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NONRUMINANT NUTRITION

Influence of homeopathy on the quality of eggs of quails stored

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ABSTRACT. This study aimed to evaluate the influence of homeopathic products in diets of quails in the egg quality when submitted to different storage periods. In the trial we used 200 Japanese quails in a completely randomized design with 4 diets: reference diet, vehicle used in homeopathic products and 2 homeopathic products - Fertsigo® and Ovosigo® with ten replicates of three eggs in each. Egg quality parameters were evaluated during 3 storage periods. Data were evaluated as repeated measures in time, the effects of the interactions between treatments and time as well as their isolated effects were verified. There was the interaction between homeopathic products and storage time in the parameters of albumen and yolk height, Haugh unit, and yolk index, in which a reduction was obtained over time. For egg weight, yolk, albumen and shell, percentage of albumen, and percentage of eggshell there was a significant effect only for homeopathy. The inclusion of homeopathic additives increased egg weight. It is indicated the addition of the product with homeopathic basis Ovosigo® and FertSigo® in diets of Japanese quails in the laying phase resulting in better egg and components but did not influence the quality maintenance of eggs of Japanese quails in the periods evaluated.

Keywords: coturniculture; alternative medicine; ultra-diluted medicine; egg production.

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Introduction

In coturniculture, eggshell quality can be considered a determining factor of production. It is influenced by bird age, nutrition, and thermal stress. Its evaluation is possible using specific methods, in wich percentage thickness, weight, and resistance to breakage are measured, inferring in quality (Lemos et al., 2017) directly influencing the egg conservation process.

In Brazil, refrigeration is not mandatory, in this sense, commercial eggs are packed from the moment of laying to the final distribution, at room temperature, being refrigerated only in consumers' homes (Xavier et al., 2008). Although Brazilian legislation through Decree No. 56,585 of July 20, 1965, determines minimum internal conditions (air chambers ranging from 4 to 10mm; translucent, firm, consistent and germ-free buds developed; clear, consistent, clear, spotless and with the chalazas intact), in practice, only the weight and characteristics of the shell have been considered (Brasil, 1997).

Due to the porosity present in the eggshell, there is loss of CO_2 and water to the medium, which provides a reduction in egg weight, a factor that is accentuated in uncooled eggs (Carvalho, Vilela, Fagundes, Souza, & Fernandes, 2016). According to Arruda, Gouveia, Lisboa, Abreu, and Abreu (2019), the maintenance of the high quality of the eggs is influenced by time and temperature during the egg storage period. Regarding time, egg quality is impaired as the storage period increases. To maintain integrity of the eggs it is recommended that soon after the procedures which they are submitted in the farm are stored in a refrigeration system with an average temperature of 0 to 4°C (Paiva et al., 2019).

To minimize egg losses due to the quality and integrity of shell, the industry seeks alternatives aimed to internal and external preservation of eggs, so research with different additives to improve the eggshell are on the rise. The occurrence of eggs with fragile shell and visible defects increases the percentage of disposal of eggs or conditions their commercialization for lower remuneration, reducing the producer profit margin (Moraleco et al., 2019). The porosity increase in eggs predisposes albumen and yolk contamination by surface pathogens penetration. In this context, the implementation of homeopathy in animal nutrition arises, aiming to reach a niche market of consumers who prioritize healthy and natural foods with minimal use of synthetic products in their diet (Hajra, Tyagi, Tyagi, Mandal, & Mir, 2018). Homeopathy is a specific therapy of body stimulation, in which drugs choice is made according to the need of each species. It is considered especially the causes of the possible factor of productive decrease, the concomitant circumstances, as well as the characteristics of the organism (Pires, 2005).

The use of homeopathy is efficient in animal production, has fast effect, leaves no residues in meat or eggs, and aims at a product of good quality and safe for the consumer, reducing losses and resulting in increased production profitability (Teixeira et al., 2016). Homeopathy encompasses stimulation characteristics in the living organism, in the case of egg production, its function would be to ensure greater preservation of eggs during the storage period. Given the above, the objective of this study was to evaluate the effect of homeopathy on the conservation of egg quality of Japanese quails in different storage periods.

Material and methods

The experiment was conducted in the Laying Aviary, located at the Federal University of Grande Dourados (UFGD/FCA) Dourados, state Mato Grosso do Sul. Quail management were carried out under the approval of the Ethics Committee on The Use of Animals (Ceua) of the University Center of Grande Dourados (Unigran/Dourados), protocol Ceua 052/18.

A completely randomized design with four treatments was used, with 10 replications. Three eggs of each repetition were considered as an experimental unit. Four experimental diets were considered: Control (TC), TC + addition of 0.02 g of calcium carbonate/bird/day (vehicle used in homeopathic products); CT + 0.02 g ave^{-1} day^{-1} of Fertsigo® (*Sepia, succus, 15 CH, Sulphur,10 CH, Vehicle, inert [q.s.p.]*) and CT + addition of 0.02 g ave^{-1} day^{-1} of Ovosigo® (*Solanum lethale 12CH Silicea terra 12CH Natrum muriaticum 30CH Calcarea phosphorica 30CH Sulphur 12CH Vehicle, inert [q.s.p.]*). Three storage periods 0 (fresh egg) 7 and 14 days were evaluated, kept at natural temperature. In the pre-experimental phase, 200 Japanese quails*(Coturnix coturnix japônica),* with 45 days of age and 80% laying rate, were housed in a conventional shed, in battery cages arranged in parallel, containing five floors and dimensions of 25 cm wide, 35 cm long and 20 cm high, corresponding to an area of 175 cm^2 housed bird. The cages had 'nipple' drinkers and feeders with feed and water supplied *ad libitum* during two periods of 28 days each, totaling 56 experimental days.

The diets used in the trial were formulated according to the requirements of Rostagno (2017; Table 1). The homeopathic products used were obtained from a commercial company and administered in the diets at a dose of 0.02 g ave^{-1} day^{-1}.

Table 1. Feed composition (%) supplied to birds during the trial period.

Ingredients	Control %	Vehicle %	FertSigo® %	OvoSigo® %
Bran de Corn	48.69	48.69	48.69	48.69
Soybean Meal	34.07	34.07	34.07	34.07
Soybean oil	2.00	2.00	2.00	2.00
Calcium Carbonate	5.24	5.24	5.24	5.24
Mineral Core[1]	4.00	4.00	4.00	4.00
Inert	6.00	5.93	5.93	5.93
Homeopathic additive	0.00	0.07	0.07	0.07
Calculated nutritional composition				
EM (kcal kg^{-1})	2800.00	2800.00	2800.00	2800.00
Crude protein (%)	19.46	19.46	19.46	19.46
Digestible lysine (%)	1.080	1.080	1.080	1.080
Methionine+Cist. (%)	0.94	0.94	0.94	0.94
Tryptophan digs. (%)	0.23	0.23	0.23	0.23
Threonine digs. (%)	0.68	0.68	0.68	0.68
Calcium (%)	3.07	3.07	3.07	3.07
Phosphorus disp. (%)	0.30	0.30	0.30	0.30
Sodium (%)	0.16	0.16	0.16	0.16
Crude fiber (%)	2.74	2.74	2.74	2.74

[1]Mineral core composed of Limestone, Sodium Chloride (Common Salt-3.85%), Dicalcium Phosphate, Calcium Iodate, Copper Sulfate, Iron Sulfate, Manganese Sulfate, Sodium Selenite, Zinc Oxide, Folic Acid, Nicotinic Acid, Choline Chloride, Biotin, Calcium Pantothenate, Vitamins (A, B1, B2, B6, B12, D3, E and K3), DL-Methionine, Antioxidant Additive (BHT), Zinc Bacitracin and Vehicle. Guarantee levels: Folic acid (min.) 900.0 mg; Pantothenic acid (min.) 12,000.00 mg; Biotin (min.) 77.0 mg; Calcium (min.-max.) 130.0 - 143.7 g; Niacin (min.) 40,000.0 mg; Selenium (min.) 370.0 mg; Vitamin A (min.) 8,800,000.0 IU; Vitamin B1 (min.) 2,500.0 mg; Vitamin growth 0.04 g; Antioxidant 0.02 g; Mn 75 mg; Zn 50 mg; Cu 8 mg; I 0.75 mg; Fe 50 mg. Copper (min.) 7,000.0 mg; iron (min.) 50.0 g; iodine (min.) 1,500.0 mg; manganese (min.) 67.5 g; zinc (min.) 45.6 g.

The lightening program of 16 hours day^{-1} was adopted and daily the maximum and minimum temperatures and relative humidity were measured by thermohygrometer. After laying, for 5 consecutive days, the 360 eggs, intact, without deformities, dirt or cracks were stored according to their treatment for subsequent egg quality analysis. Egg storage (7 and 14 days) was carried out in a room with natural ventilation, free of direct solar incidence, in a dry and airy place, with a minimum and maximum temperature of 32.8 + -0.2°C and 21.9 + -0.15°C respectively and maximum RH 69 + -1.3% and minimum RH 41.5 + -1.5%. The eggs were identified according to their treatment and weighed individually utilizing a semi-analytical scale of precision of 0.01 g. Egg quality was evaluated using the following measures, following methodologies proposed by Bittencourt et al. (2019).

Specific gravity

For specific gravity analysis, eggs were disposed in buckets with different concentrations of saline solution (NaCl), whose densities range from 1.065 to 1.100, with intervals of 0.005.

Yolk coloring

After the egg breakage, the yolk and albumen were separated on a flat surface, and the yolk color was evaluated using a model portable colorimeter (Minolta CR 410), evaluating the luminosity (L*), red (a*) and yellow (b*) parameters at three different points of the yolk surface. The color of the egg was also evaluated using the La Roche Colorimetric Range.

Yolk height and albumen

The parameters related to the height of the yolk and albumen and diameter of the yolk were measured employing a caliper with the aid of a tripod, being measured the height of the yolk in the central region and the height of the albumen at 4 cm from the yolk. This analysis was performed only by one person to have greater accuracy of the data.

Weight and percentage of yolk, albumen, and eggshell

The yolk was separated from the albumen to be weighed individually on the digital scale. The weight of the albumen was obtained by the difference between the weight of the egg, the yolk, discounting the weight of the shell. The weight of the shell was obtained after washing and drying in a 65°C oven for 72 hours. The percentage of shell, yolk, and albumen was obtained by dividing these components by egg weight and this result multiplied by 100.

Shell thickness

After the shells were washed and dried, the thickness of the shell was measured at three different points using a micrometer of precision of 0.001 mm of the Digimess brand, performing the average of these three points of thickness.

Haugh unit

The Haugh unit is the mathematical equation described by Stadelman (1999), which correlates the weight of the egg with the height of the yolk or albumen.

H = height of dense albumen (mm) and W = egg weight (g).

Yolk index

The yolk index was calculated by the relationship between the height and the diameter of the yolk.

Statistical analysis

The data obtained from the egg quality analyses were analyzed using the Statistical Analysis System (SAS, 2012), and the normality of the residues was verified using the Shapiro-Wilk test and the variances compared by the Levenes Test. Subsequently, the data were analyzed as repeated measures over time using the Repeated command of the Mixed procedure (Mixed Proc). The interaction between diets and storage time was verified as well as their isolated effects. To evaluate the interactions, the sum of squares of storage time was unfolded utilizing orthogonal polynomials and the regression equations were adjusted. When the isolated effects of the diets were evaluated, the Tukey test was used and for the isolated effect of storage time, the contrasts of orthogonal polynomials were used and the regression equations were adjusted. For all analyses, the level of 5% significance was used.

Results and discussion

For egg weight, yolk, albumen, shell, and shell thickness there was no interaction between homeopathy and storage (Table 2) only isolated effects of homeopathy and storage time were verified. The effect of homeopathy was observed for the weight of egg, yolk, albumen, shell, and storage time for egg weight ($Y = -0.0466x + 11.112$. R^2: 0.0872) and albumen weight ($Y = -0.0433x + 6.8707$. R^2 0.117) linearly decreasing.

It was observed that the addition of Ovosigo® resulted in the better egg, albumen and shell and the addition of Fertsigo® increased yolk weight. The average weight of Japanese quail eggs according to Lucena, Holanda, Holanda, and Anjos (2019) is around 10 g, close to those found in the present study.

The addition of Ovosigo® resulted in a weight of 11.064 g, being higher among all treatments. Homeopathy is a specific therapy of stimulation of the organism, this fact may explain the improvement in the performance of birds, stimulating the hormonal pathways of quails reproductive system, leading to an increase in the egg components weight. The use of homeopathy in the quail diet showed a beneficial result, due to the positive tropism of the medication on the reproductive tract, elucidated by the principle of similarity described by Boyd (1993), which reports that when one has some deficiency or disease, the medicine or additive made from that substance that produced the same symptoms in experimentation or 'artificial disease' is given. In other words, every substance that produces certain symptoms can improve them.

It can be observed by the regression equation both for egg weight and albumen there was a linear decrease ($p < 0.05$) with the passage of storage days. This fact can be explained by the reduction of water from the albumen, lost through the pores of the shell during the process of gas exchange, transferring moisture from the most concentrated medium to the one with the lowest concentration that occurs continuously after laying, being one of the main causes of egg weight loss, and can be accelerated by inadequate storage conditions, especially when associated with high temperatures (Moraleco et al., 2019). This result was described by Freitas et al. (2011) when storing eggs from commercial laying hens at room temperature for 21 days.

Table 2. Egg weight (g), yolk weight (g), albumen weight (g), shell weight (g), and shell thickness (mm) of Japanese quail eggs fed different homeopathic products and stored in 3 periods.

Variables	Time	Homeopathy				Average	EPM	Probability		
		Control	Vehicle	FertSigo®	OvoSigo®			Hom	Time	Hom*T
Egg weight	0	11.04	10.96	11.20	11.52	11.18	0.054	0.001	< 0.001	0.5532
	7	10.53	10.48	10.57	10.90	10.62				
	14	10.12	10.41	10.86	10.77	10.54				
	Average	0.57B	10.6B	10.88AB	11.06A					
Yolk weight	0	3.40	3.433	3.52	3.52	3.43	0.029	0.007	0.0546	0.1443
	7	3.29	3.23	3.37	3.21	3.28				
	14	3.47	3.11	3.69	3.52	3.45				
	Average	3.39AB	3.25B	3.53A	3.42AB					
Albumen weight	0	6.85	6.71	6.88	7.07	6.88	0.047	0.002	< 0.0001	0.2226
	7	6.47	6.45	6.43	6.96	6.58				
	14	5.88	6.46	6.30	6.62	6.32				
	Average	6.40B	6.54B	6.54B	6.88A					
Peel weight	0	0.80	0.81	0.78	0.82	0.80	0.005	0.007	0.7625	0.8552
	7	0.77	0.79	0.78	0.83	0.79				
	14	0.76	0.79	0.79	0.83	0.79				
	Average	0.78B	0.80AB	0.78B	0.83A					
Shell thickness	0	0.19	0.21	0.20	0.20	0.20	0.001	0.065	0.5553	0.3369
	7	0.20	0.19	0.19	0.20	0.20				
	14	0.21	0.20	0.19	0.20	0.20				
	Average	0.20	0.20	0.19	0.20					

Variable	Regression equation	R^2	Effect	p value
Egg weight (g)	$Y = -0.0466x + 11.112$	0,0872	Linear	p > 0.0001
Albumen weight (g)	$Y = -0.0433x + 6.8707$	0,117	Linear	p < 0.0001

*EPM: Medium standard error. Means followed by different letters in the row and column differentiate from each other by the Tukey test at 5% significance.

There was the interaction between the different types of homeopathy and the egg storage time ($p > 0.05$) for the variable Percentage of yolk and albumen according to Table 3. For the yolk percentage parameter there was quadratic effect ($Y = 0.0301x2 - 0.2869x + 31.102$. R^2: 0.0751) and for albumen percentage there was a decreasing linear effect ($Y = -0.1536x + 61{,}908$. R^2: 0.0473). Regarding the percentage of the shell, there was an effect ($p < 0.05$) of the different homeopathic inclusions, where the Ovosigo® treatment obtained higher results (Table 3).

Table 3. Percentage of yolk, albumen, and eggshell of Japanese quails fed different homeopathic products and stored in 3 periods (0.7 and 14 days).

Variables	Time	Homeopathy				Average	EPM	Probability		
		Control	Vehicle	FertSigo®	OvoSigo®			Hom	Time	Hom*T
% Yolk	0	30.749	31.318	31.517	30.752	31.084	12.004	0.248	0.058	< 0.0001
	7	30.676	30.937	31.041	29.213	30.467				
	14	34.432	30.014	34.255	32.92	32.905				
	Average	31.952	30.756	32.271	30.962					
% Albumen	0	61.878	57.984	61.462	61.945	61.64	6.803	0.27	0.092	0.0007
	7	61.041	61.276	60.817	61.166	61.61				
	14	57.984	62.319	58.47	59.352	59.53				
	Average	60.301	61.682	60.249	61.488					
% eggshell	0	7.399	7.415	7.02	7.429	7.316	9.457	0.043	0.139	0.415
	7	7.34	7.624	7.5	7.706	7.542				
	14	7.582	7.643	7.244	7.734	7.551				
	Average	7.441AB	7.56AB	7.255B	7.623A					

Variable	Regression equation	R^2	Effect	p-value
% yolk	$Y = 0.0301x2 - 0.2869x + 31.102$	0.0751	Quadratic	p =0.0057
% albumen	$Y = -0.1536x + 61.908$	0.0473	Linear	p < 0.0001

EPM: Medium standard error. Means followed by different letters in the row and column differentiate from each other by the Tukey test at 5% significance.

There was an increase in the percentage of yolk with the passing of days and a decrease in albumen, this result is related to the migration of water from the albumen to the yolk. This factor starts just after the quail posture, where there is an osmotic pressure gradient between the albumen and the yolk, which is progressively accentuated, as the water passes from the albumen to the yolk over time this factor intensifies with high temperatures (Ribeiro et al., 2015). Pombo et al. (2006) when studying the effect of heat treatment of whole eggs on weight loss and internal quality characteristics, found that gas exchange is responsible for liquefaction of the albumen and later, in an egg that is not stored correctly, the yolk absorbs water from this liquefied albumen increasing its weight, which was observed in the present research.

The results obtained in the present study reinforce those found by Santos et al. (2009) and Garcia et al. (2010), and Scott and Silversides (2000) who also reported that the percentage of albumen decreases as days go by due to the liquefaction process of the albumen together with the gas exchanges of the egg with the environment. The addition of OvoSigo® resulted in a higher percentage of the shell. The shell is composed of calcium carbonate (98%) and glycoproteins (2%), its main function is to protect the egg externally, being composed of thousands of pores responsible for gas exchange. All calcium salts secreted in the uterine lumen during shell formation are derived from the blood and serum calcium is obtained through feeding and bones (Li, Zhu, Jiang, & Wang, 2017; Mróz et al., 2019), therefore, the diet containing Ovosigo® may cause greater availability of calcium, reflecting on the highest percentage of the shell.

Regarding homeopathy and time interaction (Table 4) there was a significant effect ($p < 0.05$) for the variables albumen height, yolk height, Haugh unit, and yolk index according to the equations in Table 5. Time influenced the specific gravity ($Y = -0.0001x + 1.0663$). R^2: 0.1375).

The specific severity variable presented a linear reduction over time as demonstrated by the regression equation. The measurement of the specific gravity in eggs according to Paiva et al. (2019) helps in determining the quality of their shell, the porosity of the shell interferes with the loss of egg water since in their study, the eggs stored under refrigeration presented a specific severity higher than the eggs kept at room temperature.

Similar results of reduction in specific gravity values were obtained by Samli, Agma, and Senkoylu (2005), Barbosa, Sakomura, Mendonça, Freitas, and Fernandes (2008), Santos et al. (2009) and Freitas et al. (2011) when they demonstrated that egg water loss occurs after laying, and the result of evaporation causes a progressive increase in the air chamber and, consequently, a decrease in egg specific gravity. Also, this reduction may be related to a weight loss of eggs and albumen during storage.

The height of the albumen progressively reduced, with the passing of days, numerous chemical reactions occur in the albumen during the storage period, leading to fluidization and pH elevation, allowing the water to pass to the yolk, reducing the weight and height of albumen (Xavier et al., 2008). The homeopathic products used were not able to reduce these reactions, because the control treatment was the one that remained more stable as the days went by.

Table 4. Specific gravity, albumen height (cm) and yolk (cm), Haugh Unit (UH), and yolk index (%) eggs of Japanese quails fed different homeopathic products and stored in 3 periods (0, 7 and 14 days).

Variables	Time	Homeopathy				Average	EPM	Probability		
		Control	Vehicle	FertSigo®	OvoSigo®			Hom	Time	Hom*T
Specific gravity	0	1.066	1.066	1.066	1.067	1.067	0.001	0.421	< 0.0001	0.485
	7	1.065	1.065	1.065	1.065	1.065				
	14	1.065	1.065	1.065	1.065	1.064				
	Average	1.0656	1.0655	1.0653	1.0657					
Albumen height	0	4.00	4.31	4.39	3.68	4.10	0.055	0.1078	< 0.0001	0.0028
	7	3.21	3.07	3.11	3.15	3.13				
	14	3.50	2.97	2.68	2.92	3.021				
	Average	3.57	3.45	3.37	3.25					
Yolk height	0	10.57	10.82	11.14	10.61	10.7	0.071	0.596	< 0.0001	0.0016
	7	9.23	9.09	8.96	9.18	9.11				
	14	8.85	8.79	8.46	9.19	8.825				
	Average	9.53	9.56	9.52	9.67					
UH	0	86.82	88.67	88.88	84.63	87.27	0.35	0.0287	< 0.0001	0.0017
	7	82.62	81.14	81.78	81.84	81.81				
	14	84.79	81.11	78.61	80.27	81.20				
	Average	84.78	83.64	83.08	82.25					
Yolk index	0	0.44	0.45	0.45	0.45	0.45	0.003	< 0.0001	< 0.0001	< 0.0001
	7	0.35	0.35	0.34	0.44	0.37				
	14	0.36	0.35	0.32	0.35	0.34				
	Average	0.38	0.38	0.37	0.41					

Variable	Regression equation	R^2	Effect	p-value
Specific gravity	$Y = -0.0001x + 1.0663$	0.1375	Linear	p < 0.0001

EPM: Medium standard error. Means followed by different letters in the row and column differentiate from each other by the Tukey test at 5% significance.

Table 5. Regression equations of homeopathy interactions *versus* storage period of egg quality variables of quail quails.

Variable	Regression equation	R^2	Treatment
Yolk height	$y = -0.1159x + 10.347$	0.445	Control
Albumen height	$y = -0.0347x + 3.8074$	0.617	
Haugh Unit	$y = 0.0649x2 - 1.0531x + 86.823$	0.133	
Yolk index	$y = -0.0058x + 0.4301$	0.408	
Yolk height	$y = -0.145x + 10.598$	0.570	Vehicle
Albumen height	$y = -0.0952x + 4.2089$	0.269	
Haugh Unit	$y = -0.5364x + 87.522$	0.273	
Yolk index	$y = -0.0067x + 0.4375$	0.422	
Yolk height	$y = -0.1917x + 10.874$	0.657	FertSigo®
Albumen height	$y = -0.1225x + 4.3604$	0.382	
Haugh Unit	$y = -0.7325x + 88.55$	0.402	
Yolk index	$y = -0.0099x + 0.4437$	0.663	
Yolk height	$y = -0.1056x + 10.449$	0.445	OvoSigo®
Albumen height	$y = -0.0546x + 3.6274$	0.160	
Haugh Unit	$y = -0.295x + 84.213$	0.166	
Yolk index	$y = 0.0071x + 0.4616$	0.536	

There was a reduction of the yolk height parameter in all treatments, due to the permeability of the membrane, where the yolk absorbs part of the water from the albumen and consequently causes the change in its original shape. Similar results were found by Seibel, Barbosa, Gonçalves, and Souza-Soares (2005), who also reaffirm that this event is due to the osmotic movement of the albumen water migrating to the yolk, making it with a flattened and larger aspect.

According to Giampietro-Ganeco et al. (2015) if eggs are stored under controlled conditions (refrigerated environment) they have a higher average value of Haugh Unit, demonstrating the benefit of the use of refrigeration in maintaining the internal quality of eggs during storage. Concerning the yolk index, the interaction was observed with storage days *versus* homeopathy.

Results found by Piccinin et al. (2005) who evaluated the egg quality of Japanese quails showed that there was a constant reduction in the index and yolk, from eggs stored at room temperature, which went from 0.47 on day zero to 0.12 on the 27th day and that eggs stored at refrigerated temperature had a less pronounced drop.

There was no significant interaction between homeopathy and time (p > 0.05) for the variables L*, a*, b*. An increasing linear effect was obtained for the incidence of L* ($Y = 0.2124x + 57,167$. R^2: 0.2717) and b* (Y =

0.3792x + 37.001. R^2: 0.2592) in isolation in relation to storage time. For the incidence of color, a* there was a quadratic effect (Y = 0.0069x2 − 0.08x − 3.6664. R^2: 0.0708) in relation to storage time (Table 6).

The parameters L, and b* presented linear behavior as evidenced by the regression equation. According to Bittencourt et al. (2019) the color of the yolk comes from the presence of carotenoids (carotenes and xanthophyll), present in the diet, consequently the higher the consumption of foods rich in pigments, the greater the intense coloration of the yolk. According to Giampietro-Ganeco et al. (2012) pigmentation in refrigerated eggs is stable and decreases when eggs are stored at room temperature, however in this study, the values of L, a* and b* were higher. Over time the eggs were losing water through gas exchange with the medium, this made the pigmenting components in the yolk (carotenoids) more concentrated.

A similar result was found by Oliveira, Martins, and Santos (2011) who reported that the oxidation of foods destroys vitamins, essential fatty acids, proteins, and pigments, decreasing the light contents over the days. According to Viana, Gomes, Silva, and Freitas (2017) refrigeration maintains color stability during storage and prevents chemical reactions from leading to physicochemical destructions of the egg, which is consequently able to change the quality of the egg, in the present study the eggs were stored in a natural environment, not facilitating this preservation over the days.

Table 6. Colorimetry (L*, a*, b*) of Japanese quail eggs fed different homeopathic products and stored in 3 periods (0.7 and 14 days).

Variables	Time	Homeopathy				Average	Epm	Probability		
		Control	Vehicle	FertSigo®	OvoSigo®			Hom	Time	Hom*T
L*	0	57.06	57.21	56.29	56.59	56.79	0.152	0.0559	< 0.0001	0.359
	7	59.50	59.87	58.91	59.71	59.50				
	14	58.89	60.63	59.80	59.76	59.77				
	Average	58.48	59.24	58.33	58.69					
a*	0	-3.59	-3.79	-3.79	-3.54	-3.66	0.044	0.1074	0.0002	0.7846
	7	-4.08	-4.05	-3.75	-3.6	-3.88				
	14	-3.54	-3.47	-3.44	-3.27	-3.43				
	Average	-3.37	-3.77	-3.64	-3.49					
b*	0	37.69	36.66	37.37	36.79	37.12	0.276	0.243	< 0.0001	0.363
	7	37.92	40.60	40.05	39.71	39.57				
	14	41.77	42.64	43.54	41.37	42.33				
	Average	39.12	39.95	40.32	39.29					

Variable	Regression equation	R^2	Effect	p-value
L*	$Y = 0.2124x + 57.167$	0.2717	Linear	p < 0.0001
a*	$Y = 0.0069x2 - 0.08x - 3.6664$	0.0708	Quadratic	p < 0.0001
b*	$Y = 0.3792x + 37.001$	0.2592	Linear	p < 0.0001

EPM: Medium standard error. Means followed by different letters in row and column differentiate from each other by Tukey test at 5% significance.

Conclusion

It is indicated the addition of the product with homeopathic basis Ovosigo® and FertSigo® in diets of Japanese quails in the laying phase because they resulted in the greater weight of the egg, shell, yolk, and albumen, which adds value to the coturniculture. The different homeopathic products did not influence the conservation of the egg quality of Japanese quails in the periods evaluated.

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