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Effects of Dietary Organic and Inorganic Chromium Supplementation on Performance, Egg Shell Quality and Serum Parameters in Pharaoh Quails

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ABSTRACT

This study was conducted to determine the effects of organic and inorganic chromium (Cr) supplementation on performance parameters, eggshell quality and some serum parameters of laying Pharaoh quails (Coturnix coturnix Pharaoh). Laying quails (n: 360; 59 days old) were randomly divided into three experimental groups each including 120 birds. Basal diet applied to control group was based on corn-soybean meal without additional organic or inorganic Cr. An amount of 100 ppm organic Cr (chromium picolinate) and 1000 ppm inorganic Cr (chromium chloride) were added to diets of group I and group II, respectively. All birds received feed and water *ad libitum* during the experiment which was lasted 8 weeks. In this study, it was found that organic and inorganic chromium supplementation cause an increase in eggshell thickness ($p< 0.01$) and eggshell breaking strength ($p< 0.001$). On the other side no significant effect was detected in feed consumption, feed efficiency, egg weight and egg production ($p> 0.05$). Serum cholesterol levels of birds were not affected both by organic and inorganic chromium supplementation. Contrary to these results, serum glucose levels were also significantly ($p<0.01$) increased in inorganic Cr supplemented group compared to control group. Serum glucose level was lower in organic Cr supplemented group than in inorganic Cr supplemented group. Serum total protein levels were significantly ($p< 0.01$) increased in group I (100 ppm organic Cr). In this study more satisfied results were obtained by Cr-picolinate supplementation. It can be due to the higher bioavailability of organic chromium sources than of inorganic sources. No side effect of chromium had been recorded at supplemented doses in experimental groups.

Key Words: Chromium, quail, performance, serum glucose level, eggshell quality, cholesterol.

INTRODUCTION

Chromium (Cr) has been known to be an essential micronutrient in human nutrition for a long time. Recent studies have pointed out the potential role of chromium on carbonhydrate metabolism. It is suggested that chromium affects insulin metabolism by increasing the number of insulin receptor molecules as well as contribute to adjust blood glucose level. Chromium acts by improving insulin functions directing normalization of blood glucose level. Improved chromium supplementation also leads to increase in insulin binding and activation of insulin receptor kinase leading to increased insulin sensitivity (Anderson 1998). In recent years, there is considerable research attention on the utilization of Cr in animal feed. The beneficial effects of Cr in human health were well documented for its role as an integral component of the glucose tolerance factor (GTF), which potentiate the action of insulin. Trivalent chromium (Cr^{+3}), the form of Cr found in foods and food supplements, is considered to be one of the least toxic nutritional elements. Trivalent chromium is the form of Cr that is associated with glucose metabolism and utilized within the body to form GTF (Holdsworth and Neville 1990). Cr^{3+} can be combined with both inorganic and organic components, but organic Cr as either GTF or Cr picolinate seems to be the most bioavailable (Piva et al. 2003). One of its main functions is activation of certain enzymes, most of which are involved in the production of energy from carbohydrates, fats and proteins. The other important function is stimulation of fatty acid and cholesterol synthesis in the liver (Sahin et al. 2002). Cr is not currently considered as an essential trace element for poultry, but it is thought that this micronutrient may play a nutritional and physiological role. The National Research Council (NRC) recommends an amount of 300 µg/kg Cr for the diets of laboratory animals (NRC 1997). But, there are no NRC recommendations for Cr in poultry diets (Sands and Smith 2002). As some other minerals, Cr can also be supplemented to reduce the negative effects of environmental stress. Additionally, it may prove beneficial effects on birds under heat stress. An interest on the use of chromium in poultry nutrition was increased when Jensen et al. (1978) reported its favorable effects on albumen quality (Haugh Unit Score).

Most of the current poultry diets are basically composed of ingredients from plant origin, which are usually poor in Cr. There is a little information available on the effects of organic and inorganic Cr on performance and serum parameters of laying quails. Thus, the aim of this study was to investigate the effects

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of dietary organic and inorganic Cr supplementation on the performance, egg shell quality and some serum parameters in laying quails.

MATERIALS AND METHODS

Animals, diets and experimental design

A total of 360 female Pharaoh quails 59 day old were randomly selected from a large flock. They were housed in cages (100cm wide, 45cm depth, 21cm high at front and 17cm high at the rear) and allocated randomly to three groups of dietary treatments (120 birds in each). Each treatment comprised six replicates of twenty quails.

Quail house was provided with programmable lighting and ventilation (22 ^{o}C, 70% relative humidity and 16/8 h of light/dark circle). Feed and water were provided *ad libitum*. The experimental period was 8 weeks. Ingredients and chemical composition of the basal diet is given in Table 1. The diets were formulated to be isocaloric and isonitrogenous as meet to NRC guidelines (NRC, 1994) for nutrient requirements for quail. Laying quails (control group) were fed with a basal diet containing 18% crude protein and 2800 kcal/kg metabolizable energy without additional Cr. Chromium picolinate and chromium chloride were used as organic and inorganic source of Cr, respectively. In experimental groups, 100 ppm organic Cr (chromium picolinate) was added to diet of group I and 1000 ppm inorganic Cr (chromium chloride) to diet of group II.

Table 1. Ingredients and chemical composition of the basal diet

Ingredients	**%**
Yellow maize	63
Soybean meal	24
Sunflower meal	3
Limestone	7.4
Dicalcium phosphate	1.5
Vitamin-Mineral premix*	0.40
Methionine	0.20
L-Lysine HCl	0.15
Salt	0.35
Chemical Analysis(dry matter basis)**	
Crude protein,%	17.98
Metabolizable energy, kcal/kg***	2810
Calcium,	3.67
Available phosphorus, %	0.76

*: Provided by per kg of diet: vitamin A, 12 500 IU; vitamin D3, 2500 IU; vitamin E, 30 mg; vitamin K3, 2 mg; vitamin B1, 2 mg; vitamin B2, 5 mg; niacin, 20 mg; vitamin B6, 3 mg; vitamin B12, 0.015 mg; folic acid, 1 mg; biotin, 0.045 mg; ascorbic acid, 50 mg; apocarotenoic acid ester, 0.5 mg; choline chloride, 125 mg; manganese, 80 mg; iron, 60 mg; Zinc, 50 mg; copper, 5 mg; cobalt, 0.2 mg; iodine, 1 mg; selenium, 0.10 mg.
**: Analyzed value
***: Calculated from the tabular values

Performance variables and egg shell quality

The quails were fed in groups and the mean feed consumption in the groups was recorded weekly. Eggs were collected daily and egg production was calculated on a quail-day basis. Feed efficiency was calculated as kg of feed intake for kg of egg production at the end of the trial. Throughout the experiment, 18 eggs were collected from each group (three eggs from each replicate) at weekly intervals to determine egg traits. Eggs were weighed at weekly intervals after being stored at room temperature for 24 hours and their masses were measured. Shell thickness (without inner and outer shell membranes which were manually removed) was measured at three areas (broad end, middle portion and narrow end of the shell), by using a micrometer (Mitutuyo Corporation, 0.01-20 mm, Kawasaki, Japan) (Wells 1968). The egg shell breaking strength was measured using a cantilever system by applying increased pressure to the broad pole of the shell (Balnave and Muheereza 1997) and recorded as Newton (N) force required to crack the shell surface.

Sample collection and laboratory analysis

On the last day of the trial, 2 quails randomly selected from each replicate group were slaughtered and blood samples were obtained by heart puncture for determining serum parameters of glucose, cholesterol and total protein. Blood serum was separated by centrifugation at 1800 x g for 10 minutes; sera were collected and subsequently analyzed for serum cholesterol, total protein and glucose level by a biochemical analyzer (Architect- c8000- Autolab Analyzer). Chemical analysis of the diet was conducted using AOAC procedures (AOAC 1984).

Statistical analysis

Statistical analyses were performed using SPSS for windows (SPSS, Inc., Chicago, IL, USA). Analysis of variance was used to evaluate the effects of organic and inorganic chromium on performance, egg traits and blood parameters of laying quails. The significance of mean differences was tested by Duncan means separation when the significance of diet effect was < 0.05 (Dawson and Trapp 2001).

Results and Discussion

In the present study, chromium supplementation by chromium picolinate and chromium chloride was determined to improve the performance variables including feed intake, feed efficiency, egg production, egg weight as well as egg quality parameters (eggshell thickness and eggshell breaking strength) in laying Pharaoh quails reared under normal climate conditions. The effects of chromium on the performance and egg traits of laying quails are shown in Table 2. Data on the level of serum parameters are in Table 3.

Table 2. Mean performance and eggshell quality parameters of laying quails supplemented with organic and inorganic chromium

Parameters		*Control*		*Organic chromium (100 ppm)*		*Inorganic chromium (1000 ppm)*		
	n	x	±Sx	x	±Sx	x	±Sx	P
Feed consumption, *(g/day)*	6	37.24	0.84	37.84	1.06	36.76	0.50	-
Egg production, *(%)*	6	78.75	0.89	81.36	1.44	81.52	0.97	-
Feed efficiency, *(kg feed consumption/kg egg production)*	6	4.06	0.14	3.96	0.15	3.83	0.007	-
Egg weight, *(g)*	72	11.70	0.11	11.71	0.006	11.94	0.009	-
Eggshell thickness, *(mm x*10^{-2}*)*	18	17.73	0.15^b	18.39	0.14^a	18.33	0.12^a	*
Eggshell breaking strength, *(N)*	18	10.82	0.20^b	12.47	0.30^a	11.99	0.19^a	**

a-b : The mean values within the same row with different superscript differ significantly; *: p< 0.05 **: p< 0.01

Table 3. Mean serum parameters values of laying quails supplemented with organic and inorganic chromium

Parameters		***Control***		***Organic chromium (100 ppm)***		***Inorganic chromium (1000 ppm)***		
	n	**x**	**±Sx**	**x**	**±Sx**	**x**	**±Sx**	**P**
Cholesterol, ***mg/dL***	12	332.50	15.71	319.16	20.21	302.16	12.77	-
Glucose, ***mg/dL***	12	275.25	4.58^b	271.66	2.42^b	305.33	14.05^a	*
Total protein, ***g/dL***	12	5.75	0.25^b	7.19	0.38^a	5.81	0.31^b	*

a-b : The mean values within the same row with different superscript differ significantly; *: p< 0.05

Feed consumption, egg production, feed efficiency and egg weight were not significantly (p> 0.05) affected by dietary treatments over the 8 weeks period. The beneficial effects of Cr supplementation on performance parameters in some poultry species are documented. Sahin et al. (2002) reported that feeding 200-1200 ppb Cr- picolinate improved body weight, feed efficiency, feed consumption and egg production of laying quails under heat stress condition. Kim et al. (1997) defined that supplementing 800 ppb Cr from Cr picolinate to laying hen diets resulted in higher egg production and egg weight. Liu et al (1999) also reported that 10 ppm Cr addition enhanced egg production and egg weight of layer hens. Lien et al (1999) detected that 1600 ppb or 3200 ppb chromium picolinate supplementation into broiler breeders' diet increased feed intake and improved weight gain, but egg production and egg weight were not affected. Sands and Smith (1999) also reported that dietary chromium picolinate supplementation increased growth rate without affecting feed intake in broilers. Steele and Rosebrough (1981) reported that addition of 20 ppm chromium chloride as an inorganic Cr source increased weight gains of turkey poults. Accordingly in laying hens, Sahin et al (2001) determined that 400 ppb of dietary Cr picolinate supplementation increased egg production at a low ambient temperature (6.9^{o}C).

In present study, although the performance parameters (feed intake, feed efficiency, egg weight) were not significantly affected, Cr supplementation (particularly organic Cr) created a positive effect on those of parameters of laying quails. Similar results, indicating the increase in egg production rate of laying quails were previously obtained by 1200 ppb (4) and 1000 ppb (19) dietary Cr-picolinate supplementation.

In this study, eggshell thickness and egg breaking strength was significantly affected by organic and inorganic chromium supplementation. Kucukersan et al (2005) found that 20 ppm organic chromium and 250 ppm Vitamin E supplementation increased the egg weight and egg shell thickness in 40 weeks old laying hens. The data obtained in this study is agree with the results of other studies on laying Japanese quail (Sahin et al. 2001; 2002) and laying hens (Lien et al. 1999, Uyanık et al. 2002, Yıldız et al. 2004). In brief, these studies reported that addition of chromium to the ration creates an increase statistically significant or not on eggshell thickness and eggshell breaking strength. Positive effects on performance parameters can be related to role of chromium as an integral component of the glucose tolerance factor (GTF), which potentiates the action of insulin, one of the most important anabolic hormones (Anderson 1987, Holdsworth and Neville 1990). Due to insulin, glucose can be utilized by body cells and adequate amino acids enter the cells therefore muscle can be built (Hossain et al. 1998). There was no mortality shown during this experiment. There is also no published data about the effects of dietary chromium supplementation on animal mortality.

The effects of organic and inorganic chromium supplementation on serum parameters of laying quails are shown in Table 3. Biochemical analysis performed in this study showed that serum glucose ($p < 0.01$) and serum total protein ($p < 0.01$) values were significantly affected by chromium supplementation while there was not important change in serum cholesterol levels. Previous studies (Sand and Smith 2002, Uyanık et al 2002, Yıldız et al. 2004) reported that Cr supplementation may lead to decrease in serum cholesterol concentrations in Japanese quails and laying hens. In present experiment serum glucose values were decreased in organic chromium supplemented group ($p<0.01$) while there was a significant increase in inorganic chromium supplemented group. This data are in accordance with some previous studies (Lien et al. 1999, Sahin et al. 2001, Uyanık et al. 2002, Yıldız et al.2004) which reported decrease in serum glucose level in broiler chickens, laying hens and Japanese quails by dietary addition of Cr-picolinate. Chromium is generally accepted as the active component in the glucose tolerance factor (GTF), which increases the sensitivity of tissue receptors to insulin, resulting in increased glucose uptake by cells. Moreover insulin regulates carbohydrate and fat metabolism and protein synthesis as well as glucose utilization in tissues. Thus the decrease in serum glucose concentrations may be a result of enhanced sensitivity of tissue receptors to the insulin directed by chromium supplementation. This mechanism may influence the feed consumption and egg production. In this study, serum total protein level showed important ($p < 0.01$) increase in experimental groups. In particular, the highest increase was defined in group I (100 ppm Cr-picolinate). Accordant results were previously obtained by laying Japanese quail (Şahin et al. 2001, Yıldız et al. 2004).

In conclusion, in present study both organic and inorganic chromium sources were supplemented to quail diets in concentrations higher than tried in previous investigations. No side effect was recorded in experimental groups indicating well tolerance of used doses of chromium by quails and possibly by all the other poultries. Obtaining more satisfied results by Cr-picolinate might be related to higher bio-availability of organic chromium sources than of inorganic sources.

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