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Effects of Spirulina (Algae) supplementation to Japanese Quail (*Coturnix coturnix Japonica*) diets on growth performance and carcass traits

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ABSTRACT

This study was conducted to determine the effects of spirulina (*Sipurulina platensis*) (SP) supplementation to quail ration on bird live weights, change in live weight, feed consumption, feed conversion ratio, carcass yield and serum biochemical parameters. A total of 220 Japanese quail chicks (*Coturnix coturnix japonica*) were used in experiments. There were 4 treatment groups including a control group with 55 birds in each group. Each group was divided into 5 sub-groups with 11 birds in each. Experiments were conducted for 35 days. Control group was fed with a basal ration. Treatment groups were fed with spirulina-supplemented (1, 2 and 4%) rations. Spirulina supplementations had significant effects on live weights. However, differences in live weight gain, feed consumption, feed conversion ratio and carcass yields were not found to be significant. SP supplementation did not have significant effects on serum total cholesterol, glucose, protein, triglyceride and uric acid concentrations. Although different spirulina supplementations yielded similar growth performance and carcass traits with the control treatment, it can still be stated that such treatments slightly improved growth performance and carcass traits of quail.

Keywords: Carcass traits, Green algae, Japanese quail, Performance, Spirulina

Although high-cost rations prepared with quite expensive feed supplements to meet nutritional needs of the animals are scientifically valuable, they were not able to provide any economic gains since higher sums were paid per kg of meat, per liter of milk or per egg. In such cases, livestock production activities will not be economical since high-cost production is performed. Moving from that point on, it can be stated that animal production in essence is both a technical and an economic activity. On the other hand, the rations that are not able to meet nutritional needs of the animals are useless even if they are economic. They may negatively influence animal metabolisms, result in various diseases and ultimately reduce production quantities. Such cases in long run may also end up with death of animals and result in serious losses for the facility (Kýrkpýnar 2011). In previous studies, alternative feed crops and feed additives have been investigated both to increase profitability through reducing production costs and to preserve animal products with a great place in human and animal nutrition and to benefit from them at uppermost level (Çimrin and Tunca 2012).

Spirulina (blue-green alga) is a high-quality natural feed additive that can be used in animal and poultry nutrition (broiler, Japanese quail) (Shanmugapriya *et al.* 2015, Bonos *et al.* 2016, Farag *et al.* 2016, Aljumaily and Taha 2019). Zahroojian *et al.* (2013) observed that *Spirulina platensis* (SP) improved egg yolk colour due to its high carotenoids content. Abd El-Hady and El-Ghalid (2018) investigated the effects of dietary spirulina supplementation on body weight (BW) and body weight gain (BWG) of 480 broilers and reported 6% SP supplementation provided significant increases in final BW and BWG at 42 days of age ($P \leq 0.05$) as compared to 3% supplementation (5.45 and 6.19%) and control groups (5.89 and 6.76%). Selim *et al.* (2018) indicated that dietary supplementation of SP improved laying performance and egg quality of layer hens. Zaghari and Hajati (2018) recommended high levels of SP supplementation for improving the growth performance and immune responses of Japanese quail. The present study was conducted to investigate the effects of spirulina on performance and carcass traits of Japanese quails.

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MATERIALS AND METHODS

The experiment was carried out at the quail unit of Animal Science Department of Erciyes University between March–April 2017. This study was performed in accordance with the Animal Feed Legislation and The Animal Welfare Legislations of Turkey and no animals suffered in any of the applications.

Following hatching, quail chicks were supplied with sufficient heating and proper lighting and then included into the experiments.

Experimental diets included a basal diet (with no additive) and diets with 4 different SP levels (0, 1, 2 and 4% of the diet). Animals were fed with the experimental diets from 1 to 35 days of age. Experimental quail chicks were divided into 4 dietary treatment groups with similar mean live weights. Each treatment group (55 birds) was divided into 5 sub-groups with 11 birds in each. The cages were located in an environmentally-controlled room. Room temperature was maintained between 22–24°C and the lighting program was set at 16 h of light and 8 h of dark.

Composition of concentrate feed used in preparation of experimental rations and calculated chemical composition are provided in Table 1. Diets were composed of corn, soybean meal, corn gluten meal, vegetable oil, limestone, salt and supplements of vitamins and minerals. The feed supplied to quail contained 24% CP and 2,900 kcal/kg ME. Spirulina (*Sipurulina platensis*) was supplied from a commercial dealer. Supplements were ground to a powder form, homogeneously mixed into above-specified feeds and provided to animals *ad lib*. After drying and grounding, crude ash (CA), crude protein (CP) and ether extract (EE) content of SP was analyzed at Animal Science Laboratory of Erciyes University and dry matter (DM) ratio was identified as 91.3%, while CP, CA and EE contents were 29.75, 3.93 and 0.44% of DM, respectively.

Feed rations were equally placed in 5 kg plastic containers and feeds were added daily into the feeders in front of the animals. The feed remained in feeders, containers and over the ground were all weighed weekly and such quantities were then subtracted from the initial weights to determine feed consumptions. The body weight gain (BWG), feed consumption (FC) and feed conversion ratio (FCR) were calculated. The cumulative weight gain was divided by cumulative feed consumption to get cumulative feed conversion ratio.

Table 1. Ingredients and chemical composition of the experimental diets

Ingredient (%)	Composition
Corn	53.31
Soybean Meal	39.69
Corn Gluten	3.07
Vegetable Oil	1.00
Marble Powder	1.22
Dicalcium Phosphate	0.77
Lysine	0.06
Methionine	0.12
Vitamin-Mineral Premix*	0.50
Salt	0.25
*Calculated Nutrients***	
Metabolic Energy, Kcal/kg	2,900.00
Dry Matter (%)	89.07
Crude Protein (%)	24.00
Calcium (%)	0.81
Phosphorus (%)	0.30
Sodium (%)	0.12
Lysine (%)	1.30
Methionine + Cysteine (%)	0.89

*Vitamin-mineral premix is for per 2.5 kg: vitamin A, 12,500,000 IU; vitamin D_3, 3,000,000 IU; vitamin E, 20,000 mg; vitamin K_3, 3,000 mg; vitamin B_1, 2,500 mg; vitamin B_2, 7,000 mg; vitamin B_6, 5,000 mg; vitamin B_{12}, 20 mg; niacin, 20,000 mg; Cal-D-Pan, 15,000 mg; folic acid, 1,000 mg; biotin, 20 mg; vitamin C, 50,000 mg; choline chloride, 300,000 mg; manganese, 80,000 mg; iron, 70,000 mg; zinc, 50,000 mg; copper, 6,250 mg; iodine, 1,250 mg; cobalt, 200 mg; selenium, 150 mg; canthaxanthin, 0 mg; apo-carotenoic acid est., 0 mg; lasolosid sodium, 90,000 mg. **These values were calculated from the Tables in NRC.

At the end of the experiments, two quail (one male and one female) from each group were slaughtered, hot carcass weight and yield, hearth, liver and gizzard weights were determined with a digital scale (±0.01 g). Such weights were then proportioned to the final live weight (LW) to get internal organ, gizzard, hearth and liver ratios (g/LW at the end of experiments). Blood samples (10 ml) were taken from *Vena jugularis* of 2 quail in each cage (one male and one female) by using vacutainers containing EDTA, then centrifuged (NUVE NF400, Ankara, Turkey) at 4,000 rpm for 10 min and the sera were separated for laboratory analysis. Serum biochemical parameters (total cholesterol, glucose, total protein, triglyceride and uric acid) were analyzed with an automated biochemistry analyzer (AMS Vegasys, Rome, Italy) using commercial kits (AMS Diagnostics, Rome, Italy).

Statistical analyses: The experimental data were subjected to analysis of variance using General Linear Model procedure of SPSS computer software (IBM Corp., NY, USA), and means were separated using Duncan's Multiple Range Test. The results of the statistical analysis were presented as mean values and standard error of the means (SEM). Level of significance was considered as $P<0.05$.

RESULTS AND DISCUSSION

Live weight (LW) and change in live weight (CLW) parameters of experimental groups are provided in Table 2. As compared to control group, higher live weight gains were observed in experimental groups fed with spirulina-supplemented rations during the initial three weeks of the experiments ($P<0.05$). However, live weight gains of the fourth week were not significantly influenced by SP supplements ($P>0.05$). Live weights increased with increasing spirulina supplementation into the rations. The greatest live weight gain was observed in 4% SP supplemented group. Present findings comply with the findings of Kanagaraju and Omprakash (2016) reporting greater BW values for Japanese quails fed with a diet containing 1% SP. Present findings on live weight gains also comply with the findings of Cheong *et al.* (2015) and Sugiharto *et al.* (2018).

Live weight gain of spirulina-supplemented groups was quite high in the first week of the experiments ($P<0.05$). However, the changes in live weights in the second and third weeks were not found to be significant ($P>0.05$). In the fourth week of the experiments on the other hand, the greatest change in live weight was observed in control treatment ($P<0.05$). Similar with the present findings,

Table 2. Weekly live weights and change in live weights of treatment groups

Parameter	Treatment groups				MSE	P
	Control	1 SP (%)	2 SP (%)	4 SP (%)		
LW (g)						
Initial	33.71	33.49	33.47	33.73	0.177	0.130
1st week	67.60[c]	70.58[b]	71.74[ab]	73.96[a]	0.476	*<0.001*
2nd week	112.60[c]	115.94[bc]	116.82[ab]	119.94[a]	0.655	*0.001*
3rd week	145.81[b]	152.21[a]	154.00[a]	154.45[a]	0.862	*0.001*
4th week	174.27	177.24	179.97	181.35	1.541	0.378
CLW (g)						
1st week	33.88[b]	37.09[a]	38.27[a]	39.23[a]	0.472	*<0.001*
2nd week	45.00	45.36	45.18	45.99	0.718	0.967
3rd week	33.21	36.28	37.08	34.51	0.971	0.492
4th week	34.18[a]	22.05[b]	27.35[ab]	22.79[b]	1.676	*0.040*
General	140.56	143.75	146.51	146.63	1.544	0.464

[a–c], The means indicated with different letters in the same row are significantly different; SP, Spirulina; LW, Live weight; CLW, Change in live weight; MSE, Mean standard error; P, Probability.

Table 3. Weekly and cumulative feed consumptions and feed conversion ratios of treatment groups

Parameter	Treatment groups				MSE	P
	Control	1 SP (%)	2 SP (%)	4 SP (%)		
Weekly FC (g)						
1st week	81.02	78.66	76.32	83.24	1.334	0.305
2nd week	129.62	129.74	137.46	136.46	1.736	0.223
3rd week	164.14	166.56	165.88	163.52	2.201	0.964
4th week	172.60	167.32	177.10	169.48	1.769	0.236
Cumulative FC (g)						
1st week	81.02	78.66	76.32	83.24	1.334	0.305
2nd week	210.62	208.42	213.80	219.70	2.310	0.358
3rd week	374.78	374.96	379.66	383.22	3.150	0.772
4th week	547.38	542.30	556.76	552.76	3.756	0.584
FCR (g/g)						
1st week	2.46	2.13	2.03	2.13	0.073	0.177
2nd week	2.89	2.86	3.04	2.97	0.038	0.337
3rd week	4.96	4.59	4.48	4.74	0.072	0.085
4th week	6.16	6.85	7.11	6.50	0.293	0.720
General	4.12	4.11	4.16	4.09	0.075	0.987

SP, Spirulina; FC, Feed consumption; FCR, Feed conversion ratio; MSE, Mean standard error; P, Probability.

Abouelezz (2017) reported that BWG of Japanese quail increased significantly with the SP supplementation (1% and 2.5%). Previous studies also indicated that 4% SP supplementation did not have any negative impacts on growth performance of the animals (Ross and Dominy 1990, Venkataraman *et al.* 1994). In another study, Toyomizu *et al.* (2001) reported that 50–100 g/kg SP addition did not have significant effects on growth rate, but growth suppression was reported for supplementation ratios over 200 g/kg. Abd-El Hady and Ghalid (2018) reported significant effects of spirulina supplementation on body weight and body weight gain (P<0.05). Zaghari and Hajati (2018) reported greater BW gains with 5 g SP/kg supplementations into quail diets.

Weekly and cumulative feed consumptions (FC) and feed conversion ratio (FCR) values of experimental groups are provided in Table 3.

The differences in weekly and cumulative feed consumptions of the treatment groups were not found to be significant (P>0.05). Present findings were different from the results of earlier studies (Ross and Dominy 1990, Nikodémusz *et al.* 2010). Similar with the present findings, Kanagaraju and Omprakash (2016) reported smaller cumulative FC values for 1% spirulina-supplemented birds than the control birds. Abd El-Hady and El-Ghalid (2018) indicated that SP did not have any significant effects on feed consumption of quail.

The differences in weekly and overall feed conversion ratios were not found to be significant (P>0.05). El-Deek and Al-Harthi (2009) reported that brown algae of *Sargassum* spp. did not have any negative impacts on feed conversion ratios. Some other researchers indicated that spirulina supplementation increased feed conversion ratios (Ross and Dominy 1990, Nikodémusz *et al.* 2010, Dany 2014). Abd El-Hady and El-Ghalid (2018) reported that spirulina supplementation had significant effects on feed conversion ratio of quail (P<0.05). Contrary to present findings, Nikodémusz *et al.* (2010) reported different feed conversion ratios for experimental groups. Slaughter, carcass and serum biochemical parameters of experimental groups are provided in Table 4.

In general, SP supplementations did not significantly influence carcass parameters (P>0.05). It was also indicated in earlier studies that spirulina supplementation did not have significant effects on carcass and slaughter parameters (Toyomizu *et al.* 2000, El-Deek and Brikaa 2009). It was reported in some other studies that spirulina supplementations increased carcass yields of broiler chicks and Japanese quail (Raju *et al.* 2004, Kaoud 2012, Mariey *et al.* 2014, Jamil *et al.* 2015). SP treatments on the other hand significantly affected hot-cold carcass losses (P<0.05). Zaghari and Hajati (2018) also indicated that SP supplementations did not have significant effects on carcass yield of quail as compared to the control group. Similar to present findings, Cheong *et al.* (2015) also reported insignificant effects of SP on carcass yield and breast percentage.

The effects of SP supplementations on serum biochemical parameters are provided in Table 4. The differences in serum biochemical parameters of treatment groups were not found to be significant (P>0.05). Present findings were similar with the results of Sugiharto *et al.* (2018) reported for SP supplementations to broiler rations. According to Zaghari and Hayati (2018), SP yielded lower cholesterol levels. Mahmoud *et al.* (2015) reported significant reduction of cholesterol and triglyceride concentration with spirulina supplementations into broiler diets.

Table 4. Slaughter, carcass and serum biochemical parameters of treatment groups

Parameter	Treatment groups				MSE	P
	Control	1 SP (%)	2 SP (%)	4 SP (%)		
Slaughter and carcass parameters						
Pre-slaughter LW (g)	175.65	177.84	180.00	182.70	2.344	0.745
Hot carcass weight (g)	120.65	120.20	119.30	125.35	1.385	0.413
Cold carcass weight (g)	117.38	116.70	116.71	121.97	1.353	0.451
Hot carcass yield (%)	68.77	67.75	66.52	68.81	0.357	0.075
Cold carcass yield (%)	66.90	65.77	65.07	66.97	0.351	0.163
Hot-cold carcass loss (%)	2.72[a]	2.92[a]	2.18[b]	2.67[ab]	0.092	0.038
Serum biochemical parameters						
Total cholesterol (mg/dL)	238.81	267.40	250.30	256.53	7.550	0.597
Glucose (mg/dL)	358.10	345.55	341.60	361.00	5.622	0.561
Total protein (g/dL)	2.72	3.41	3.01	3.05	0.107	0.148
Triglyceride (mg/dL)	331.94	367.40	394.82	383.75	39.814	0.432
Uric acid (mg/dL)	6.03	5.80	5.58	6.96	0.260	0.270

[a, b], The means indicated with different letters in the same row are significantly different; SP, Spirulina; LW, Live weight; MSE, Mean standard error; P, Probability.

Present findings revealed that spirulina supplementation to quail rations increased live weight of the animals and did not have any toxic impacts on animals. It was observed in present study conducted with three different spirulina supplementation ratios to quail rations that supplementary substances did not have significant effects on feed consumptions, feed conversion ratios, carcass yields, internal organ weights, slaughter weights and serum biochemical parameters of quail. Such findings obtained for quail may also be valid for the other poultry. Therefore, further research is recommended to be done with other poultry species.

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