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EFFECTS OF SPIRULINA (*S. PLATENSIS*) ADDITION TO DIETS OF BREEDER QUAILS

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Abstract: The experiment aimed to investigate how different levels of Spirulina (spirulina platensis) supplementation in the diet of breeder Japanese quail (Coturnix coturnix japonica) affect their laying performance, egg quality, and hatchability parameters. The study was carried out with 96 breeding quails (72 female, 24 male). Quails were randomly distributed to 4 treatment groups with 24 subgroups (1 male 3 female). The feeding trial lasted for 8 weeks, during which time four diets were prepared with powdered Spirulina supplementation at 0% (control), 0.75%, 1.5%, and 2.25% to the basal diet. At the end of the experiment, feed consumption was higher in the control group than in the other groups (P<0.05). The control group had the highest feed conversion ratio (FCR) while the group fed with 2.25% SP had the lowest FCR (P<0.05). No considerable differences were observed between the groups in terms of egg production, body weight, egg weight, and egg mass. Similarly, eggshell thickness, eggshell weight, eggshell ratio, egg shape, albumen, and yolk index parameters were not significantly affected by the treatment. L* value, which is one of the egg yolk color parameters, decreased linearly with increasing spirulina levels in the diet, while a* and b* values increased (P<0.01). Differences between treatment groups in terms of incubation parameters were not significant. In conclusion; the addition of 0.75%, 1.5%, and 2.25% SP to the diets of breeder Japanese quail had positive effects on feed intake and feed conversion ratio, and egg yolk color, but had no negative effects on egg quality and hatching parameters. It was concluded that spirulina can be used at a 2.25% level in breeder Japanese quail diets.

Keywords: Breeder Japanese quail, Spirulina (*spirulina platensis*), Incubation parameters, Performance, Egg yolk color, Egg quality

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1. Introduction

Spirulina, an edible cyanobacterium, has a spiral-shaped and filamentous structure. This bacterium is commonly found in alkaline lakes in nature. Previously, it was classified as a type of blue-green algae (Becker, 2007; Gupta et al., 2008). This is the reason why it attracts attention as animal feed, and human food due to its high crude protein, essential amino acid, fat, vitamin, and mineral content in its dry matter (Mišurcová et al., 2014; Salmeán et al., 2015). Spirulina platensis has antioxidant, anti-inflammatory, immune-modulating, and hepatoprotective functions (Jeyaprakash and Chinnaswamy, 2005; Abdel-Daim et al., 2015; Ibrahim and Abdel-Daim, 2015; Jamil et al., 2015). It can be grown in bioreactors or open ponds without using agricultural land (Chen et al., 2016). It is a sustainable resource that can be obtained without using agricultural land. Microorganisms, which can synthesize the nutrients (carbohydrates, protein, lipids, minerals, and vitamins) that form the basis of nutrition from simple organic and inorganic substances, gain great importance in solving the problem of food insufficiency in the world. Cellulose is not found in the cell wall of Spirulina Platensis. This can be absorbed by improving mucosal digestion and intestinal function. While the population of beneficial microorganisms (such as Bifidobacter, and Lactobacillus) increases, harmful microorganisms (such as Candida) are suppressed. The increase in the Lactobacillus-type microorganism population positively affects food digestion and absorption (Seyidoglu et al., 2017). There are some desirable properties in a source that can be used as an alternative in animal nutrition. Ideally, the features expected from this new source are high nutritional value and efficiency of conversion to animal products, optimizing quality of product, and using water and land efficiently (Poppi and McLennan, 2010). Spirulina is a strong candidate with the potential to meet all of these features. This trial was carried out to find out the effects of powdered spirulina added to breeder quail diets in the amounts of 0, 0.75, 1.5, and 2.25% on egg quality, performance, and hatching parameters. The efficacy of spirulina as a viable feed additive was evaluated in the investigation.

2. Materials and Methods

A total of 96 breeder quails (*Coturnix coturnix japonica*), 72 females and 24 males, aged 10 weeks, were used in the study. Four treatment groups were created to distribute quails, with each group having 24 subgroups. In each subgroup, there were 3 female quails and 1 male quail. For eight weeks, a specialized feed was prepared to meet the nutritional requirements of breeding quail. The feed was formulated to contain 2900 Kcal/kg metabolizable energy and 20% crude protein (Council, 1994). Spirulina (Spirulina platensis) powder form was used in the experiment. A set of rations for a trial was prepared, including a basal ration (0%) mainly made from corn and soybean meal. The preparation involved the use of Spirulina (*Spirulina platensis*) at different percentages of 0.75%, 1.5%, and 2.25% (Table 1).

Table 1. Nutrient content of experimental diets

Ingredients	Spirulina%			
	0	0.75	1.5	2.25
Corn	50.1	50.05	50.0	50.4
Spirulina	0	0.75	1.5	2.25
Soybean meal	36	35	34.0	33
Crude oil	6.2	6.5	6.5	6.5
Limestone	5.10	5.10	5.15	5.15
Dicalcium phosphate(DCP)	1.8	1.8	1.85	1.85
Salt	0.25	0.25	0.25	0.25
Premiks[1]	0.25	0.25	0.25	0.25
L-Lysine	0.10	0.10	0.15	0.15
DL-Methionine	0.20	0.20	0.20	0.20
Calculated nutrients				
Crude protein, %	20.0076	20.0038	20.0	20.0304
Energy, kcal/kg ME	2904.05	2928.99	2927.0	2938.91
Calcium, %	2.5049	2.5015	2.5294	2.5261
Available phosphorus, %	0.3508	0.3503	0.3589	0.3585
Lysine, %	1.0492	1.0251	1.0410	1.0178
Methionine, %	0.4768	0.4711	0.4654	0.4604
Methionine-cysteine, %	0.20	0.20	0.20	0.20

The experiment was carried out in multi-storey breeder cages with 3 cells (45x30x25 cm) on each floor in the quail unit located at the Faculty of Agriculture Department of Animal Science Farm of Selçuk University. In the experiment, quails were given trial rations for 8 weeks. During the trial, a 16-hour light/8-hour dark lighting program was applied. Feed and water were given ad libitum. At the beginning and end of the experiment, the animals in each cage were weighed as a group. In the experiment, two periods of measurement were made, each lasting 4 weeks. The given results are the average of the measurements taken in two periods. The amount of feed given was recorded daily. At the end of each period, feed intake (FI) was calculated from these records as the daily average FI per quail. For each period, the feed conversion ratio was calculated by dividing the daily average feed intake (in grams) per quail by the egg mass (in grams) during that period. Egg production (EP) was recorded daily and determined from these records at the end of each period. The weight of eggs (EW) was calculated by taking an average of the egg weights collected during the final two days of each period. To determine egg mass, the formula EM= (egg production x egg weight)/100 was used. Eggs were gathered during the final two days of each period for the experiment, where various factors were measured including shell thickness, weight, shape index, yolk and albumen index, and Haugh unit. The colorimeter (Konica Minolta CR410) was used to measure L*, a*, and b* values of egg yolk. End of the experiment, to determine the hatching properties, the eggs were collected for 7 days, and those with hatchability properties were numbered according to groups and placed in the incubator. The number of chicks hatched after the seventeenth day and the number of fertile and non-fertile eggs was determined by breaking the eggs that did not hatch after the twentieth day. The data obtained was used to calculate the hatching efficiency, fertility rate, and hatchability (Erensayın, 2000). One-way analysis of variance (ANOVA) was used for statistical analysis of the experiment's data (Minitab, 2000) and to determine the differences between the means, Duncan's multiple comparisons test was utilized.

3. Results

The effects of supplementing breeder Japanese quail diets with SP at varying levels (0%, 0.75%, 1.5%, and 2.25%) on parameters such as LWC, FI, FCR, EP, EW, and EM are presented in Table 2. The live weight change, egg weight, egg mass, and egg production of breeder quails were not affected by the addition of spirulina in their diets. However, the inclusion of spirulina resulted in a decrease in feed intake and feed conversion ratio. The lowest feed consumption was in the 2.25% SP group (P<0.05). The best feed conversion ratio was in the 2.25% SP group (P<0.05). Table 3 presents the effects of adding spirulina to the diets of breeder Japanese quails on egg quality parameters, including yolk L*, a*, and b* values. The effect of spirulina supplements on breeder Japanese quail diets on eggshell thickness, eggshell weight, eggshell ratio, yolk index, and Haugh Unit were not statistically significant. Table 4 presents the outcomes of incorporating spirulina into the diets of breeder quails, and its effect on the incubation parameters. There were no significant differences observed in the incubation parameters, including chick's weight, hatchability, and fertility, between the treatment groups (P>0.05), indicating that the treatment did not have a significant impact on these parameters.

Table 2. The effect of dietary different levels of SP on the performance parameters of breeder quails

Parameters	Control	0.75%SP	1.5%SP	2.25%SP	P-Value
Live weight change (g)	12.79±1.72	15.38±1.35	14.54±1.47	10.62±0.84	0.106
Feed intake (g)	29.00±0.59[a]	27.68±0.42[ab]	27.45±0.42[ab]	27.05±0.84[b]	0.019
Feed conversion ratio	2.79±0.11[a]	2.59±0.14[ab]	2.47±0.08[ab]	2.34±0.07[b]	0.011
Egg production (%)	87.14±1.38	90.63±1.42	89.76±1.21	90.46±0.66	0.180
Egg weight (g)	12.00±0.20	11.92±0.47	12.46±0.31	12.34±0.25	0.593
Egg mass (g/quail/day)	10.46±0.30	10.79±0.44	11.18±0.36	11.15±0.22	0.414

[a, b]The differences indicated by different letters on the same row are statistically significant, P<0.05

Table 3. The effect of dietary different levels of SP on the egg quality, yolk L*, a* and b* values of breeder Japanese quails

Parameters	Control	0.75%SP	1.5%SP	2.25%SP	P-Value
Eggshell thickness(mm)	0.218±0.004	0.228±0.003	0.224±0.004	0.230±0.004	0.189
Eggshell weight (g)	0.97 ± 0.03	0.99 ± 0.04	1.00 ± 0.02	1.02 ± 0.02	0.703
Eggshell ratio (%)	8.07±0.14	8.32±0.17	8.06±0.16	8.26±0.15	0.542
Egg shape index(%)	77.08±0.86	75.44±0.64	76.89±0.49	75.16±1.14	0.263
Albumen index (%)	5.11±0.38	5.63±0.13	5.31±0.33	5.17±0.18	0.556
Yolk index (%)	47.06±1.27	47.34±0.48	46.29±1.08	47.90±1.18	0.750
Haugh Unit	90.39±1.11	91.20±0.45	90.63±1.19	90.36±0.45	0.896
L*	46.02±0.73[A]	45.37±0.50[AB]	43.13±0.24[B]	40.70±0.80[C]	0.000
a*	6.44±0.21[A]	6.80±0.23[A]	7.71±0.20[B]	7.88±0.21[B]	0.000
b*	25.57±0.50[A]	26.81±0.49[AB]	27.24±0.20[B]	28.81±0.62[B]	0.001

[A, B]The differences indicated by different letters on the same row are statistically significant, P<0.01

Table 4. The effect of dietary different levels of spirulina on incubation parameters of breeder Japanese quails.

Parameters	Control	0.75%SP	1.5%SP	2.25%SP	P-Value
Chick’s weight (g)	8.39±0.18	8.40±0.40	8.74±0.28	9.19±0.26	0.199
Hatchability of fertile eggs (%)	95.00±3.42	96.30±2.34	91.30±3.36	96.30±2.34	0.587
Fertility (%)	93.33±3.33	91.67±1.67	98.33±1.67	93.33±2.11	0.226
Hatchability of setting eggs (%)	88.33±3.07	88.33±3.07	90.00±4.47	90.00±3.65	0.975

4. Discussion

Numerous studies have shown that spirulina has an impact on poultry performance. It has been reported that diets containing Spirulina positively affect the production performance of laying poultry (Takashi, 2003; Nikodémusz et al., 2010). Similarly, adding spirulina has been reported to improve the FCR of laying hens (Kharde et al., 2012; Shanmugapriya et al., 2015). According to Mariey et al. (2012), adding 0.2 % spirulina to the laying hen feed improved FCR, EW, EM, EP, and FCR (P<0.05). It is similar to the results of the current study, but studies are reporting that adding spirulina to poultry diets does not affect performance data. Reportedly, the inclusion of spirulina in quail diets does not have any impact on their feed intake (Hajati and Zaghari, 2019; Omri et al., 2019). Zahroojian et al. (2013) stated that SP addition to laying hen diets had no statistically significant effect on EP, FI, FCR, and EW (P>0.05). Additionally, Hajati and Zaghari (2019) stated that SP did not affect FCR, EW, and EP. The reason for the differences in the results may be the amount of SP used the housing conditions of the animals, the animal species, the compositions of feed raw materials and production systems, etc.

Selim et al. (2018) conclusively demonstrated that the supplementation of spirulina (0, 0.1, 0.2, and 0.3%) to laying hen rations did not affect the shell percentage, albumen index, yolk index, shape index, and Haugh Unit. Similarly, studies are reporting that adding different amounts of spirulina to laying hen diets does not affect egg quality (Zahroojian et al., 2013; Curabay et al., 2021). The spirulina supplement to breeder quail diets decreased the L* value and increased the a* and b* values. A decrease in L* results in decreased brightness, while an increase in a* and b* leads to increased redness and yellowness. Egg yolks in laying hens supplemented with spirulina were reported to be redder and less yellow than the control group (P< 0.01) (Omri et al., 2019). The inclusion of 2.5% SP in the diet of quails resulted in an increase in the a* and b* values of the breast meat (Göçmen, 2022). Studies are reporting that adding SP to the diet increases the egg yolk score (Mariey et al., 2012; Selim et al., 2018). Spirulina's high carotenoids, including β-carotene, zeaxanthin, and xanthophylls, accumulate in the yolk, resulting in its characteristic color (Anderson et al., 1991; Takashi, 2003; Kotrbáček et al., 2013). Spirulina is a good source of xanthophyll for yolk (Ross and Dominy, 1990). According to Abouelezz (2017) report, adding 1% spirulina to the feed and 0.25% to the drinking water increased fertility in Japanese quails. The addition of up to 12% spirulina to Japanese quail diets positively affected fertility and hatchability (Ross and Dominy, 1990).

5. Conclusion

As a result, spirulina addition to breeder quail diets at 0 %, 0.75 %, 1.5 %, and 2.25 % levels did not affect EP, EW, and EM, but improved FI and FCR. There were no significant findings in regards to eggshell thickness, shell weight, shell ratio, yolk index, and Haugh Unit. None of these factors showed any significant variation or change. Egg yolk L* value decreased, and a* and b* values increased. Decreased feed intake as a result of the supplementation of spirulina to quail feeds in the experiment and improvement of FCR without affecting egg production are the desired changes in performance. The color of egg yolk is a parameter that affects consumer preference. The color of egg yolk can be altered by Spirulina, which is a natural feed additive. Further scientific research is required to establish the appropriate practices for incorporating spirulina into poultry nutrition.

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	B.D.	R.G.
C	20	80
D	20	80
S	20	80
DCP	60	40
DAI	50	50
L	80	20
W	60	40
CR	40	60
SR	50	50
PM	40	60
FA	50	50

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

In the year 2023, a research study was carried out at the Livestock Facilities of Selçuk University's Faculty of Agriculture. The authors declare that the study was carried out by the animal welfare rules specified in Article 9 of the Republic of Turkey Law No. 5996.

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