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Effects of Colostrum Powder Supplementation on the Performance, Egg Quality and Egg Yolk Lipid Peroxidation in Japanese Quails

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Summary: This study was conducted to determine the effect of supplementary colostrum powder (CL-P) on egg production, egg quality, serum and egg yolk vitamin levels, and malondialdehyde (MDA) levels in laying quail. A total of 90 five-week-old laying quail were divided into three groups consisting of six replicate cages with five birds per cage. The birds were fed randomly one of three diets: a basal diet or a basal diet supplemented with either 2.5 or 5% CL-P. Dietary CL-P supplementation caused linear increases in feed intake, egg production, and egg weight, and improved feed conversion. In addition, shell weight and shell thickness increased, whereas egg yolk color and Haugh units were unaffected. In serum and egg yolks, the vitamin A levels increased linearly while the MDA levels decreased linearly with increasing amounts of supplemental CL-P. In contrast, the serum vitamin E levels increased linearly whereas the egg yolk vitamin E levels were unaffected by increasing amounts of supplemental CL-P. Dietary CL-P may enhance performance and egg quality in poultry.

Key words: Colostrum powder, malondialdehyde, performance, quail

Japon Bıldırcınlarında Toz Kolostrum Katılmasının Performans, Yumurta Kalitesi ve Yumurta Sarısı Lipit Peroksidasyon Düzeyleri Üzerine Etkisi

Özet: Bu çalışma, yumurtacı bıldırcınlarda toz kolostrum katılmasının (CL-P) yumurta verimi, yumurta kalitesi, serum ve yumurta sarısı vitamin ve malondialdehit (MDA) düzeyleri üzerine etkisini belirlemek amacıyla yürütülmüştür. Beş haftalık yaşta 90 adet yumurtacı bıldırcınlar rastgele olarak 3 gruba ayrıldı. Her bir kafeste 5 adet bıldırcın bulunan 6 tekrarlı kafesler oluşturuldu. Birinci grubun temel diyetine herhangi bir ilave yapılmadı. İkinci grubun temel diyetine % 2.5, üçüncü grubun temel diyetine ise %5 oranında CL-P ilave edildi. Diyete ilave edilen CL-P katkısı bıldırcınlarda, yem tüketimi ($P<0.001$), yumurta verimi ($P<0.01$), yumurta ağırlığı ($P<0.001$), kabuk ağırlığı ($P<0.01$) ve kabuk kalınlığını ($P<0.01$) lineer olarak artırmış ve yemden yararlanmayı da ($P<0.05$) iyileştirmiş, fakat yumurta sarısı rengi ve Haugh birimini değiştirmemiştir. Artan CL-P konsantrasyonu ile serum ve yumurta sarısı vitamin A seviyelerinde ($P<0.01$) lineer bir artış ve MDA seviyelerinde (sırasıyla $P<0.01$; $P<0.001$) lineer bir düşüş görülmüştür. Diğer taraftan, artan CL-P konsantrasyonu ile serum vitamin E seviyesi ($P<0.01$) lineer olarak artarken yumurta sarısı vitamin E seviyesi değişmemiştir. Kanatlılarda diyete ilave edilen CL-P'nin performans ve yumurta kalitesinin iyileştirilmesinde faydalı olabileceği söylenebilir.

Anahtar kelimeler: Bıldırcın, malondialdehit, performans, toz kolostrum

Introduction

Colostrum, the milk secreted by female mammals during the first few days following parturition, is a nutrient-dense liquid for newborns that has a different color and composition than mature milk (7,26). The primary importance of colostrum is derived from the amount of immunoglobulins (Igs) it contains; Igs play a major role in the immune system (7). Colostrum is important for the growth of developing cells and tissues during the early phase of life because it contains immune-regulating components, nutritional substances, transferrin, essential and

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nonessential amino acids, fatty acids, and antimicrobials and greater amounts of protein, fats, vitamins, and minerals than are present in mature milk (2,7,13,17). In addition, colostrum is responsible for important morphological and functional improvements in the gastrointestinal tract (16), tissue and organ development and repair, and metabolic and endocrine changes (24) in newborn calves, lambs, and pigs (20). The substances that are present in colostrum, including nutrients, antibodies, growth factors, and vitamins A, E, and C, can be transferred easily to newborns by feeding after birth (19,25). Moreover, colostrum has a greater anti oxidant capacity than mature milk (27).

Although newborns need only a few liters of colostrum after birth, female mammals produce larger quantities of colostrum. This excess colostrum has been evaluated for use in powdered form in poultry nutrition as a highly nutritious feed additive that includes essential and nonessential amino acids, fatty acids, proteins, fats, vitamins, and minerals (26). Because the effect of colostrum powder (CL-P) as a dietary supplement for quail has not been investigated, the aim of this study was to determine the effect of CL-P supplementation on performance, egg quality, and lipid peroxidation in laying quails.

Table 1. Ingredient and nutrient composition of the basal diet*

Ingredient	%
Corn	57.35
Soybean meal, CP (44%),	28.21
Soy oil	3.53
Limestone	8.42
Dicalcium phosphate	1.69
Salt	0.30
Vitamin-mineral premix**	0.35
DL-Methionine	0.15
Chemical analyses, dry matter basis	
Crude protein	18.27
Crude fat	4.98
Crude fiber	3.72
Crude ash	7.37
Calcium	3.92
Phosphorus	0.59
*Calculated compositions****	
Methionine	0.43
Lysine	1.01
Metabolizable energy, kcal/kg	2912

* CL-P was added into diets at expense of corn.
** Per kilogram contained the following: vitamin A, 8,000 IU; vitamin D_3, 3,000 IU; vitamin E, 25 IU; menadione, 1.5 mg; vitamin B_{12}, 0.02 mg; biotin, 0.1 mg; folacin, 1 mg; niacin, 50 mg; pantothenic acid, 15 mg; pyridoxine, 4 mg; riboflavin, 10 mg; thiamin, 3 mg; copper (copper sulfate), 10.00 mg; iodine (ethylenediamine dihydriodide), 1.00 mg; iron (ferrous sulfate monohydrate), 50.00 mg; manganese (manganese sulfate monohydrate), 60.00 mg; zinc (zinc sulfate monohydrate), 60.00 mg; and selenium (sodium selenite), 0.42 mg.
*** Calculated value according to tabular values listed for the feed ingredients (9).

Materials and methods

Animals, treatments, and management

Ninety five-week-old Japanese quail (*Coturnix coturnix japonica*) provided by a commercial company (Insanay Kanatli Hayvan Uretim Paz. Tic. Inc., Elazig, Turkey) were used in accordance with the Local Animal Care and Use Committee of Dicle University, Diyarbakir, Turkey. The birds were assigned randomly to three groups with 30 birds in each group and six replicate cages with 5 birds per cage.

The quails were fed one of three diets (Table 1) for 90 days: a basal diet not supplemented with CL-P or a basal diet supplemented with either 2.5 or 5% CL-P containing 13% protein, 0.3% fat, and 59% carbohydrate (Alpha Lipid Lifeline Colostrum Powder, Manukau, New Zealand). Diets were stored in opaque polyethylene bags in a cool (18-20°C) and dry environment (35-40 % humidity) until fed to the experimental birds. The quails were housed in cages (25x45x30 cm) with 3 compartments and 5 floors. Each cage compartment was equipped with a nipple drinker and a trough-type feeder. The birds were exposed to a 16-h/8-h light/dark illumination cycle. The diets and fresh water were offered *ad libitum* throughout the experiment.

Performance variables and egg quality

Feed consumption was measured weekly and egg production and egg weights were recorded daily. For egg quality parameters such as yolk weight, yolk color, shell weight, shell thickness and Haugh units, two eggs collected randomly from each of six replicates per group were randomly collected on the 1^{st}, 2^{nd}, 3^{rd}, 30^{th}, 31^{st}, 32^{nd}, 61^{st}, 62^{nd}, 63^{rd}, 88^{th}, 89^{th} and 90^{th} days of the experimental period (90 days).

Egg yolk color was determined using a Roche Color Fan according to the CIE standard colorimetric system (F. Hoffman-La Roche Ltd., Basel, Switzerland). Feed conversion was calculated using the formula: Feed conversion = feed consumed (g) / egg mass (egg number x egg weight). Haugh units were also calculated using the formula: Haugh unit = 100 × log (H + 7.57 − 1.7 × W0.37), where H = albumen height (mm) and W = egg weight (g) (6).

Sample collection and laboratory analysis

At the end of the study, twelve birds (two birds per replicate) were bled and killed by cervical dislocation. Blood samples were placed into additive-free vacutainers, which were centrifuged at 3.000×*g* for 10 min and aliquots were transferred to microfuge tubes. Serum samples were kept on ice and protected from light to avoid oxidation during sampling and then stored at −80°C until analysis. Two eggs collected randomly from each of six replicates per group were randomly collected on the 1^{st}, 2^{nd}, 3^{rd}, 30^{th}, 31^{st}, 32^{nd}, 61^{st}, 62^{nd}, 63^{rd}, 88^{th}, 89^{th} and 90^{th} days of the experimental period (90 days). The egg yolk and albumen were separated and stored at −80°C until analysis after egg yolk weights recorded.

Chemical analysis of the basal diet was performed in triplicate using procedures described by (AOAC). Energy and amino acid (methionine and lysine) contents were calculated from tabular values listed for the feedstuffs (9). The vitamin A, vitamin E (15), and malondialdehyde (MDA) (10) levels in serum and egg yolks were determined using a fully automatic high performance liquid chromatography (HPLC) system (Shimadzu, Kyoto, Japan). The HPLC equipment consisted of a pump (LC-20AD); a Diode Array Detector (SPDM-10A) for carotenoids, vitamins, and MDA; a column oven (CTO-10ASVP); an autosampler (SIL-20A); a degasser unit (DGU-20A5); a column (Inertsil ODS-3; 250x4.6 mm, 5 μm); and a computer system equipped with LC solution software (Shimadzu).

Statistical analysis

A 10% improvement in the egg yolk MDA concentration was considered to be significant at a type I error of 0.05. The data were subjected to a one-way analysis of variance (ANOVA) using the PROC MIXED procedure (22). The linear model used to test the effect of dietary CL-P supplementation on performance and egg quality was: yij = μ + b0 + Ri + ej, where y = response variable; μ = population mean; b0 = covariate (measurements obtained at the end of the pretest period); R = CL-P supplementation; and e = residual error being N (σ, μ; 0,1). The model also included orthogonal polynomial contrasts to determine CL-P supplementation effects and changes in the response variable with increasing dietary CL-P supplementation. Mean differences of interaction effects were compared to Tukey test. Statistical significance was declared at $P<0.05$.

Results

The mean egg production values (78.20, 78.49, and 78.08%; P>0.05) and egg weights (11.03, 10.95, and 11.12 g; P>0.05) were similar at the beginning of the trial. Quail fed a diet supplemented with 5% CL-P consumed the largest amounts of feed (P<0.001), produced the greatest numbers of eggs (P<0.01), produced the heaviest eggs (P<0.001) and egg yolks (P<0.001), and exhibited the most efficient feed conversion (P<0.05), followed by quail fed a diet supplemented with 2.5% CL-P (Table 2). In addition, as the dietary CL-P concentration increased, shell weight (P<0.01) and shell thickness (P<0.01) increased linearly (Table 2); however, the dietary treatments did not affect egg yolk color or Haugh units. Control quail exhibited the poorest performance indices (Table 2).

The vitamin and MDA levels in serum and egg yolks were affected by the CL-P concentration (Table 3). Serum vitamin A and E concentrations increased for quail given a diet supple-

Table 2. Effects of colostrum powder (CL-P) supplementation to quail diets on performance and egg quality*

Variable♣	CL-P, %			SEM	Statistical significance, *P* > F¶		
	0	2.5	5		S	L	Q
Egg production§, %	80.15^{b}	84.34^{a}	87.44^{a}	0.983	0.01	0.0001	NS
Egg weight†, g	11.23^{c}	11.79^{b}	12.50^{a}	0.150	0.001	0.0001	NS
Feed intake, g/d	30.16^{b}	31.42^{ab}	33.14^{a}	0.450	0.001	0.001	NS
Feed conversion	3.36^{a}	3.17^{ab}	3.04^{b}	0.072	0.05	0.003	NS
Shell weight, g	0.88^{b}	0.91^{b}	0.97^{a}	0.017	0.01	0.002	NS
Shell thickness, mm	0.234^{b}	0.243^{b}	0.263^{a}	0.005	0.01	0.0001	NS
Haugh unit	90.88	91.63	91.11	0.887	NS	NS	NS
Egg yolk color	5.83	5.83	5.80	0.246	NS	NS	NS
Egg yolk weight, g	2.84^{c}	3.13^{b}	3.53^{a}	0.052	0.001	0.0001	NS

* Data are the least square means from a 90-day animal experimentation.
♣ Different letters within the same rows indicate differences among groups (P<0.05).
¶ Statistical contrast: S = CL-P supplementation effect (quail supplemented with CL-P vs. quail not supplemented with CL-P); L = Linear effect of increasing dietary CL-P; Q = Quadratic effect of increasing dietary CL-P. NS = Not significant.
§ n = 30 quails per group.
† n = 12 eggs per group.

Table 3. Effects of colostrum powder (CL-P) supplementation to quail diets on serum-egg yolk vitamin and MDA levels*

Variable♣	CL-P, %			SEM	Statistical significance, *P* > F¶		
	0	2.5	5		S	L	Q
Serum§, μg/ml							
Vitamin A	4.40^{b}	6.86^{a}	7.77^{a}	0.372	0.001	0.0001	NS
Vitamin E	7.31^{b}	9.88^{a}	11.08^{a}	0.432	0.001	0.0001	NS
Malondialdehyde	0.36^{a}	0.21^{b}	0.17^{b}	0.018	0.001	0.0001	0.010
Egg yolk†, μg/g							
Vitamin A	9.71^{b}	10.96^{ab}	11.83^{a}	0.356	0.01	0.0001	NS
Vitamin E	118.67	116.90	117.74	3.227	NS	NS	NS
Malondialdehyde	0.33^{a}	0.25^{b}	0.21^{b}	0.010	0.001	0.0001	NS

* Data are the least square means from a 90-day animal experimentation.
♣ Different letters within the same rows indicate differences among groups (P<0.05).
¶ Statistical contrast: S = CL-P supplementation effect (quail supplemented with CL-P vs. quail not supplemented with CL-P); L = Linear effect of increasing dietary CL-P; Q = Quadratic effect of increasing dietary CL-P. NS = Not significant.
§ n = 12 quails per group.
† n = 12 eggs per group.

mented with CL-P (P<0.001, for both; Table 3). The egg yolk vitamin A concentration also increased (P<0.01), whereas the egg yolk vitamin E concentration did not differ between treatments (Table 3). Quail fed a diet supplemented with CL-P had lower serum and egg yolk MDA levels (P<0.001, for both; Table 3) than quail fed the diet without CL-P. In serum and yolk, the vitamin A and E concentrations increased linearly while the MDA concentrations decreased as the CL-P concentration increased in the diet. Despite no changes in the vitamin E levels in the egg yolks, the vitamin E levels in serum increased linearly with increasing dietary CL-P concentration.

Discussion

Colostrum is nutritious for newborns because of its content of nutrients, Igs, growth factors, and fatty acids (7). Although poultry cannot benefit from the Igs present in colostrum, the use of CL -P as a feed additive in poultry diets is useful because of its nutritional and performance-enhancing properties. In this study, CL-P caused significant improvements in feed intake, egg production, and feed efficiency in laying quail (Table 2). Moreover, quail fed a diet supplemented with 5% CL-P exhibited higher egg weights and shell quality than quail fed a diet not supplemented with CL-P (Table 2). Because studies of CL-P as a dietary supplement for quail are lacking, our results are not directly comparable to previously published studies; however, the positive impacts of CL-P supplementation on feed intake, body weight gain, and feed efficiency we observed are in agreement with the results of a previous study done with broilers (21). On the other hands, it has been stated that spray-dried plasma and spray-dried colostrum are the rich kinds of protein supplement, include highly similar contents (especially immunglobulins) with colostrum, exerting important growth performance benefits in pigs, broilers and turkeys (3,4,11). King et al. (12) also achieved significant improvement in feed conversion in days of 14 at growing stage of broilers that supplemented with spray-dried colostrum.

Colostrum also contains enzymatic antioxidants such as lactoperoxidase, superoxide dismutase, catalase, and non-enzymatic antioxidants such as vitamins A, E, and C and lactoferrin (19,24). Vitamin E, which accumulates primarily in cell membranes, is one of the most important antioxidants, and it strongly inhibits MDA formation (5,14,18). MDA is created as a final product of lipid peroxidation and is recognized as a marker of lipid peroxidation caused by reactive oxygen species (8,19,23). In this study, significantly higher vitamin A and E levels in serum and vitamin A levels in egg yolks were accompanied by lower MDA levels in serum and egg yolks in quail receiving 5% CL-P in their diet. No previous reports on dietary CL-P supplementation in birds have been published so we cannot compare our results with similar studies in quail or other poultry species.

Our results show that CL-P supplementation to laying quail diets improved performance and egg quality and enhanced the antioxidant status in a dose-dependent manner. The use of 5% CL -P may be beneficial for performance and egg quality in poultry.

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