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Pequi peel meal in laying hen diet

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ABSTRACT. This study evaluated the effect of pequi peel meal in the diet for laying hens on performance and egg quality. Hy-Line® Brown hens (n=160) aged 55 weeks with 1642±63g body weight were distributed in a completely randomized design with five treatments and four replications of eight birds each. The treatments consisted of isometric substitution of corn by pequi peel meal at 0, 2.5, 5.0, 7.5 and 10%. The performance and internal and external egg quality were evaluated. Egg production, egg mass and feed conversion worsened linearly with increasing replacement of corn with pequi peel meal, while the yolk color increased linearly. The other variables related to performance and internal and external egg quality were not significantly affected by the treatments. It can be concluded that the use of pequi peel meal replacing corn in laying hen diet does not change the internal and external egg quality, improves the pigmentation of egg yolk, and impairs performance of laying hens.

Keywords: alternative feed, poultry, alternative poultry farming, *Caryocar brasiliense*.

Farelo da casca de pequi na alimentação de poedeiras

RESUMO. Objetivou-se avaliar o efeito da inclusão do farelo da casca do pequi na ração de poedeiras sobre o desempenho e a qualidade dos ovos. Foram utilizadas 160 poedeiras comerciais da linhagem Hy-Line® Brown, com 55 semanas de idade e 1642±63g de peso corporal, distribuídas em delineamento inteiramente casualizado com cinco tratamentos com quatro repetições de oito aves cada. Os tratamentos consistiram na substituição isométrica do milho por farelo de casca de pequi nas doses de 0, 2,5, 5,0, 7,5 e 10%. Foram avaliados o desempenho e a qualidade interna e externa dos ovos. A produção de ovos, a massa de ovos e a conversão alimentar pioraram linearmente com substituição do milho por farelo de casca de pequi, enquanto a coloração da gema aumentou linearmente. As demais variáveis de desempenho e de qualidade interna e externa dos ovos não foram influenciadas significativamente pelos tratamentos experimentais. Conclui-se que a utilização do farelo da casca do pequi em substituição isométrica ao milho na alimentação de poedeiras não altera a qualidade interna e externa dos ovos, melhora a pigmentação da gema do ovo e prejudica o desempenho das poedeiras.

Palavras-chave: alimentos alternativos, avicultura, avicultura alternativa, *Caryocar brasiliense.*

Introduction

Feeding represents up to 70% total production costs in the poultry sector, mainly due to the high cost of ingredients comprising the base of diets, such as corn and soybean meal, which represent 80-90% ingredients in feed (Rodrigues, Rostagno, & Albino, 2003). Moreover, price variation of these ingredients throughout the year creates an opportunity for the use of alternative ingredients in animal feed. Alternative food may maintain production rates and quality of the final product, in addition to reducing the production costs, becoming useful in profit optimization (Brum Júnior et al., 2007).

Pequi (*Caryocar brasiliense*) is a fruit of a native tree to the Brazilian cerrado. It is well distributed in the northern and central western Brazil, and is mainly extractively exploited during the growing season, which is from September to March (Gonçalves, Vilas Boas, Resende, Machado, & Vilas Boas, 2011). According to Vera et al. (2007), after the extraction of pequi, there remains the peel, which accounts for approximately 70% total weight of the fruit. Drying followed by grinding has been the simplest form of storage of pequi fruit peel, in the form of peel meal. Peel meal is rich in dietary fiber, calcium, magnesium, and copper (Soares Junior et al., 2010). In agreement with Carvalho et al. (2006), pequi fruit has 7.25 mg 100g^{-1} fruit of carotenoids. Carotenoids, besides promoting antioxidant activity and being precursors of vitamin A, have compounds that act as natural pigments (Uenojo, Junio, & Pastore, 2007). The provision of a diet with natural food rich in carotenoids can increase the intensity of pigmentation of egg yolk, a desirable attribute. Pessoa et al. (2013) mention works in which the digestibility of crude protein and ether extract of pequi peel meal was satisfactory for Nile tilapia and goats, indicating its possible use in animal feed.

Therefore, and for being abundant in some regions of Brazil, the use of pequi peel meal in isometric substitution of corn in feed for laying hens can be a technically and economically viable alternative. However, in the scientific literature there are no studies using the pequi peel meal in feed for laying hens. In this way, the goal of the present study was to evaluate the effect of pequi peel meal in laying hen diet, in an isometric substitution of corn, on the performance and internal and external egg quality.

Material and methods

The experiment was conducted at the Poultry Sector of the Institute of Agricultural Sciences, Federal University of Minas Gerais, Montes Claros, State of Minas Gerais. Hy-line® Brown laying hens (n = 160), aged 55 weeks and with 1642 ± 63g body weight, were housed in pairs, in galvanized wire cages (80 cm long, 38 cm wide and 60 cm high), at a density of 1520 cm^2 $bird^{-1}$. The lighting schedule was 16:8 light dark cycle. Birds received feed and water ad libitum and other management aspects were made according to the manual of the strain.

Hens were distributed in a completely randomized design with five treatments and four replications of eight birds each, totaling 20 experimental units. The treatments consisted of isometric substitution of corn by pequi peel meal at 0, 2.5, 5.0, 7.5 and 10%. Fresh pequi peel, discarded by marketers of the Montes Claros Central Market, was collected and then washed, cut into pieces of about 10 cm, left in the sun for a day and oven-dried at 55°C for 72 hours, ground in a grinding mill (Pessoa et al., 2013). Pequi peel meal presented, as fed basis, 4.29% crude protein, 0.97% ether extract, 3.0% mineral matter, 0.28% calcium, 0.09% phosphorus, 19.56% crude fiber, 61.86% nitrogen free extract and 89.68% dry matter (Pessoa et al., 2013). Metabolizable energy of pequi peel meal was estimated by the equation proposed by Rostagno et al. (2011) for ingredients of vegetable origin and considering digestibility of 85%, resulting in 2,411 kcal metabolizable energy per kg ingredient. The experimental diets are presented in Table 1.

Table 1. Percentage composition of experimental diets.

	Pequi peel meal (%)				
Ingredients	0.0	2.5	5.0	7.5	10.0
Ground corn	56.0	53.5	51.0	48.5	46
Pequi peel meal	0.0	2.5	5.0	7.5	10.0
Limestone	4.0	4.0	4.0	4.0	4.0
Concentrate[1,2,3]	40	40	40	40	40
Total	100	100	100	100	100
Calculated composition[4] (natural matter)					
Metabolizable energy (kcal kg^{-1})	2670	2647	2624	2601	2578
Crude protein (%)	16.65	16.55	16.45	16.35	16.25
Calcium (%)	3.95	3.96	3.97	3.97	3.98
Total phosphorus (%)	0.62	0.62	0.61	0.61	0.60
Crude fiber (%)	2.57	3.01	3.46	3.91	4.35

[1]Composition per kg concentrate: crude protein: 300 g, metabolizable energy: 2000 kcal, calcium: 60 g, total phosphorus: 12 g, sodium: 4 g, methionine: 3700 mg, lysine: 15 g, crude fiber: 40 g, also containing vitamins, microminerals and antimicrobial agent. [2]Basic composition of the concentrate: limestone, common salt, soybean meal, defatted corn germ meal, wheat bran, beef and bone meal, hydrolyzed feather meal, zinc bacitracin, DL- methionine, vitamin A, vitamin D_3, vitamin E, vitamin B_1, vitamin B_2, vitamin B_6, vitamin B_{12}, manganese oxide, sulfate iron, copper sulfate, calcium iodate, sodium selenite, zinc sulfate, folic acid, pantothenic acid, and niacin. [3]Formula suggested by the manufacturer: 56% corn, 4% limestone and 40% concentrate. [4]The nutritional composition of corn, limestone and the estimated level of metabolizable energy of pequi peel meal were calculated according to Rostagno et al. (2011).

The performance was evaluated, from 55 to 65 weeks of age, by means of feed intake (g $bird^{-1}$ day^{-1}), egg production (% $bird^{-1}$ day^{-1}), egg weight (g), egg mass (g $bird^{-1}$ day^{-1}) and feed conversion (g g^{-1}). Feed intake was calculated as the difference between the amount provided at the beginning and the leftovers at the end of the evaluation period. Egg production was obtained by daily records of egg laying and expressing the results as a percentage of the number of hens housed. Egg weight was obtained at the end of the tenth experimental week, through the average of all production. Egg mass was calculated by multiplying the production by the egg weight. Feed conversion was obtained by the relationship between feed intake and egg mass.

The internal egg quality was determined in all the eggs at the end of the 65th week of age through the Haugh unit, yolk and albumen percentage and yolk color. The Haugh unit (HU) was obtained by the formula proposed by Nesheim, Austic and Card (1979), wherein $HU = 100 \log (h + 7.57 - 1.7 p^{0.37})$, where h is albumen height (mm) and p is egg weight (g). Albumen height was obtained 1 cm from the yolk with the aid of an altimeter. Egg weight was obtained with an analytical balance. Percentages of yolk and albumen were expressed in relation to fresh egg, with the yolk and albumen obtained by manual separation.

Quality of egg shell was obtained in all the eggs produced at the end of the tenth experimental week, by means of shell thickness (mm), shell percentage (% fresh egg) and the specific gravity of eggs (g mL^{-1} water). To determine the percentage and thickness of shells, these were manually taken and placed to dry at room temperature for 72 hours. Shell thickness was obtained with a thickness gauge and shell weight, using an analytical balance. Specific gravity was obtained by immersing eggs in 20 liter buckets with specific gravities ranging from the 1.0650 to 1.0950 at 0.005 intervals, following the protocol established by Moreng and Avens (1990).

Data were checked for the presence of outliers, normality of studentized errors (Cramer-Von-Mises test) and homogeneity of variance (Brown-Forsythe test). After checking the assumptions, an analysis of variance was applied and in case of significance ($p < 0.05$), it was employed a polynomial regression analysis using the software SAS® (Littell, Stroup, & Freund, 2000).

Results and discussion

Results of performance are presented in Table 2. There was no effect of including pequi peel meal in the diet of laying hens on feed intake and egg weight. Egg production (EP = -2.1079 Pequi + 66.3218; R^2 = 0.38) and egg mass (MA = -1.0158 Pequi + 39.5669; R^2 = 0.29) decreased linearly, as well as, feed conversion increased linearly (FC = 0.0898 Pequi + 2.5005; R^2 = 0.33), with increasing level of inclusion of pequi meal replacing corn. For each percentage of pequi meal inclusion, in isometric substitution of corn, egg production decreased by 2.1079 percentage points, egg mass decreased 1.0158 g and feed conversion increased by 0.0898 units.

Table 2. Feed intake (FI, g $bird^{-1}$ day^{-1}), egg production (EP, % $bird^{-1}$ day^{-1}), egg weight (EW, g), egg mass (MA, g $bird^{-1}$ day^{-1}) and feed conversion (FC, g g^{-1}) of commercial laying hens fed pequi peel meal in isometric substitution of corn.

	Pequi peel meal (%)					*p-value*	CV, %
	0	2.5	5	7.5	10		
FI	98.3	98.1	96.6	98.6	96.8	0.370	9.98
EP	65.833	62.031	55.781	49.531	45.735	0.035	19.55
EW	59.117	62.204	61.726	62.947	64.991	0.260	8.13
MA	38.783	38.494	34.23	31.201	29.731	0.002	18.54
FC	2.582	2.602	2.923	3.265	3.374	0.008	17.43

EP = –2.1079 Pequi + 66.3218 (R^2 = 0.38), MA = –1.0158 Pequi + 39.5669 (R^2 = 0.29), FC = 0.0898 Pequi + 2.5005 (R^2 = 0.33). Where 'Pequi' corresponds to the level of isometric substitution of corn by pequi peel meal, ranging from 0 to 10%. R^2 was calculated as the sum of squares of the model divided by the total sum of squares.

Pequi peel meal is an important source of dietary fiber and values of crude fiber content calculated were 2.57, 3.01, 3.46, 3.91, 4.35% with the inclusion of pequi meal at 0, 2.5, 5.0, 7.5 and 10.0%, respectively. According to Soares Junior et al. (2010), fiber content in pequi peel meal may reach 38%, being considered a high fiber content food. The fiber acts as a physical barrier hindering the action of endogenous enzymes, increases intestinal viscosity, and increases the rate of passage of digesta. As a result, morphology and physiology of the gastrointestinal tract are impaired with consequent lower utilization of the feed nutrients (Budiño and Castro Junior, 2009).

Moreover, pequi peel meal contains tannin (Bezerra, Silva, Ferreira, Ferri, & Santos, 2002), a substance which impairs the digestibility of various nutrients as it is capable of forming complexes with macromolecules, such as proteins, impeding nutrient absorption and promoting endogenous losses of amino acids in poultry (Mansoori & Acamovic, 2007).

Another important aspect is that pequi peel meal has lower content of metabolizable energy (2411 kcal kg^{-1}) and crude protein (4.29%) compared to corn. So that, the isometric substitution of corn with pequi meal decreased the nutritional density of the feed, which can be seen by the lower values of metabolizable energy and crude protein of diets with increasing levels of inclusion of pequi meal.

The results for internal and external egg quality are listed in Table 3, indicating no significant difference for the variables, except for the yolk color. Yolk color increased significantly with the inclusion of pequi meal replacing corn (Color = 0.1666 Pequi + 7.7167; R^2 = 0.60). Each percentage of pequi meal included has increased 0.1666 units yolk color.

These results are explained by the presence of natural pigments like carotenoids, giving a yellowish tint to the fruit and peel of pequi (Ribeiro, 2000); these pigments are deposited in the yolk. Yolk color is an important feature for consumer acceptance, and thus the added value of the product should be emphasized, since there is valuation of the egg.

Table 3. Specific gravity (SG, g mL^{-1}), shell thickness (ST, mm), shell percentage, Haugh unit (HU), albumen percentage, yolk percentage and yolk color of commercial laying hens fed pequi peel meal in isometric substitution of corn.

	Pequi peel meal (%)					*p-value*	CV, %
	0	2.5	5	7.5	10		
SG	1.092	1.090	1.089	1.084	1.091	0.12	0.29
ST	0.61	0.61	0.61	0.61	0.62	0.45	2.7
Shell	16.90	16.36	16.10	15.91	11.16	0.56	30.43
HU	89.74	93.26	94.42	92.90	90.80	0.14	3.95
Albumen	57.32	58.70	58.43	59.92	63.07	0.26	8.13
Yolk	25.78	24.94	25.47	24.17	25.78	0.35	5.93
Color	7.50	8.21	8.80	8.96	9.13	0.0002	5.73

Color = 0.1666 Pequi + 7.7167 (R^2 = 0.60). Where 'Pequi' corresponds to the level of isometric substitution of corn by pequi peel meal, ranging from 0 to 10%. R^2 was calculated as the sum of squares of the model divided by the total sum of squares.

Specific gravity, shell thickness, shell percentage, Haugh unit and percentage of albumen and yolk were not affected by replacing corn with pequi meal. The increased levels of fibers with the inclusion of pequi meal in the diets did not affect the availability of calcium and therefore did not affect the quality of the egg shell. Another hypothesis raised to explain the absence of changes in the external quality is the highest amount of calcium and phosphorus in the pequi peel meal, 0.28 and 0.25%, respectively, compared to 0.03% calcium and 0.09 % phosphorus found in corn, showing that the partial replacement using pequi meal is not detrimental to the external and internal egg quality.

Considering the prices of ingredients in May 2015, in the state of São Paulo, diets with 0, 2.5, 5.0, 7.5 and 10.0% inclusion of pequi peel meal presented, respectively, costs of R$ 0.923, 0.914, 0.906, 0.897, 0.888 kg^{-1}, representing a reduction of approximately 3.79% in feed cost when comparing the treatments with 0 and 10% inclusion of pequi peel meal. Nevertheless, the reduced feed conversion when comparing treatments with 0 and 10% pequi peel meal was 23.47%. Thus, the isometric substitution of corn by pequi peel meal in the feed is neither technically nor economically feasible.

At last, due to the nutritional characteristics of pequi meal, its abundance in some Brazilian regions and the low processing cost, it is recommended the completion of further studies on the supplementary use of this by-product. Therefore, there may be feed savings, which can benefit small farmers in pequi producing regions.

Conclusion

The use of pequi peel mean in place of corn in diets for laying hens impairs performance, without changing internal and external egg quality and improves the pigmentation of egg yolk.

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