Yolk |
|---|---|---|---|---|---|---|
| (%) | | (%) | | unit | (g $cm^{-3}$) | color |
| 0 | 30.72 | 61.04 | 8.21 | 87.17 | 1.067 | 5.85 |
| 5 | 30.91 | 60.90 | 8.19 | 87.44 | 1.067 | 5.74 |
| 10 | 31.01 | 61.16 | 7.83* | 87.78 | 1.065 | 5.46* |
| 15 | 30.79 | 61.21 | 7.76* | 87.00 | 1.065 | 5.39* |
| 20 | 30.63 | 61.47 | 7.77* | 87.57 | 1.061* | 5.13* |
| 25 | 31.22 | 60.88 | 7.90* | 87.26 | 1.062* | 4.73* |
| 30 | 31.15 | 60.88 | 7.73* | 87.55 | 1.061* | 4.29* |
| Mean | 30.92 | 61.08 | 7.91 | 87.40 | 1.060 | 5.23 |
| | | | p values for the analysis of variance | | | |
| Inclusion levels | 0.31 | 0.35 | 0.001 | 0.91 | 0.001 | 0.001 |
| Linear effect | 0.30 | 0.07 | 0.00 | 0.70 | 0.001 | 0.02 |
| Quadratic effect | 0.21 | 0.06 | 0.06 | 0.71 | 0.06 | 0.90 |
| CV (%) | 1.79 | 0.95 | 2.88 | 1.40 | 0.25 | 4.69 |

*Significantly different at 5% probability, by Dunnett test.

Sarkar et al., 2011). Contrary to these results, Samli et al. (2006) and Filardi et al. (2007) found that the inclusion of up to 15% of rice bran had no negative effect on egg quality of commercial laying hens. Rezaei (2006) found that inclusion of rice bran up to 25% did not influence egg shell quality of laying hens.

Shell proportion obtained with PRWB at 30% is satisfactory when compared to values presented in the literature. Costa et al. (2010) reported values of shell percentage from 6.81 to 7.50%, for Japanese quails fed different levels of Ca in the final third of the laying phase.

Color reduction was probably a consequence of pigment decrease in the diet with PRWB addition, since corn proportion decreased as PRWB levels increased (Table 1). Corn, which is the main energy source in the diets, is rich in pigments as xanthophylls, which give the yellow color to the yolks. According to Silva et al. (2000), total or partial substitution of corn by alternative feed which are poor in carotenoid pigments, may lead to color reduction in the yolk, whose intensity depends on the level of substitution.

Although the reports on the preference of the consumer to a much pigmented yolk are not common, this observation should be taken into account regarding the inclusion of PRWB at levels above 5%.

Diet costs per kilogram of eggs, index of cost, and index of economic efficiency were only affected by PRWB inclusion at 30% (Table 5). The observed reduction in these variables points to the economic viability this inclusion level of PRWB in diets for laying hens. However, Brum Júnior et al. (2007) showed that the optimum inclusion level of rice bran into laying hens diets was 18.01%, and Filardi et al. (2007) found that the rice bran addition at levels above 6% increased the cost per kilogram of eggs.

**Table 5.** Economic evaluation of parboiled rice whole bran (PRWB) inclusion in the diet.

| Levels of PRWB (%) | Diet cost (R$ kg$^{-1}$) | Cost index | Economic efficiency index |
|---|---|---|---|
| | | ---------------- (%) | ---------------- |
| 0 | 2.31 | 112.29 | 89.57 |
| 5 | 2.21 | 107.25 | 94.25 |
| 10 | 2.24 | 108.67 | 92.33 |
| 15 | 2.10 | 102.00 | 98.86 |
| 20 | 2.08 | 101.00 | 99.63 |
| 25 | 2.07 | 100.29 | 99.86 |
| 30 | 2.06* | 100.00* | 100.00* |
| Mean | 0.94 | 104.04 | 96.87 |
| | p values for the analysis of variance | | |
| Inclusion levels | 0.04 | 0.04 | 0.03 |
| Linear effect | 0.31 | 0.32 | 0.29 |
| Quadratic effect | 0.56 | 0.57 | 0.53 |
| CV (%) | 8.25 | 8.32 | 7.89 |

*Significantly different at 1% probability, by Dunnett test.

## Conclusions

1. The laying performance of Japanese quail is not affected by the evaluated inclusion levels of parboiled rice whole bran (PRWB).
2. Among egg quality traits, only shell percentage, specific weight, and yolk color are reduced by PRWB inclusion.
3. Parboiled rice whole bran inclusion up to 30% reduces the cost of laying diet for Japanese quails.

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