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Productive performance, egg quality and bone characteristics of quails fed with meal and canola oil

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ABSTRACT. This study evaluated the effect of canola meal and oil in quail diet on productive performance, egg quality and bone characteristics. Quails (n = 84) with 150-days-of-age and average weight of 234±17 g were used in this experiment that lasted 84 days. The experiment consisted of a completely randomized design with 4 treatments, 7 replications with 3 birds each. Four diets were formulated: SM+SO - control diet with soybean meal and oil; MC+SO - 25% replacement of soybean meal with canola meal; MC+CO - 25% replacement of soybean meal with canola meal and complete replacement of canola oil with soybean oil; SM+OC - control diet with soybean meal and canola oil. Productive performance, internal and external egg quality and bone characteristics were evaluated. The diet with canola meal and oil (MC+CO) decreased ($p < 0.05$) feed conversion. Albumen height was lower ($p < 0.05$) for treatments with canola meal and oil (MC+CO). Regardless of the oil used, the dietary canola meal (MC+SO and MC+CO) reduced the weight and length of tibia ($p < 0.05$), but increased its ash content ($p < 0.05$). The mixture of canola oil and meal decreases feed conversion, and negatively affects internal egg quality and bone characteristics of quails.

Keywords: alternative ingredient, performance, nutrition.

Desempenho produtivo, qualidade de ovos e características ósseas de codornas alimentadas com farelo e óleo de canola

RESUMO. Este estudo avaliou o efeito do farelo e do óleo de canola na dieta de codornas sobre o desempenho produtivo, qualidade de ovos e características ósseas. Foram utilizadas 84 codornas com 150 dias de idade e peso médio de 234±17 g por um período de 84 dias. Foi utilizado um delineamento experimental inteiramente ao acaso, com 4 tratamentos, 7 repetições com 3 aves cada. Foram formuladas quatro dietas: FS+OS - dieta controle com farelo e óleo de soja; FC+OS - 25% de substituição do farelo de soja pelo de canola; FC+OC - 25% de substituição do farelo de soja pelo de canola e óleo de canola substituindo totalmente o óleo de soja; FS+OC - dieta controle com farelo de soja e óleo de canola. Foi avaliado o desempenho produtivo, a qualidade interna e externa dos ovos e as características ósseas. A dieta com farelo e o óleo de canola (FC+OC) piorou ($p < 0,05$) a conversão alimentar. A altura do albúmen foi menor ($p < 0,05$) para os tratamentos com farelo e óleo de canola (FC+OC). Independentemente do óleo utilizado o farelo de canola (FC+OS e FC+OC) na dieta reduziu ($p < 0,05$) o peso e o comprimento das tíbias, porém aumentou ($p < 0,05$) o teor de cinzas. A mistura de óleo e farelo de canola piora a conversão alimentar, afeta negativamente a qualidade interna dos ovos e as características ósseas das codornas.

Palavras-chave: alimento alternativo, desempenho, nutrição.

Introduction

World production of canola oil ranks second among industrialized products derived from oil plants (United States Department of Agriculture [USDA], 2011). Industrial oil extraction generates canola meal as a by-product which can be purchased at low cost in the market. In some countries, such as Canada and the United States, its use is widespread in poultry production, mainly in feeding broilers and laying hens (Newkirk & Classen, 2002). However, little is known about its use in feed for quails.

In laying hen nutrition, studies have shown that canola meal can replace partially (20-30%) soybean meal without affecting feed intake, production, size and quality of eggs (Ciurescu, 2009; Ismail, Al-Busadah, & El-Bahr, 2013). At high levels in the diet, canola meal can cause liver hemorrhagic syndrome due to the presence of glucosinolates (Khajali & Slominski, 2012).

In turn, canola oil is an excellent source of monounsaturated acids, and linolenic acid. Diets formulated with 4% canola oil increase the amount of omega-3 in eggs and in broiler tissue (Fouladi, Doust, & Ahmadzade, 2008), which can be beneficial for human health (An, Guo, Ma, Yuan, & Liu, 2010). Furthermore, lipids also play an important role in bone metabolism in birds, especially long chain fatty acids, such as linolenic acid (18:3, ω3). While high consumption of linoleic acid (18:3, ω6) negatively influences bone metabolism by excessively stimulating the resorptive phase, due to the elevated production of a prostaglandin, linolenic acid has an opposite function, decreasing bone resorption process (Mazzuco, 2006).

Linolenic acid contributes to minimize the bone resorption process. However, excessive linoleic acid can negatively influence the bone metabolism by stimulating bone resorption due to high endogenous production of prostaglandins. Thus, the lowest ω6: ω3 ratio in the diet could reduce the development of bone metabolic diseases (Li et al., 1999).

Bone quality can be measured by various techniques, such as mineral composition, ash content, shear strength and Seedor index. The Seedor index is a calculation that considers bone volume, and the result can indicate bone mineral density (Paz et al., 2008). Bone consists of approximately 70 minerals, 20 organic matrix and about 10% water. The mineral matrix is mainly composed of Ca and P in the form of hydroxyapatite crystals, constituting approximately 60 to 70% of the bone weight, the other minerals such as calcium carbonate (13%) and magnesium phosphate (2%) are also found (Rath, Huff, Huff, & Balog, 2000).

In this context, the objective of this study was to evaluate the effect of canola meal and oil in laying quail diet on productive performance, egg quality and bone characteristics.

Material and methods

All procedures adopted throughout the experimental period were approved by the Ethics Committee on Animal Experimentation under the number 2165. The experiment was conducted in Laboratory for Teaching and Experimentation in Animal Science Prof. Renato Peixoto (Leezo) - Poultry Sector, Department of Animal Science-FAEM- UFPel.

There were used 84 dual-purpose female quails, originated from crosses between males of the line *Coturnix coturnix coturnix*, with females of the line *Coturnix coturnix japonica*. Birds with 150 days-of-age and average weight of 234±17 g were assigned to a completely randomized experimental design with 4 treatments, 7 replications with 3 birds each.

Birds were housed in metal cages equipped with metal trough feeders and nipple drinkers. During the experimental period, quails were given water and food ad libitum. The lighting program used was 17 hours light and 7 hours dark. Birds were evaluated during three cycles of 28 days each.

Diets were formulated to meet the nutritional requirements according to the recommendations of Rostagno et al. (2011 - Table 1) in a total of four treatments: SM+SO - control diet with soybean meal and oil; MC+SO - control diet with 25% canola meal replacing soybean meal; MC+CO - control diet with 25% of canola meal replacing soybean meal and canola oil completely replacing soybean oil; MC+SO - control diet with soybean meal and canola oil.

Table 1. Composition of experimental diets.

Ingredients	SM+SO	MC+SO	MC+CO	SM+OC
Corn (7.88% CP)	41.62	45.44	45.44	41.64
Soybean meal (45% CP)	35.17	26.38	26.38	35.17
Canola meal (38% CP)	0.00	8.79	8.79	0.00
Soybean oil	4.21	4.21	0.00	0.00
Canola oil	0.00	0.00	4.21	4.21
Rice bran	1.52	3.25	3.25	1.51
Limestone	7.08	7.10	7.10	7.08
Dicalcium phosphate	1.15	0.99	0.99	1.15
Salt	0.27	0.25	0.25	0.27
L-lysine HCL (99%)	0.14	0.21	0.21	0.14
DL – methionine (99%)	0.10	0.08	0.08	0.10
Inert (kaolin)	5.44	0.00	0.00	5.43
Vitamin and mineral mix[1]	3.00	3.00	3.00	3.00
Antimycotoxin additive	0.30	0.30	0.30	0.30
Calculated composition				
Crude protein (%)	19.50	19.50	19.50	19.50
Metabolizable energy (kcal kg^{-1})	2800	2800	2800	2800
Calcium (%)	3.05	3.05	3.05	3.05
Phosphorus (%)	0.29	0.29	0.29	0.29
Potassium (%)	0.78	0.71	0.71	0.78
Sodium (%)	0.23	0.23	0.23	0.23
Chlorine (%)	0.20	0.20	0.20	0.20
Methionine (%)	0.39	0.39	0.39	0.39
Lysine (%)	1.09	1.09	1.09	1.09
Methionine+Cystine (%)	0.62	0.65	0.65	0.62

SM+SO – control diet with soybean meal and oil; MC+SO - control diet with 25% canola meal replacing soybean meal; MC+CO - control diet with 25% canola meal replacing soybean meal and canola oil completely replacing soybean oil; SM+OC - control diet with soybean meal and canola oil). [1]Assurance levels per kg of the product: Folic acid: 16.7 mg; Pantothenic acid: 204.6 mg, zinc bacitracin: 600 mg; BHT: 700 mg; biotin: 1.4 mg; calcium: 197.5 mg; cobalt: 5.1 mg; copper: 244 mg; choline: 42 g; iron: 1695 mg; fluorine (maximum): 400 mg; phosphorus: 50 g; iodine: 29 mg; manganese: 1485 mg; methionine: 11 g; niacin: 840 mg; selenium: 3.2 mg; sodium: 36 g; vitamin A: 207000 UI; vitamin B1: 40 mg; vitamin B12:430 mcg; vitamin B2: 120 mg; vitamin B6: 54 mg; vitamin D3: 43200 UI;vitamin E: 540 mg; vitamin K3: 51.5 mg; zinc: 1535 mg.

At the end of each production period, we evaluated the productive performance, internal and external egg quality. For the productive performance, eggs were collected daily for obtaining the egg production (%), and egg weight (g); calculation of egg mass (MO, g $bird^{-1}$ day^{-1}) was made by multiplying egg production by the average egg weight. Feed was provided daily and leftovers were collected only at the end of the cycle. Feed intake (g) was determined by weight difference between the amount of feed supplied and leftovers in the trough, the result was divided by the number of birds of the replication. Feed conversion by egg mass was calculated by the relationship between feed intake and egg mass produced; feed conversion per dozen eggs was calculated as the ratio between feed intake and egg production by multiplying the result by 12. Birds were weighed at the end of the experiment to obtain the average bird weight (g).

For the internal quality, the following variables were analyzed: albumen height (mm), yolk color, percentage of yolk (%), percentage of white (%) and Haugh unit. To determine the albumen height (mm), we used a specific rule (FHK). Egg yolk color was determined by colorimetric score of Roche®. The percentage of yolk and white was determined by weighing the yolk (g) and the white (g) on a digital scale (Marte, AS 5500C, accurate to 0.1 g), and the result is multiplied by 100 and divided by the egg weight. The Haugh unit (Haugh, 1937) was obtained from the egg weight and albumen height, through the formula: $UH = 100 \log (H+7.57 - 1.7 W^{0.37})$, where: H = albumen height and W = egg weight.

External egg quality was evaluated by the variables: length (mm), diameter (mm), egg shape index, specific gravity (g cm^{-3}), shell thickness (μm) and shell percentage (%). To calculate the shape index, we measured the length and diameter of the eggs using a digital caliper (Electronic Digital Caliper 150 mm) accurate to 0.01 mm. To determine the specific gravity, eggs were immersed in NaCl solution with density ranging from 1.050 to 1.098 g cm^{-3}, with an interval of 0.004 g cm^{-3}, and removed as soon as they floated. Shells were identified, washed and dried at room temperature for later weighing and thickness measurement. To determine the shell percentage, eggs were individually weighed on an analytical digital scale (UniBloc, AUY-220, accurate to 0.1 g), the result was multiplied by 100 and divided by the egg weight. Thickness (μm) was measured in the central ring of the shell of each egg, using a manual micrometer (Starrett) accurate to 0.01 μm.

As for bone quality, at the end of the three production cycles, quails were slaughtered. Upon slaughtering, the right tibias were removed, deboned, measured for length and diameter (mm) with the aid of a digital caliper (Electronic Digital Caliper 150 mm) and weighed on a digital scale (Shimadzu AUY 220 accurate to 0.0001 g). Bone density (g cm^{-1}) was calculated by Seedor index, which is the value obtained by dividing the bone weight by bone length (Seedor, 1995). Subsequently, tibias underwent three washes with petroleum ether, remaining for 24 hours each wash, in glass tubes with caps. Tibias were weighed and dried at 105°C for 24 hours for dry weight and fat free dry weight (PES). After, we determined the ash content according to Association Of Official Analytical Chemistry (AOAC, 2002).

Data were subjected to analysis of variance using the General Linear Models Procedure (GLM) of SAS® (Statistical Analysis System [SAS], 2002). Means were compared by the following orthogonal contrasts, at 5% probability: C1 - soybean meal versus canola meal, C2 - soybean oil versus canola oil, C3 - soybean meal+soybean oil versus canola meal+canola oil.

Results and discussion

There was no effect ($p > 0.05$) on weight gain, feed intake and feed conversion per mass and per dozen eggs caused by the replacement of 25% soybean meal with canola meal (Table 2). These results differ from those found by Hameed, Ahmad, and Rabbani (2002), who found that above 15% replacement of soybean meal with canola meal caused a reduction of weight gain in Japanese quails, attributing this result to the presence of high levels of non-starch polysaccharides in canola meal. On the other hand, as in this study, Sariçiçek, Kılıç, and Garipoğlu (2005) found no difference in performance when used up to 25% replacement of soybean meal with canola meal in Japanese quail diet.

Table 2. Productive performance of quails fed canola meal and oil.

Treatments[1]	PROD (%)	PAVE (g)	POVO (g)	CR (g)	MO (g)	CADZ	CAMO
SM+SO	84.01	242.59	12.93	2224.61	10.88	2.64	2.46
MC+SO	78.52	237.11	13.02	2331.02	10.25	3.01	2.79
MC+CO	81.17	239.33	12.75	2356.27	10.34	2.93	2.76
SM+OC	81.29	248.52	12.97	2504.23	10.59	3.06	2.84
CV (%)	6.54	6.88	3.84	8.39	8.39	8.62	7.23
orthogonal contrast F-test							
Contrast 1	ns	ns	ns	ns	ns	ns	ns
Contrast 2	ns	ns	ns	*	ns	ns	*
Contrast 3	ns	ns	ns	ns	ns	*	*

[1]SM+SO – control diet with soybean meal and oil; MC+SO - control diet with 25% canola meal replacing soybean meal; MC+CO - control diet with 25% canola meal replacing soybean meal and canola oil completely replacing soybean oil; SM+OC - control diet with soybean meal and canola oil. PROD = Mean egg production; PAVE = Mean weight of quails; POVO = Mean weight of eggs; CR = Feed conversion; MO = Egg mass; CADZ = Feed conversion per dozen eggs; CAMO = Feed conversion per egg mass. CV = coefficient of variation, contrast 1= FS x FC, contrast 2 = OS x OC, contrast 3= SM+SO x MC+CO; ns = non-significant. *Significant at 5% probability..

Agah, Nassiri-Moghaddam, Tahmasbi, and Lotfollahian (2010) used different levels of canola grain in diet for laying hens and observed that egg production and egg weight decreased linearly with increasing in canola grain level in the diet. In turn, in this experiment there were no significant differences for these variables.

The replacement of soybean oil with canola oil (contrast 2) in the diet increased ($p < 0.05$) feed intake, resulting therefore in a lower feed conversion per dozen and per mass of eggs produced. These results differ from those found by Ismail, Al-Busadah, and El-Bahr (2013), who verified no significant differences in feed conversion by the inclusion of canola oil in the diet for laying hens. In addition, Costa et al. (2008) also found lower feed conversion in laying hens with increasing levels of canola oil when compared with soybean oil. The higher feed intake and lowest feed conversion may be related to the lower metabolizable energy of canola oil. Junqueira et al. (2005) evaluated the metabolizable energy of different sources of oil for broilers and reported a lower value for canola oil (8129 kcal kg^{-1}) compared to soybean oil (9201 kcal kg^{-1}). Canola oil may have contributed to a lower metabolizable energy in the feed, which increased feed intake and reduced feed conversion. Barreto et al. (2007) observed a higher feed intake with lower levels of metabolizable energy in the feed for laying quails.

Regarding the internal quality of eggs, the yolk color was different ($p < 0.05$) for all contrasts. Treatment with soybean meal and oil showed ($p < 0.05$) a lighter color when compared to the others; a darker color was obtained with the presence of canola meal and oil in the diet (Table 3). The diet composition (Table 1) demonstrated that the control treatment (SM+SO) had lower inclusion of corn and consequently a smaller supply of pigments (xanthophyll and carotene) through the diet, which may explain the lighter coloring for yolk (Yannakopoulos, Tserveni-Gousi, & Christaki, 2005). However, with the same corn content, the diet with replacement of soybean oil with canola oil showed a more intense yolk color ($p < 0.05$) compared with the control treatment, which confirms the results of Ceylan, Ciftçi, Mizrak, Kahraman, and Efil (2011), who evaluated 1.5 and 3% canola oil in the diet for laying hens and observed a more intense color in yolk than the treatment with soybean oil. According to Seibel (2005), the degree of yolk pigmentation may change depending on the fatty acid profile in the diet. Thus the replacement of soybean oil with canola oil may have changed the fatty acid profile in the diet. Yolk color influences the consumer's perception of the sensory and nutritional properties, the more intense is the color, the greater is the acceptance (Silva, Albino, & Godoi, 2000).

The diet with soybean meal and oil showed higher ($p < 0.05$) albumen height and, consequently, higher Haugh unit, for the other variables no statistical differences were detected ($p > 0.05$).

These results corroborate those verified by Ceylan et al. (2011) and Sarıçiçek et al. (2005), which evaluated the replacement of soybean oil with other sources of oil (fish, flaxseed, canola and sunflower) and found no significant differences for internal and external egg quality, except for the color of the yolk.

In the analysis of bone characteristics, there was no difference ($p > 0.05$) between the oils in any of the variables studied. However, there were differences ($p > 0.05$) between the replacement of meals; the weight, length and density showed higher values for the birds fed 100% soybean meal (Table 4). The ash content was higher ($p < 0.05$) for birds fed the diet containing 25% canola meal replacing soybean meal, contrary to what was expected, since the presence of anti-nutritional factors in canola meal, such as fiber and tannin, may decrease the absorption of minerals.

Table 3. Internal and external egg quality of quails fed canola meal and oil.

Treatments[1]	COLOR	ALB (μm)	YOLK (%)	WHITE (%)	HAUGH	SI	GRAV	THIC (μm)	SHELL (%)
SM+SO	4.16	5.50	32.02	49.82	94.18	76.61	1071.6	24.21	8.45
MC+SO	4.56	5.33	32.18	48.29	92.99	76.35	1072.68	25.02	8.74
MC+CO	4.62	5.18	32.57	49.24	92.57	77.04	1071.65	24.2	8.69
SM+OC	4.55	5.22	32.92	49.15	92.72	76.44	1072.53	24.52	8.62
CV (%)	5.9	4.41	4.93	4.89	1.45	2.27	0.17	3.14	3.7
orthogonal contrast F-test									
Contrast 1	*	ns	ns	ns	ns	ns	ns	ns	ns
Contrast 2	*	*	ns	ns	ns	ns	ns	ns	ns
Contrast 3	*	*	ns	ns	*	ns	ns	ns	ns

[1]SM+SO – control diet with soybean meal and oil; MC+SO - control diet with 25% canola meal replacing soybean meal; MC+CO - control diet with 25% canola meal replacing soybean meal and canola oil completely replacing soybean oil; SM+OC - control diet with soybean meal and canola oil. COLOR = yolk color; ALB = albumem height; YOLK = yolk percentage; WHITE = white percentage; HAUGH = Haugh Unit, SI = Shape index; GRAV = specific gravity; THIC = shell thickness; SHELL = shell percentage. CV = coefficient of variation. contrast 1= FS x FC, contrast 2 = OS x OC, contrast 3 = SM+SO x MC+CO; ns = non-significant. *Significant at 5% probability.

Elkin, Freed, Hamaker, Zhang, and Parsons (1996) working with sorghum, an alternative food with high levels of tannins, observed lower bone development of birds and justified the results by the lower absorption of protein and minerals caused by tannin. Canola meal and sorghum have tannin in their composition, which may have led to a lower bone development.

Table 4. Bone characteristics of laying quails fed canola meal and oil.

Treatments[1]	WEIGHT (g)	LENG (μm)	DENS (g μm^{-1})	WID (μm)	CZ (%)
SM+SO	0.380	33.980	0.012	2.620	38.830
MC+SO	0.320	32.510	0.010	2.530	40.440
MC+CO	0.330	32.550	0.010	2.630	41.960
SM+OC	0.370	33.500	0.011	2.570	37.290
CV (%)	6.85	1.77	7.35	4.73	5.57
	orthogonal contrast F-test				
Contrast 1	*	*	*	ns	*
Contrast 2	ns	ns	ns	ns	ns
Contrast 3	ns	ns	ns	ns	ns

[1]SM+SO – control diet with soybean meal and oil; MC+SO - control diet with 25% canola meal replacing soybean meal; MC+CO - control diet with 25% canola meal replacing soybean meal and canola oil completely replacing soybean oil; SM+OC - control diet with soybean meal and canola oil. WEIGHT = Tibia weight; LENG = Length; DENS = bone density; WID = Width; CZ = Ash percentage. CV = coefficient of variation. contrast 1 = FS x FC, contrast 2 = OS x OC, contrast 3 = SM+SO x MC+CO; ns = non-significant. *Significant at 5% probability.

Conclusion

The replacement of soybean meal with canola meal at 25% caused no significant alteration in productive performance. The mixture of canola oil and meal reduces feed conversion, and negatively affects internal egg quality and bone characteristics of quails.

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