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Effect of feeding canola meal to laying Japanese quails

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ABSTRACT. This study evaluated the effect of different levels of canola meal in the diet to laying Japanese quails on productive performance, egg quality and economic viability. A total of 120 80-day-old Japanese quails (*Coturnix coturnix japonica)* with average weight 146.54 ± 12 g were evaluated during 84 days. Dietary treatments consisted of the replacement of soybean meal with canola meal at 0, 10, 20, 30, 40 or 50%. We evaluated economic viability, productive performance, internal and external quality of eggs. Data were analyzed by polynomial regression at 5%. Body weight decreased linearly as the level of canola meal increased ($p = 0.0055$). Egg weight ($p = 0.0032$) and diameter ($p = 0.0398$) showed a quadratic response, increasing up to 30% substitution with subsequent reduction. Yolk color increased linearly as the level of canola meal increased ($p = 0.0039$). Canola meal can substitute soybean meal up to 30% without impairing productive performance, egg quality and diet cost.

Keywords: alternative ingredient, nutrition, performance, protein.

Efeito do farelo de canola na dieta de codornas japonesas

RESUMO. Este estudo avaliou o efeito de níveis dietéticos de farelo de canola para codornas japonesas em postura sobre o desempenho produtivo, a qualidade dos ovos e a viabilidade econômica. Foram utilizadas 120 codornas japonesas (*Coturnix coturnix japonica*) com peso médio de 146,54 ± 12 g e 80 dias de idade foram avaliadas por 84 dias. Os tratamentos foram constituídos de níveis de substituição do farelo de soja pelo farelo de canola em 0, 10, 20, 30, 40 ou 50% na dieta. Foi avaliada a viabilidade econômica, o desempenho produtivo, a qualidade interna e a externa dos ovos. Os dados foram analisados por meio de regressão polinomial com 5% de significância. O peso corporal diminuiu linearmente com o aumento do nível de farelo de canola ($p = 0{,}0055$). O peso do ovo ($p = 0{,}0032$) e o diâmetro ($p = 0{,}0398$) apresentaram respostas quadráticas, aumentando até o nível de 30% de substituição e reduzindo posteriormente. A cor da gema aumentou de forma linear com o aumento do nível de farelo de canola ($p = 0{,}0039$). O farelo de canola pode substituir o farelo de soja em até 30% sem prejudicar o desempenho produtivo, qualidade do ovo e custo de dieta.

Palavras-chave: alimento alternativo, nutrição, desempenho, proteína.

Introduction

Canola is a winter crop originally derived from rapeseed varieties, which have been altered by genetic selection that has markedly reduced its detrimental components, erucic acid and glucosinolate to a negligible level less than 20 $\mu g\ g^{-1}$ (Leeson et al., 2001).

World production of canola oil ranks second among industrialized products derived from oil plants. The industrial extraction of oil generates canola meal as a byproduct, which can be acquired by producers at a low price. In some countries, such as Canada and the United States, its use is widespread in poultry production, mainly for feeding broilers and laying hens. However, little is known about its use in the feeding of laying quails.

Several factors have contributed for the increase in quail production, including rapid growth, early sexual maturity and production, high productivity, small area required for large populations, high longevity of egg production, low initial investment and rapid profit. In addition, egg quality is considered an interesting alternative for human diet, due to its high digestibility and biological value of protein (Leandro et al., 2005).

Just as in the production of broilers and laying hens, nutrition is one of the most important factors impacting the costs of quail production, primarily due to the continuous fluctuation of prices of traditional dietary ingredients (corn and soybean meal), which leads to an increasing interest on the search for suitable alternative ingredients (Farahat et al., 2013). One of the ingredients that have been tested as an alternative to substitute, in part or completely, soybean meal in diets for animals is canola meal (D'oliveira et al., 1997; Prado & Martins, 1999). It has been commonly added to poultry diets in substitution of soybean meal. However, its use is still limited due to the low available energy and the presence of anti-nutritional factors, which affect its nutritional value and electrolyte balance. The main anti-nutritional factors include glucosinolates, sinapine, phytic acid, tannins and fiber (Khajali & Slominski, 2012).

Canola meal and soybean meal have a similar protein composition, with differences in lysine content, 1.72 and 2.57%, and in methionine content, 0.70 and 0.50%, respectively. Soybean meal is more energetic when compared to canola meal (2,254 kcal vs. 1,692 kcal). The low values of digestible and metabolizable energy found in canola meal are mainly due to the high levels of fiber, which can be up to three times higher than in soybean meal, 11.2% and 5.3%, respectively (Rostagno et al., 2011).

Najib and Al-Khateeb (2004) report that the replacement of soybean meal with canola meal is possible in up to 10% in the diet of laying without causing loss in productive performance or internal and external quality.

Therefore, this study evaluated the effect of replacing soybean meal with canola meal on productive performance, economic viability and egg quality of laying Japanese quails.

Material and methods

The procedures adopted in this experiment complied with the Brazilian guidelines for the scientific use of animals (Federal Act 11,794 as of October 8, 2008) and the experimental protocol of this project was approved by the Ethics Committee on Animal Experimentation of the Federal University of Pelotas under protocol number 805.

A total of 120 laying Japanese quails (*Coturnix coturnix japonica*), 80-day-old, with 146.54 ± 12 g of body weight, were housed in metallic cages to evaluate three productive periods of 28 days each.

A completely randomized design was used. The dietary treatments consisted of five levels of substitution of soybean meal with canola meal: 0, 10, 20, 30, 40 and 50%, with five replicates of four quails each (Table 1). Diets were formulated to meet the nutritional requirements, in accordance with the recommendations of Silva and Costa (2009). The diets were isocaloric and isoproteic. In order to make the diets isoenergetic, soybean oil was added with increasing substitution of soybean meal with canola meal in the diet.

Eggs were collected and weighed daily for the calculation of total production (%) and average weight (g). Egg mass was calculated by the product of the percentage of eggs produced (bird day^{-1}) and the average egg weight of each cage. Feed conversion by egg mass was obtained by the ratio of feed intake and egg mass (g g^{-1}) produced. Feed conversion per dozen eggs was obtained dividing the amount of feed consumed by birds by dozen eggs (g dozen^{-1}) produced.

The following variables of internal egg quality were analyzed: albumen height, yolk color, yolk percentage, percentage of albumen and Haugh unit.

Table 1. Composition of experimental diets (%).

		Substitution Levels of Soybean Meal with Canola Meal (%)					
Ingredient	U$ kg^{-1}	0	10	20	30	40	50
Corn	0.28	52.26	50.99	49.53	48.17	46.88	45.44
Soybean Meal (45%)	0.83	37.30	34.40	31.60	28.70	25.80	23.00
Canola Meal (38%)	0.34	0.00	3.73	7.46	11.19	14.92	18.65
Limestone	0.11	6.08	6.04	6.01	5.97	5.94	5.90
Common salt	0.17	0.43	0.43	0.43	0.43	0.39	0.38
Soybean Oil	1.36	0.93	1.41	1.97	2.54	3.07	3.63
Vitamin-mineral premix[1]	2.91	3.00	3.00	3.00	3.00	3.00	3.00
Price (U$ kg^{-1})		0.56	0.55	0.54	0.54	0.53	0.52
Calculated nutrient content							
E. Met. (kcal kg^{-1})		2.700	2.700	2.700	2.700	2.700	2.700
Crude protein (%)		21.00	21.00	21.00	21.00	21.00	21.00
Calcium (%)		3.050	3.050	3.050	3.050	3.050	3.050
Total P (%)		0.670	0.680	0.690	0.700	0.710	0.721
Available P (%)		0.451	0.453	0.456	0.458	0.460	0.463
Met+Cys dig. (%)		0.589	0.592	0.618	0.632	0.646	0.650
Lysine dig. (%)		1.209	1.198	1.188	1.177	1.166	1.156
Linoleic acid (%)		1.884	2.111	2.346	2.582	2.805	3.038
Crude fat (%)		3.354	3.832	4.329	4.826	5.299	5.791
Crude fiber (%)		3.678	3.837	4.000	4.162	4.326	4.488
Sodium (%)		0.203	0.206	0.209	0.213	0.200	0.200

[1]Composition per kilogram of product: Vitamin A (IU) 207000; Vitamin D 3 (IU) 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 Zinc (mg) 600; BHT (mg) 700; Calcium (g) 197.5; Cobalt (mg) 5.1; Fluoride (mg) 400; Phosphorus (g) 50; Sodium (g) 36.

To determine the albumen height (mm), a specific ruler (FHK trademark) was used. The evaluation of yolk color was performed using the Roche® color fan. The percentage of yolk and albumen was determined by weighing the yolk (g) and albumen (g) on a digital scale (Marte, model AS 5500C, accurate to 0.1 g), multiplying the result by 100 and dividing by the egg weight. The Haugh unit was obtained from the egg weight and albumen height, according to the formula:

$$UH = 100\log(H + 7.57 - 1.7\,W^{0.37})$$

where H = albumen height; W = egg weight.

The following variables of external egg quality were measured: egg length (mm), egg diameter (mm) and shape index diameter (mm)/height (cm)] x 100; specific gravity (g cm^{-3}), shell thickness (mm) and shell percentage. The diameter was obtained in the central ring of each egg. A digital caliper (Electronic Digital Caliper 150 mm) accurate to 0.01 mm was used for measurement of egg length and diameter. For the evaluation of specific gravity, eggs were placed in a perforated plastic bucket and immersed in saline solutions, with densities ranging from 1.050 to 1.098 g cm^{-3} and intervals of 0.004 g cm^{-3}. The eggs were removed when they floated. The shells were identified, washed and air-dried for the evaluation of weight and thickness. For determination of the percentage of shell, they were individually weighed on an analytical digital scale (UniBloc, AUY-220, accurate to 0.1 mg) and the result was multiplied by 100 and divided by the egg weight. Shell thickness (μm) was measured in the central ring of each egg with a manual micrometer (Starret) accurate to 0.01 mm.

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

The economic viability was obtained considering the cost per kilogram of diet, multiplied by the number of dozens eggs produced within 84 days and its respectively selling price. The values were obtained from the Brazilian exchange rate and subsequently converted into U.S. dollars, considering the period when the experiment was conducted (June 2012). The selling price of a dozen eggs used for the calculation was R$ 0.60 (equivalent to U$ 0.29). The gross income was obtained by subtracting the cost from the gross revenue.

A polynomial regression analysis was applied to predict the effect of the levels of canola meal in the diet on productive performance, internal and external quality of eggs and economic viability. Data were analyzed using the GLM procedure of SAS (SAS, 2002). The polynomial regression models were selected based on the significance of the regression coefficients ($p < 0.05$) and the value of the coefficient of determination.

Results and discussion

The results of egg production, egg weight and body weigh are listed in Table 2. Egg production was not affected by the substitution of soybean meal with canola meal ($p > 0.05$). Egg weight showed an increasing quadratic response ($p < 0.05$) up to 24% of inclusion of canola meal, which decreased thereafter. As the level of substitution of soybean meal with canola meal was increased, a linear decrease was observed for body weight ($p < 0.05$).

Egg weight may be altered mainly by the presence of methionine and linoleic acid in the diet (Harms & Russell, 2004; Sohail et al., 2002). In the present study, the levels of both linoleic acid and methionine increased with the inclusion of canola meal. In addition, there was an increase in the level of oil by increasing the level of canola meal in the diets, so as to keep them isoenergetic.

When oil is added to the diet, the fatty acid synthesis is reduced and the bird has more energy for productive performance (Costa et al., 2008). However, although the levels of methionine, linoleic acid and oil have increased with the inclusion of canola meal in the diet, egg weight showed an increasing quadratic response up to the level of 30% of canola meal, with subsequent reduction. This fact may be associated with increased fiber content in the diet, which can compromise the digestibility of nutrients in diets and, in general, is associated with poor performance and reduced egg weight (Roberts et al., 2007). Araújo and Silva (2008) verified that the inclusion of an alternative ingredient with high fiber content in the diet caused a linear reduction in body weight gain of pullets and lighter birds at the end of the growing phase, lower production and lower egg mass, as well as poor feed efficiency during the laying phase.

Reducing body weight with increasing levels of substitution of soybean meal with canola meal can be attributed to several anti-nutritional factors, including fiber, glucosinolates and sinapine present in canola meal (Woyengo et al., 2011). Both glucosinolate and sinapine give a bitter taste and may be responsible for the decrease in voluntary feed intake (Mailer et al., 2008). In addition, glucosinolates can be hydrolyzed and form toxic glucosinolates, which may also reduce voluntary feed intake. The fiber content increased with increasing levels of canola meal in the diet (Table 1). High fiber content in diets can accelerate the rate of passage of digesta, which results in a shorter time for digestion and absorption of nutrients (Khajali & Slominski, 2012).

Regarding egg quality, a linear increase in yolk color was observed (0.0039) with increasing levels of canola meal in the diet (Table 3).

Yolk color is directly related to the presence of carotenoids in the diet. Nevertheless, the amount of corn in the diet was reduced as the level of canola meal was increased. In our study, the increase in yolk color may have been caused by an increased bioavailability of carotenoids due to the higher level of oil in the diet, since they are fat soluble.

Albumen height, yolk percentage, percentage of albumen and Haugh unit were not affected by the inclusion of canola meal in the diet ($p > 0.05$), as shown in Table 4. Once the internal egg quality is influenced by the daily protein intake, which guarantees the required levels of amino acids (Moura et al., 2010; Pinto et al., 2002), the supply of isonitrogenous diets had no effect on these variables.

Likewise, egg length, egg shape index, specific gravity, shell thickness and shell percentage were not affected ($p > 0.05$) by replacing soybean meal with canola meal (Table 3). The diameter of eggs showed a quadratic response, increasing up to the level of 36% of inclusion of canola meal in the diet and decreasing afterwards. This response is related to egg weight, which showed a similar behavior, due to the increase in linoleic acid and methionine levels in the diets.

A reduction in the cost of the diets was verified with increasing levels of replacement of soybean meal with canola meal (Table 4).

According to Anaeto and Adighibe (2011), protein replacement in diets increases the cost per kilogram of diet compared with energy replacement. The results herein obtained corroborate this affirmation. Even with the rise in oil level due to the increasing substitution of soybean meal with canola meal, the cost per kilogram of diet decreased by 7.14% when comparing the level 0% with the highest level of inclusion of canola meal (50%). Furthermore, the replacement of 30% of soybean meal with canola meal resulted in an increase of 14.6% in gross income. These results demonstrate the importance of alternative feedstuffs for the economics of poultry production.

Table 2. Productive performance of laying quails fed different levels of canola meal.

Parameters	Levels of canola meal replacing soybean meal (%)						CV (%)	p*
	0	10	20	30	40	50		
Egg production (%)	59.76	60.09	62.82	65.56	60.35	64.52	14.11	0.5144
Egg weight (g)	10.46	10.77	10.96	11.24	11.91	10.66	2.95	0.0032
Body weight (g)	156.46	158.48	158.51	151.91	151.07	152.03	3.52	0.0055
Feed conversion per mass (kg kg^{-1})	3.35	3.30	3.39	3.28	3.35	3.40	8.22	0.1871
Feed conversion per dozen (kg kg^{-1})	1.54	1.49	1.47	1.49	1.50	1.49	6.07	0.1034

* p = significance level for polynomial regression; CV (%) coefficient of variation. Equation fitted for egg weight = $10.43 + 0.048x - 0.001x^2$ ($R^2 = 0.67$); Equation fitted for weight of the bird = $159.39 - 0.1852x$ ($R^2 = 0.69$).

Table 3. Internal and external egg quality of laying quails fed different levels of canola meal.

Parameters	Levels of canola meal replacing soybean meal (%)						CV(%)	p*
	0	10	20	30	40	50		
Albumen height (mm)	4.57	4.52	4.84	4.70	4.81	4.60	4.56	0.3328
Yolk color	3.39	3.60	3.47	3.68	4.01	4.06	4.83	0.0039
Percentage of yolk (%)	30.25	30.54	31.14	31.57	31.57	31.54	4.63	0.6862
Percentage of albumen (%)	49.69	51.19	48.94	49.61	49.24	50.35	4.63	0.6862
Haugh unit	91.51	91.54	92.07	90.49	91.85	92.09	1.17	0.1343
Length (mm)	30.88	31.68	31.78	31.69	31.76	31.40	1.83	0.1013
Diameter (mm)	24.12	25.13	24.86	25.15	25.03	25.08	2.26	0.0398
Shape index	79.17	79.40	78.25	79.45	78.90	79.92	2.06	0.6521
Specific gravity (g.cm^{-3})	1066	1066	1064	1062	1066	1062	0.68	0.5857
Shell thickness (μm)	21.60	21.50	20.90	21.66	21.16	21.16	3.18	0.2699
Percentage of shell (%)	8.20	8.14	7.97	8.00	8.18	8.07	4.68	0.8967

* p = significance level for polynomial regression; CV (%) coefficient of variation. Equation fitted for yolk color = $3.45 + 0.012x$ ($R^2 = 0.86$). Equation fitted for egg diameter = $24.30 + 0.051x - 0.0007x^2$ ($R^2 = 0.69$).

Table 4. Economic viability of using canola meal in the diets for laying quails.

Performance	Levels of canola meal replacing soybean meal (%)					
	0	10	20	30	40	50
Diet cost (U$ kg-¹)	0.56	0.55	0.54	0.54	0.53	0.52
Consumed died cost (U$)	0.94	0.92	0.91	0.91	0.89	0.87
Egg production (dozen)	4.18	4.21	4.40	4.59	4.22	4.52
Cost (U$ kg^{-1} dozen^{-1})	0.22	0.22	0.21	0.20	0.21	0.19
Revenue (egg dozen R$ at sale)	1.21	1.22	1.28	1.33	1.23	1.31
Gross income (quail 84^{-1} days)	0.99	1.00	1.07	1.13	1.01	1.12

Conclusion

Although canola meal has decreased body weight of laying Japanese quail, it can replace up to 30% soybean meal in the diet without affecting the productive performance, external and internal quality of eggs, especially at times when the price is in favor of canola meal.

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