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Paprika and/or marigold extracts improve productivity and yolk color in egg-laying quails

Extratos de páprica e/ou marigold melhora produtividade e cor de gema em codornas de postura

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Abstract
This study was conducted to evaluate the effects of paprika and marigold extracts on the productivity of Japanese quails, quality and sensorial analysis of eggs. Japanese quails were allocated in a completely randomized design and factorial arrangement 2 × 2 + 1, and four replicates. Diets were formulated based on: 1) corn (control), and 2) sorghum (S) without pigments, 3) S + 0.06% paprika extract (PE), 4) S + 0.01% marigold extract (ME), and 5) S + 0.06% PE and 0.01% ME. There was no effect of the control and factorial interaction on feed intake, egg-laying rate, or egg mass; however, the feed: gain ratio was lower among quail fed with diets containing both extracts. The inclusion of PE and ME in the diets improved the feed: gain ratio and yolk color; the inclusion of PE reduced the feed intake and specific weight of the eggs. Compared to the control, treatments based on sorghum or sorghum + PE led to a difference in egg taste and yolk color in the sensorial analysis. It was concluded that paprika and marigold extracts could be included in quail diets because of improvements in feed: gain ratio and yolk color.
Key words: feed additives, poultry feeding, yolk pigmentation

Resumo
Este estudo foi conduzido para avaliar os efeitos dos extratos de páprica e marigold sobre a produtividade de codornas Japonesas, qualidade e análise sensorial dos ovos. Codornas Japonesas foram alocadas em delineamento completamente ao acaso e arranjo fatorial 2 × 2 + 1, e quatro repetições. As dietas foram formuladas baseadas em: 1) milho (controle) e 2) sorgo (S) sem pigmentos, 3) S + 0,06% de extrato de páprica (EP), 4) S + 0,01% de extrato de marigold (EM) e 5) S + 0,06% EP + 0,01% EM. Não houve efeito da interação controle e fatorial sobre consumo de ração, taxa de postura ou massa de ovo; entretanto, a conversão alimentar foi menor entre codornas alimentadas com dietas contendo ambos os extratos. A inclusão de EP e EM nas dietas melhorou a conversão alimentar e a cor de gema; a inclusão de EP reduziu o consumo de ração e o peso específico dos ovos. Comparado com o controle, os tratamentos baseados em sorgo ou sorgo + EP levaram à diferença no sabor do ovo e na cor da gema na análise sensorial. Concluiu-se que os extratos de páprica

e marigold poderiam ser incluídos em dietas para codornas por melhorar a conversão alimentar e a cor de gema.
Palavras chave: aditivos alimentares, alimentação de aves, pigmentação de gema

Introduction

Consumers prefer products with intense and brilliant color, relating it to high quality and vitamin content. Visual appearance, mainly color, is a decisive factor influencing the purchasing decision-making in the process of consumer behavior(1). Corn is the most commonly used ingredient serving as the energy source in the diets of birds; however, its price occasionally increases, and the partial or total replacement of corn with sorghum is a common practice. Compared to corn, sorghum is poor in carotenoids, resulting in the production of eggs with few pigmented yolks, which are not quite attractive to consumers(2).

Synthetic pigments may cause allergic reactions, apart from being the subject of studies on their carcinogenic potential after metabolism by intestinal microflora(3) and are related to the occurrence or exacerbation of the symptoms of attention deficit hyperactivity disorder(4). The option of using natural pigments has increased because of the restriction by consumers demand and laws in developed countries banning the use of synthetic pigments in food products for animals and humans(5).

Paprika is obtained from dehydrated red pepper (*Capsicum annuum*) fruits. Its xanthophylls are capsanthin, capsorubin, zeaxanthin, capsolutein, β-carotene, and β-cryptoxanthin(6). Capsaicinoids have antioxidant(7) and thermogenic effects(8). According to Huang et al.(9), via its antioxidant activity, capsaicin reduces plasma cholesterol levels and atheromatous plaque formation in humans. Marigold (*Tagetes erecta* Linn.) is a source of lutein(10), and the xanthophylls present in yolk include lutein and zeaxanthin(11). Marigold extracts have approximately 1.2% of xanthophylls, with 80–90% of lutein, which is a yellow carotenoid.

Moura et al.(2) evaluated the inclusion of paprika and/or marigold extracts in diets of quails and observed that yolk color was similar to that obtained using corn-based diets. By studying the effects of marigold extract at 0, 150, 250, and 350 mg/kg included in diets of hens, Skrivan et al.(11) noted that the marigold extract did not affect feed intake; however, the extract at 150 mg/kg improved egg production and egg mass, although it reduced egg weight.

This study was conducted to evaluate the effects of dietary supplementation with paprika and/or marigold extracts on the productivity of Japanese quails, egg quality and sensorial analysis.

Material and methods

This study was approved by the Ethics Committee on Animal Use of the Universidade de Rio Verde (protocol n. 01/14, approved on March 18, 2014) and by the Ethics Committee on Research (CAAE 36757814.8.0000.5077, approved on November 05, 2014).

Using a completely randomized design and factorial arrangement 2 × 2 + 1, one hundred and forty 50-day-old Japanese quails were distributed among 5 treatments and 4 replicates for 84 days. The quails were housed in metal cages (25 cm × 15 cm × 33 cm, length × height × width) containing a feeder and drinker of the gutter-type. The birds were subjected to a light exposure program from the 40th day of age. Initially, they were exposed daily to light for 14 h. The duration of light exposure increased weekly by increments of 30 min until the quails were exposed to light for 17 h per day, and this rate was maintained until the end of the experiment. Water and diets were provided *ad libitum*.

The commercial products Sun Gold SG-20® and Sun Red S-50® (Seifun Comércio e Indústria Ltda, São Paulo, Brazil) contained marigold (ME) (*Tagetes erecta*) and paprika (PE) (*Capsicum annum*) extracts as sources of natural yellow and red pigments, respectively. Experimental rations were formulated according to the nutritional requirements of quails as recommended by Rostagno et al.[(12)] (Table 1). Diets were formulated based on 1- corn (control) and 2- sorghum (S) without pigments, 3- S + 0.06% PE, 4- S + 0.01% ME, 5- S + 0.06% PE and 0.01% ME.

Daily feed intake (DFI), egg production, egg mass, feed: gain ratio (FGR) per kilogram of egg and per dozen eggs were evaluated. Eggs were collected twice a day and percentage egg production was calculated by dividing the total number of eggs per cage by the number of quails. The eggs collected in the last 3 days of each period were weighed individually to obtain the average egg weight. Egg mass was the product of egg production and average egg weight per cage.

The diameter and height of the yolk and thick albumen of three eggs were measured using a digital caliper and a micrometer, respectively. Average eggshell thickness was determined at three locations (at both poles and in the middle) using a DIGIMESS digital caliper with a precision of 0.001 mm. The Haugh unit was determined using the formula HU = 100 × log (H − 1,7 × W0.37 + 7.6), where H is albumen height (mm), and W is egg weight (g). A DSM color fan was used to evaluate yolk color, using five eggs from each replicate.

Additionally, eggshells were weighed. Albumen weight was calculated by subtracting the weights of the yolk and eggshell from egg weight. Based on the data, the percentage of each component was calculated. Two eggs were used to determine egg pH. The remaining eggs were used to determine specific weight by immersing them in recipients containing saline solutions (NaCl), whose densities ranged from 1.050 to 1.100, with intervals of 0.005.

Table 1. Composition of experimental diets containing paprika (PE) and/or marigold (ME) extracts for egg-laying quails

Ingredients (kg)	Control (corn)	Sorghum-based diets (S)			
		S	S + PE	S + ME	S + PE + ME
Ground corn	51.00	0.00	0.00	0.00	0.00
Soybean meal	35.37	34.29	34.29	34.29	34.29
Soybean oil	3.75	5.39	5.39	5.39	5.39
Ground sorghum	0.00	50.30	50.30	50.30	50.30
Paprika extract[1]	0.00	0.00	0.06	0.00	0.06
Marigold extract[2]	0.00	0.00	0.00	0.01	0.01
Dicalcium phosphate	1.18	1.14	1.14	1.14	1.14
Limestone	7.18	7.22	7.22	7.22	7.22
DL-methionine 99%	0.28	0.37	0.37	0.37	0.37
L-lysine 78.8%	0.13	0.18	0.18	0.18	0.18
Common salt	0.34	0.34	0.34	0.34	0.34
Vitaminic supplement[3]	0.20	0.20	0.20	0.20	0.20
Washed sand	0.07	0.07	0.01	0.06	0.00
Mineral supplement[4]	0.50	0.50	0.50	0.50	0.50
Total	100	100	100	100	100
		Calculated composition[5]			
Crude protein (%)	19.9	19.9	19.9	19.9	19.9
Metabolizable energy (kcal/kg)	2851	2851	2851	2851	2851
Calcium (%)	3.10	3.10	3.10	3.10	3.10
Available phosphorus (%)	0.33	0.33	0.33	0.33	0.33
Sodium (%)	0.15	0.15	0.15	0.15	0.15
Total lysine (%)	1.12	1.12	1.12	1.12	1.12
Total methionine (%)	0.55	0.54	0.54	0.54	0.54
Total methionine+cystine (%)	1.91	0.89	0.89	0.89	0.89

[1]Each kg contain: concentrated extract of paprika oleoresin, silica, calcium carbonate, wheat bran, ethoxyquin. Guarantee level: 5 g/kg xanthophyll. [2]Each kg contain saponified marigold oleoresin, colloidal silica, calcium carbonate, ethoxyquin. Guarantee level: 20 g/kg xanthophyll. [3]Each kg contain: vit A 2000000 UI; vit D_3 5000000 UI; vit E 40500 UI; vit K_3 4800 mg; vit B_{12} 28000 mcg; niacin 87000 mg; pantothenic acid 29000 mg; folic acid 1600 mg; thiamine 3600 mg; riboflavin 12000 mg; pyridoxine 6000 mg; biotin 60 mg. [4]Each kg contain: Cu 16000 mg; Fe 200000 mg; I 1200 mg; Mn 240 g; Se 200 mg; Zn 160000 mg; Mg 200 mg.[5]According to Rostagno et al.(13).

The sensorial analysis was performed based on the methodology described by Moura et al.(13) and 48 eggs were used per treatment. The eggs were boiled during 10 min, being the time counted after the begin of the boiling of the water and, after that, the eggs were cooled in running tap water. The eggs were manually shelled and lengthwise cut, always by the same people.

The eggs were used for egg taste and yolk color analysis by a panel of 48 non-trained tasters, recruited among college students (24 male and 24 female). The sensorial analysis was performed in two phases with egg samples being evaluated for egg taste (1st phase) and yolk color (2nd phase). The score for comparison was 0 – no difference; 1 – slight difference; 3 – moderate difference, and 5 – intense difference.

Results were then used for a paired comparison test, according to the methodology described by Anzaldúa-Morales(14). The tasters were accommodated in individual cabins, with natural light, and received an evaluation form containing the numbers of standard (control treatment) and test samples. The latter were encrypted with a random 3-digit number, with all samples being individually compared to the standard sample. All samples were placed on a white plastic dish. All tasters ingested mineral water without gas prior to sample tastings.

Performance and egg quality variables were subjected to ANOVA using the Sisvar software(15), and the means of the factorial arrangement were compared using Tukey's test at 5% probability. Dunnett's test at 5% probability was used to compare the means of the factorial × control treatment.

The results of the sensorial analysis were evaluated using Table of Minimum Number of Coinciding Responses, at 5% probability(14). According to the methodology, it was necessary that at least 23 tasters detected any difference among the samples.

Results

There was no effect ($P > 0.05$) of the control × factorial interaction on daily feed intake, egg-laying rate, and egg mass; however, the FGR values (kg/kg and kg/dozen) were lower with the diets containing both extracts than with the control treatment. The PE × ME interaction affected the FGR with either extract ($P < 0.05$), with the optimal values obtained with the inclusion of both extracts in the diets. Daily feed intake was reduced ($P < 0.04$) by 13.75% when PE was included in the diets (Table 2).

There was no effect ($P > 0.05$) of the treatments on egg quality, excluding yolk color, which was affected by the extracts separately and by the control × factorial interaction. Through the inclusion of PE or ME, yolk color was improved ($P < 0.016$); however, the yolk color was similar to that obtained with the control treatment (5.83) when both extracts were added to the diets (4.75) (Table 3). The interaction between PE × ME affected ($P < 0.026$) the specific weight, with lower values obtained in eggs of birds fed diets containing only PE (Table 3).

The treatments affected the egg taste and yolk color ($P < 0.05$). With respect to the egg taste, 25 tasters noted a slight difference between eggs from treatment based on sorghum rather than corn (control). In case of yolk color, 23 tasters detected a slight difference with the treatment based on sorghum, and 23 tasters noted a moderate difference for the treatment based on sorghum + 0.06% PE (Table 4).

Table 2. Productive performance of Japanese quails fed with diets containing paprika (PE) and/or marigold (ME) extracts

Treatment	Daily feed intake (g/day)	Feed: gain ratio (kg/kg)	Feed: gain ratio (kg/doz)	Laying rate (%)	Egg mass (g/bird/day)
Control (C)	32.77	3.34	0.49	80.07	9.79
		Effect of paprika extract levels (%)			
0.0	37.82[a]	3.37	0.48	89.08	10.74
0.06	32.62[b]	3.17	0.46	85.61	10.41
		Effect of marigold extract levels (%)			
0.0	35.93	3.32	0.48	85.25	10.34
0.01	34.52	3.21	0.47	89.44	10.81
		Effect of paprika and marigold extract interaction levels			
0.0 × 0.0	34.95	3.21[a]	0.45[a]	88.52	11.65
0.06 ×0.0	32.38	3.21[a]	0.47[a]	81.99	10.04
0.0 × 0.01	36.32	3.34[a]	0.49[a]	89.64	10.83
0.06 × 0.01	29.31	2.74[b]*	0.39[b]*	89.24	10.79
		Standard error of the mean			
	1.29	0.10	0.02	5.46	0.67
		p value			
C × Factorial	0.161	0.040	0.006	0.155	0.358
PE	0.010	0.019	0.047	0.256	0.269
ME	0.450	0.157	0.322	0.909	0.960
PE × ME	0.065	0.020	0.008	0.217	0.291

*Means followed by an asterisk differ from the control treatment as shown by Dunnett's test.
[a,b]Means followed by different letters in a row differ as shown by Tukey's test.

Table 3. Quality of eggs of Japanese quails fed with diets containing paprika (PE) and/or marigold (ME) extracts

Treatment	EW (g)	YP (%)	YH (mm)	YD (mm)	YI	YC	AP (%)	AH (mm)	AD (mm)	AI	ESP (%)	EST (mm)	SW (g/cm³)	Egg pH
Control (C)	12.21	31.42	7.50	20.83	0.360	5.83	60.38	1.16	42.16	0.028	8.19	0.226	1,069	8.33
						Effect of the paprika extract levels (%)								
0	11.90	31.09	7.50	20.62	0.365	3.62[b]	60.64	1.18	40.93	0.029	8.26	0.232	1,068	8.00
0.06	12.21	30.54	7.68	20.37	0.377	4.37[a]	61.22	1.31	43.25	0.030	8.25	0.233	1,067	7.87
						Effect of the marigold extract levels (%)								
0	12.00	30.28	7.62	20.37	0.375	3.63[b]	61.23	1.12	41.56	0.033	8.50	0.234	1,067	7.75
0.01	12.11	31.35	7.56	20.63	0.367	4.38[a]	60.63	1.37	42.62	0.026	8.01	0.231	1,068	8.12
						Effect of the interaction paprika e marigold extracts								
0 × 0	11.71	30.69	7.50	20.38	0.370	3.25*	60.77	1.25	40.25	0.029	8.55	0.236	1,069[a]	8.00
0.06 × 0	12.29	29.86	7.75	20.38	0.381	4.00*	61.68	1.62	42.87	0.037	8.45	0.233	1,065[b]	7.50
0 × 0.01	12.09	31.50	7.50	20.87	0.359	4.00*	60.52	1.25	41.62	0.030	7.97	0.227	1,067[a]	8.00
0.06 × 0.01	12.13	31.21	7.63	20.37	0.374	4.75	60.75	1.00	43.62	0.023	8.04	0.235	1,069[a]	8.25
						Standard error of the mean								
	0.18	1.05	0.27	0.53	0.02	0.42	1.09	0.25	1.94	0.005	0.22	0.009	0,001	0.49
							p value							
C × Factorial	0.254	0.796	0.950	0.912	0.872	0.002	0.925	0.495	0.780	0.571	0.355	0.929	0,125	0.493
PE	0.134	0.626	0.525	0.675	0.497	0.016	0.639	0.657	0.288	0.921	0.961	0.851	0,287	0.662
ME	0.587	0.358	0.831	0.675	0.648	0.016	0.627	0.380	0.619	0.324	0.076	0.755	0,492	0.205
PE × ME	0.169	0.816	0.831	0.675	0.914	0.997	0.774	0.197	0.883	0.257	0.741	0.593	0,026	0.204

EW - egg weight, YP - yolk percentage, YH – Yolk height, YD – yolk diameter, YI - yolk index, YC - yolk color, AP = albumen percentage, AH – albumen height, AD – albumen diameter, AI - albumen index, ESP = eggshell percentage, EST = eggshell thickness, SW – specific weight.
*Means followed by an asterisk differ from control treatment by Dunnett test.
[a,b]Means followed by different letters in a row are different by Tukey test.

Table 4. Results of paired-comparison test for egg taste and yolk color from Japanese quails fed with diets containing paprika (PE) and/or marigold (ME) extracts

	Egg taste				Yolk color			
Treatments	**Answer profile[1]**				**Answer profile[1]**			
Diets with corn	-	-	-	-	-	-	-	-
Diets with sorghum (S)	12	25	10	1	2	23	13	10
S + 0.06% PE	11	19	15	3	4	9	23	12
S + 0.01% ME	10	17	16	5	4	21	19	4
S + 0.06% PE + 0.01% ME	15	11	16	6	14	15	9	10

[1]Number of tasters that detected no difference (0), slight difference (1), moderate difference (3), and intense difference (5).

Discussion

Paprika and marigold, similar to other herbal extracts, have substances stimulating the secretion of mucosa and pancreatic enzymes, which increase nutrient digestibility in the small intestine, and pottentially improve gastrointestinal morphology[16]; this is a possible reason for the lower feed intake and higher FGR, than the control treatment.

Carbohydrates, lipids, and proteins are the major macronutrients required for the full development of birds. Platel and Srinivasan[17] studied the use of capsaicin in diets of rats, and noted that the activities of lipase, amylase, trypsin, and chymotrypsin increased by 36%, 72%, 120%, and 25%, respectively. Platel and Srinivasan[18] reported that capsaicin stimulates the secretion and increases the activity of salivary amylase and pancreatic lipase and stimulates the production and secretion of bile slightly. According to them, capsaicin may increase trypsin activity by 120–165%. Jamroz et al.[19] analyzed an extract comprising capsaicin, cinnamaldehyde, and carvacrol in broiler diets, and confirmed an improvement in FGR and nutrient digestibility, apart from an increase in pancreatic lipase activity.

Lutein, present in ME, has antioxidant activity[20,21,22], with a protective effect on the mucosa of the gastrointestinal tract, and increases the production and secretion of digestive enzymes. Thus, it is possible that ME contributed to the increased digestion and absorption of nutrients, which resulted in a higher FGR. Different results were obtained by Englmaierová & Skrivan[23], Skrivan et al.[11], and Oliveira et al.[24], who added ME to the diets of egg-laying hens and did not observe effects on the productivity of the birds.

Egg quality was not affected by the treatments, except by the yolk color, in agreement with Sujatha et al.[25], Moura et al.[26], and Oliveira et al.[24] that did not observe differences caused by PE and/or ME on the egg quality of egg-laying birds.

The colorimetric score of yolk was increased (+21%) by PE or ME. Birds do not synthesize carotenoids, and these pigments should be obtained from the diet[27]. Additionally, Moura et al.[26] and Oliveira et al.[24] did not detect an effect of PE and ME on yolk color; however, Moura et al.[2] reported an associative effect of these extracts on yolk pigmentation.

Thus, we observed that PE caused a slight reduction in eggshell quality without negatively affecting egg quality, as the value 1.065 for specific weight is considered normal for quail eggs.

There was a slight difference detected by tasters for the egg taste, illustrating that sorghum used in diets gives a slightly different taste compared to the standard sample (eggs from quails fed with corn-based diets). Thus, it can be stated that sorghum, as well as pigments, may be used in diets for quails without impairing the taste of the eggs. Regarding yolk color analysis, the tasters considered that, compared to the treatment based on corn, there was a slight difference with the sorghum-based treatment and a moderate difference with the treatment based on sorghum + PE, which corroborates the results obtained with the colorimetric fan. In both of these treatments, yolks were visually less pigmented compared to the standard sample. This result is due to sorghum being poor in carotenoids. Yolk color is an important quality factor, followed by freshness and eggshell quality, with consumers tending to prefer a more pigmented yolk[23].

Conclusion

At the doses tested, paprika and marigold extracts could be included in quail diets owing to the improvement in feed: gain ratio and yolk color.

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