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Effect of Dietary Chromium Supplementation on Performance and Carcass Traits of Broiler Chicks

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Abstract: This study investigated the effect of dietary supplementation of chromium from chromium picolinate source on the performance, carcass traits of broilers. Three hundred sixty one day old commercial male broilers (Ross 308) were randomly allocated to one of 24 floor pens in a completely randomized design with six treatment and four replicate groups and fifteen chicks per each pen. Dietary treatments consisted of 0 (control), 400, 800, 1200, 1600 and 2000 µg Cr per kg of basal diet. Feed intake, body weight gain and feed conversion ratio were measured during 1 to 21, 21 to 42 and 1 to 42 days of age. At 42 days of age two birds from each pen were selected and after weighing slaughtered and dissected manually. Carcass yield, liver, abdominal fat, pancreas, thighs and breast weight declared as percentage of live body weight. The results showed that performance of broilers was not affected by dietary supplemental chromium. Also supplementation of broiler diet didn't influence carcass traits. Nevertheless there is a non significant increase in liver and pancreas weight while increasing the Cr content of the diet. It can be concluded that chromium content of the basal starter and finisher diet and drinking water is adequate to normal requirement of broilers under such experimental conditions and supplementing of Cr may not be essential.

Key words: Broiler chicken, chromium picolinate, performance, carcass traits

INTRODUCTION

Chromium (Cr) is a metallic element appraised to constitute about 1/3000 of the earths crust, which the ore Chromite ($FeOCr_2O_3$) is used as Cr source and with poor absorption, its been used as a marker for the passage of foods and nutrients through the gastrointestinal tract (McDowell, 1992). Reported values for feedstuffs range from 0.01 to 4.2 mg Cr/Kg DM, with cereals relatively poor and legumes relatively rich in Cr (Underwood and Suttle, 1999).

Desirable absorption, different tissue distribution and availability to the embryo are denominated for organically bound (Glucose Tolerance Factor) form of the Cr (Mertz and Roginski, 1971). The organic compound Glucose Tolerance Factor (GTF) is more active biologically (about 50 times) than inorganic Cr trivalent (Cr^{+3}), considering Cr hexavalent (Cr^{+6}), which is hardly ever found neither in animal tissue nor in plants body (McDowell, 1992).

Established data reveals that Cr hexavalent is inorganic and toxic, also it has poor absorption (0.5-3.0%), instead trivalent Cr is organic form with 25-30% bioavailability (Mowat, 1994). Cr is a necessary trace element in animal body (NRC, 1980) and its essentially for mammals was first proved by Schwartz and Mertz (1959), who demonstrated enhancements in glucose tolerance by means of supplements of trivalent Cr in rats.

Regarding metabolism numerous studies have validated prominent function of Cr in the metabolism of carbohydrates, lipids, proteins and nucleic acids (Steele and Rosebrough, 1981; Okada *et al.*, 1984; Anderson and Kozlovsky, 1985; McCarty, 1991), although potentiating the function of insulin via organometallic GTF molecule is the original function of Cr in the metabolism (Anderson, 1987; Sahin *et al.*, 2001; Pechova *et al.*, 2002; Sahin *et al.*, 2003). Presence of Cr in the GTF molecule caused Cr to be recognized as a GTF, which enhances metabolism of Glucose, intensifies glycogenesis from glucose and speeds up glucose transport (Rosebrough and Steele, 1981).

One of organic and low-toxic forms of trivalent Cr is Chromium Picolinate (CrPic) which can stimulate insulin activity (Evans, 1989; Evans and Bowman, 1992). Page (1991) showed that Cr involved in protein synthesis through its essentiality as a cofactor of insulin which can promote amino acid uptake into muscular cells. Enhancement in lipogenesis from glucose and lipid storage into liver and adipose tissues are associated with Cr functions (Steele and Rosebrough, 1979). Cr can increases High-Density Lipoproteins (HDL) and reduce lipid, Low-Density Lipoproteins (LDL), total cholesterol (Press *et al.*, 1990). Cr can also improve stress resistance and increases immune responses (Chang and Mowat, 1992). Favorable effects did not achieved in

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growth performance of broilers while diet supplemented with 20 mg/kg Cr chloride or 0.8 mg/kg CrPic (Cupo and Donaldson, 1987; Kim *et al.*, 1996a,b; Lien *et al.*, 1993). Positive effects was obtained when the supplemental Cr (CrPic form) concentration was increased to 1.6 to 3.2 mg/kg (Lien *et al.*, 1999). Reduced plasma cholesterol (Anderson, 1986; Press *et al.*, 1990; Boleman *et al.*, 1995; Lien *et al.*, 1998, 2001) and egg yolk cholesterol contents (Lien *et al.*, 1996) are some other mentioned effects of CrPic supplementation.

According to The National Research Councils (NRC) recommendation, the value of Cr supplementation is 300 microgram Cr per kg diet for laboratory animals (NRC, 1995) but there are no NRC recommendations for Cr in poultry diets (NRC, 1994).

In the present study, the effects of various dietary concentrations of CrPic on the growth performance, carcass characteristics of broiler chicks were investigated.

MATERIALS AND METHODS

Animals and diets and experimental design: Three hundred sixty one day old commercial male broiler (Ross 308) during the period from June 29 to July 10 (2011) were randomly allocated to one of 24 floor pens in a single brooder house with six treatment and four replicate groups and fifteen chicks per each pen.

Dietary treatments consisted of 0 (control), 400, 800, 1200, 1600 and 2000 µg Cr/kg of basal diet. Initial body weight of each pen was recorded after weighing. All pens were equipped with feeders and waterers. The birds were fed by either a control diet or the control diet supplemented with Cr until the day of 21st as starter, followed by a finishing diet from the day of 21st to the day of 42nd. The ingredients and chemical composition of the starter and grower basal diets are shown in Table 1. The basal diets were prepared based on corn-soybean meal and formulated according to NRC (1994) guideline, contained 20.48-18.25% Crude Protein (CP) and 2850-2920 kcal/kg Metabolizable Energy (ME). The dietary treatments consisted of the supplementation of the basal diet with 0 (control), 400, 800, 1200, 1600, 2000 µg Cr per kg diet, supplied from chromium picolinate (CrPic: Assay 99.20% and Cr content 12.30%). CrPic was first mixed with specific amount of mineral premix and then blended with small amounts of basal diet, afterward larger amounts of basal diet were mixed until a homogeneous mixture of the diet was obtained. Experimental diets were provided *ad libitum*.

Sample collection and laboratory analysis: Feed consumption of each pen was recorded and on the 21st and 42nd day all chickens per pen were weight in groups. Body Weight Gain (BWG) and Feed Conversion Ratio (FCR) was calculated from obtained data. At the end of the experiment two chickens per each pen were chosen based on weight closeness to the mean of each pen as representative sample and were slaughtered after weighing. The carcasses were dissected manually and the following criteria were recorded: carcass yield, Breast meat weight, Thighs meat weight, pancreas weight, Liver weight and abdominal fat weight. These Criteria declared as percentage of live body weight.

Table 1: Composition of the basal diets

Ingredients	Starter (1-21)	Grower (22-42)
Corn	62.04	68.32
Soybean meal (44% CP)	34.33	28.15
Dicalcium Phosphate	1.42	1.20
Oyster Shell	1.25	1.44
Common Salt	0.30	0.30
Vitamin Premix[1]	0.25	0.25
Mineral Premix[2]	0.25	0.25
DL-Methionine	0.14	0.10
L-Lysin mono hydro chloride	0.02	0.00
Calculated value		
Metabolizable Energy (ME) (kcal/kg)	2850.00	2920.00
CP (%)	20.48	18.25
Calcium (%)	0.90	0.90
Available Phosphorus (%)	0.40	0.35
Sodium (%)	0.13	0.14
Chloride (%)	0.22	0.22
Potassium (%)	0.87	0.77
Chromium[3] (mg/kg)	0.041	0.036
Chromium content of drinking water[3] (ppm)	0.02	0.02
Methionine + Cysteine (%)	0.80	0.70
Lysine (%)	1.10	0.935
Tryptophan (%)	0.29	0.25

[1]Vitamin Premix provides the following per kg: Vitamine (Vit) A, 4800000 IU; Vit D, 1000000 IU; Vit E, 10000 IU; Vit K, 850 mg; thiamin (B1), 605 mg; riboflavine (B2), 2400 mg; panthothenic acid (B3), 3990 mg; nicotinic acid (B5), 13930 mg; Pyridoxine hydrochloride (B6), 121 mg; folic acid (B9), 1190 mg; cyanocobalamin (B12), 8 mg; biotin (H2), 80 mg; choline chloride, 120000 mg.

[2]Mineral premix provides the following per kg: manganese, 46.8 mg; iron, 14.8 mg; zinc, 27 mg; copper, 2.475 mg; iodine, 0.44 mg; selenium, 0.06 mg.

[3]Chromium content of the basal diet and drinking water was determined by atomic absorption spectrophotometry

Analyses of chromium in foods and water: Concentrations of Cr in the starter and the finisher foods also in water was determined by atomic absorption spectrometer with a graphite furnace (VARIAN spectrAA 220) according to the methodology suggested by the Perkin Elmer (1982) Inc., with some modifications. The samples of ground foods (5 g) were oven-dried and then de-carbonized in a glazed ceramic crucible at 180°C. The samples were then ignited in a muffle furnace at 400°C for 4 h. The ash (0.5 g) was treated with concentrated nitric acid under mild heat to oxidize the trivalent forms of Cr to the hexavalent (Cr VI) form, which could be detected more accurately. After complete digestion, the acid-extracted sample was cooled at room temperature and filtered through ash-lees Whatman filter paper (No. 1). The crucible was washed several times with triple distilled water and the final volume was made up to 10 ml. Subsequent analysis of Cr was done in the atomic absorption spectrophotometer. A 2% solution of ammonium chloride was added in both the standard and experimental samples to reduce interference caused by the presence of Fe in the samples.

Statistical analyses: General linear model of SAS statistical program (SAS, 1997) was used to identify the variance among groups. Significant differences between treatments means were examined with Duncan's new multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Effects of supplementary dietary Cr on performance of broilers summarized in Table 2. According to the result of this table, treatments contain various levels of supplementary Cr did not affect feed intake, weight gain and FCR of broilers in experimental periods. Numerically maximum amount of feed intake in 1 to 21 days of age attributed to 1600 µg Cr/kg treatment also in 21 to 42 and overall period 800 µg Cr/kg treatment had highest feed intake in compared to control group and other treatments. Regarding weight gain in 1 to 21 days of age the highest number is belonging to 2000 µg Cr/kg treatment, similarly in 21 to 42 and in overall experimental period treatment containing 400 µg Cr/kg diet had highest number in weight gain. Although the supplementary Cr statistically did not affect FCR but 2000 µg Cr/kg treatment in 1 to 21 days of age improved this parameter. Treatment with 400 µg Cr/kg diet had better FCR in 21 to 42 and overall experimental period.

There are contradictory reports concerning the effects of supplementary Cr on feed intake of broilers at normal rearing conditions. In general it is hypothesized that supplementation of Cr to the diet improves nutrient utilization such as carbohydrates and proteins by the role of Cr in increasing the sensitiveness of insulin receptors to insulin hormone (Mertz, 1969) and consequently increases the absorption of glucose by cells and considering that trivalent Cr is needed for proper metabolism of glucose in the body and the amount of Cr affects the ability of insulin in maintaining blood sugar levels (NRC, 1997) therefore by increasing levels of chromium in the diet, the metabolism of nutrients, including carbohydrates completely done and insulin hormone can also maintain blood sugar at longer time intervals. So it seems that by increasing dietary Cr levels in normal and in case there is no deficiency in Cr requirements decreases in feed intake is logical, while these effects were not observed in this study. The main reason could be due to the lack of need for additional chromium in normal rearing conditions and in states that there is not Cr deficiency in broilers. Amatya *et al.* (2004) studied the effect of different sources of chromium in broilers chicks and did not observed changes in feed intake. But Lien *et al.* (1999) reported increased levels of feed intake when dietary Cr supplemented at 1600 and 3200 micrograms of Cr per kg of diet.

With respect to weight gain and FCR in 1 to 21 days of age diet supplemented with 2000 µg Cr/kg also in 21 to 42 days of age and overall experimental period supplementation of 400 µg Cr/kg diet numerically had better responses. Increases in body weight gain in some treatments could be due to the chromium role in improving amino acid uptake by tissues and muscle cells and increases in protein retention in the body (Mertz and Roginski, 1969). In previous studies conducted with different sources of chromium including chromium picolinate (Lien *et al.*, 1999; Contreras *et al.*, 2000; Sahin *et al.*, 2002, 2005), also with organic chromium (Gursoy, 2000), increases in daily body weight gain of broilers was observed. Contrary to the above results, some researchers have not reported positive effect of chromium supplementation on daily body weight gain of broilers (Kim *et al.*, 1996b; Lee *et al.*, 2003; Debski *et al.*, 2004). Also Uyanik *et al.* (2002) used chromium chloride in the diet and did not observe effect on body weight gain of broiler chickens.

Table 2: Effect of supplemental chromium on performance of broilers at different period of ages

	Treatments (chromium levels) µg Cr/kg diet							
Performance	0 (control)	400	800	1200	1600	2000	SEM	p-value
Feed intake (g)								
1-21	1020.08	1014.09	991.00	1017.50	1036.20	1019.17	14.21	0.41
21-42	2921.60	2889.00	3044.80	2953.00	2914.30	2982.20	93.65	0.84
1-42	3941.70	3943.20	4035.80	3958.50	4002.70	4001.30	89.99	0.96
Body weight gain (g)								
1-21	632.50	617.15	622.53	614.28	624.01	642.62	8.90	0.27
21-42	1010.42	1297.92	1172.75	1181.87	1184.58	1282.17	57.33	0.50
1-42	1842.92	1931.86	1795.28	1792.77	1829.88	1924.78	54.67	0.31
Feed conversion ratio (FCR)								
1-21	1.61	1.64	1.59	1.65	1.66	1.58	0.026	0.24
21-42	2.42	2.24	2.59	2.51	2.46	2.35	0.13	0.74
1-42	2.14	2.04	2.24	2.21	2.18	2.08	0.07	0.42

Table 3: Effect of supplemental chromium on carcass traits of broilers at the end of experimental period

	Treatments (chromium levels) µg Cr/kg diet							
Carcass traits* (%)	0 (control)	400	800	1200	1600	2000	SEM	p-value
Carcass yield	63.90	64.40	63.10	64.96	63.60	63.30	0.47	0.12
Liver	2.08	2.10	2.28	2.46	2.31	2.50	0.14	0.25
Abdominal fat	1.92	1.67	2.01	1.98	1.93	1.96	0.20	0.88
Thighs meat	27.63	27.26	26.65	27.03	25.56	27.47	0.52	0.11
Breast meat	22.19	22.17	21.81	23.05	21.96	21.66	0.57	0.62
Pancreas	0.28	0.30	0.34	0.29	0.31	0.32	0.017	0.12

*Percentage of live body weight

Lien *et al.* (1999) fed broilers chromium picolinate at levels of 0, 800, 1600 and 3200 µg Cr/kg and reported no difference in feed conversion ratio. Amatya *et al.* (2004), Debski *et al.* (2004), Lee *et al.* (2003), Hossain *et al.* (1998) and Kim *et al.* (1996a,b) did not observe difference in feed conversion of broiler chicks fed with chromium supplements. Some researchers have reported improved feed conversion of broilers when using chromium supplements (Sahin *et al.*, 2002, 2003). In studies have been conducted with chromium picolinate (Sahin *et al.*, 2002, 2005), chromium chloride (Uyanik *et al.*, 2002; Ahmed *et al.*, 2005), chromium yeast (Hossain *et al.*, 1998), also studies with use of organic chromium (Gursoy, 2000) and study which was performed by Kroliczewska *et al.* (2004), all showed improvements in feed conversion.

Results of the average relative weight of some carcass characteristics in 42 days of age affected by diets containing different amounts of Cr showed in Table 3. As seen in this table percentage of carcass yield was not affected by treatments. In this factor the maximum and minimum number was respectively related to 1200 and 800 µg Cr/kg treatments. In general it can be concluded that the addition of chromium supplementation to broiler diet, did not affect net carcass yield. In confirmation of these results, Anandhi *et al.* (2006) applied different levels of organic Cr in broiler diet and found that there was no difference between different groups in carcass yield. However, previous studies conducted with different sources of Cr including Cr picolinate (Toghyani *et al.*, 2006; Sahin *et al.*, 2005), Cr yeast (Hossain *et al.*, 1998; Debski *et al.*, 2004) and also studies with use of organic Cr (Gursoy, 2000) all showed improvement in the carcass yield.

Addition of Cr to the broiler diet did not have significant effect on the liver, abdominal fat, thighs, breast and pancreas weight. There is a non significant increase in liver weight while increasing the Cr content of the diet. It can be concluded that, with increasing amounts of Cr and parallel to it increase in insulin hormone secretion and with regard to the insulin function which causes storage of glycogen and fatty acids in the liver, increase in liver weight was not far from expectation. There are conflicting reports about the effect of Cr on the liver weight in broiler chicks. Lien *et al.* (1999) did not observe effect of Crpic at levels of 1600 and 3200 µg Cr/kg on liver weight but they reported increases in liver weight while using 800 µg Cr/kg of diet. Sahin *et al.* (2002, 2003) were observed increased liver weight in broiler chickens fed with Cr picolinate at all levels. In other study which was conducted by Toghyani *et al.* (2006), using different levels of Cr picolinate in broiler diet under heat stress did not affect percentage of liver weight. In this study non significant effect of Cr supplementation on abdominal fat is in agreement with those of Lien *et al.* (1999), but is in incoherence with those of Ward *et al.* (1993), Hossain *et al.* (1998) and Sahin *et al.* (2003).

As remarked in liver weight, again there is a non significant increase in pancreas weight while increasing the Cr content of the diet. With insulin secretion from beta cells of the pancreas and the role of Cr in insulin activation and on the other hand significant effect of Cr supplementation on increase of insulin secretion it is not unexpected that the pancreas weight in treatments containing Cr should be higher in comparison with control group. The observed differences in the various studies about the percentage of carcass composition weight of broiler chickens fed with Cr supplementation could be due to the circumstances in which the broiler chicks raise types and levels of Cr supplements which is used and the amount and bioavailability of Cr in the basal diet.

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