Meat oxidative stability and growth performance of broilers fed diets supplemented with different levels of chromium picolinate

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The objectives of this study were to investigate the effects of different levels of chromium picolinate on broiler performance and lipid oxidation in their breast and thigh muscles stored chilled for different periods. Two hundreds and forty male broilers (Ross 308) allocated to four treatments in a completely randomized design. Treatments supplemented with 0 (control), 500, 1000 or 1500 ppb Cr in the form of chromium picolinate. Each treatment consisted of 4 pens with 15 birds in each pen. Birds were raised from 5 to 42 days of age. The experiment was conducted during summer and all birds kept under temperature of 33 ± 3 °C. Birds were fed ad libitum with a corn-soybean meal basal diet for starting (5-21d) and finishing (21-42d) periods. Feed intake and body weight were measured at 21 and 42 days of age. Twelve chicks from each treatment slaughtered at 42d, skinless and deboned breast and thigh meat were stored in refrigerator (4°C) during 2 and 6 days to measure meat stability using TBARS methods. Body weight of broilers fed supplemental chromium for 21 and 42 days increased significantly (P<0.05). Body weight gain and feed intake of broilers fed 1500 ppb Cr increased (P<0.01) at 5 to 21 and 5 to 42 days of age. No significant difference in feed conversion was observed. Tissue type (breast and thigh muscles) and storage time significantly influenced TBARs value (P<0.05). TBARs value (mg malonaldehyde/ kg meat) of thigh muscle in each storage time was higher than breast muscle (P<0.05). Overall TBARs values of the tissues, especially in thigh meat, significantly increased as their storage time increased from 2 to 6 days. It was also found that increasing dietary chromium supplementation, especially 1500 ppb Cr, significantly decreased lipid oxidation and TBARs value of thigh and breast muscle for 2d storage (P<0.05). On the 6th days of storage, dietary Cr supplement not significantly tended to decrease lipid oxidation of breast and thigh muscles. The results show that in heat stress condition, supplemental chromium especially 1500 ppb improved performance and oxidative stability of thigh and breast meat of broiler during refrigerated storage.

Key words: broiler; chromium picolinate; performance; lipid oxidation; heat stress

Introduction

Lipid oxidation is one of the most important mechanisms of quality loss and affect directly acceptability of meat and meat products by the consumers. High ambient temperature negatively influence meat quality and performance of broilers. Heat stress stimulates the release of corticosterone and catecholamines and initiates lipid peroxidation in cell membranes (Edens and Siegel, 1975). Lipid oxidation can be prevented by dietary antioxidant in poultry products (Morrissey et al., 1997)

One of the methods for alleviate the effect of high environmental temperature on the performance of broilers is dietary manipulations. In this respect, trivalent chromium is used in the poultry diet because of the reported benefits of chromium supplementation in broiler under heat stress (sahin *et al*., 2002, 2003), also because of the fact that stress condition increase chromium metabolisation from the

tissues that is irreversibly excreted through the urine (Borel *et al*., 1984; Mertz, 1992; Anderson,1994). Trivalent chromium is a well known essential trace element for human and animals (Schwartz and Mertz, 1959). Trivalent chromium improves insulin effectiveness by enhancing its binding to receptors and the sensitiveness of the target cell (Anderson,1997).This element is also involved in carbohydrate, lipid, protein and nucleic acid metabolic function (Steele and Rosebrough, 1981; Ohba *et al*., 1986; McCarty, 1991). Recent studies have shown that chromium has antioxidant properties (Sahin et al., 2003). Research on animals has confirmed that chromium from organic complex such as chromium picolinate, nicotinate and high chromium yeast is absorbed more efficiently, about 25-30 % more than inorganic compounds like chromium chloride (CrCl3), which are poorly absorbed (1-3 %) regardless of does or dietary chromium status (Underwood, 1999; Mowat, 1994; Olin *et al*.,1994).

The poultry diet may be deficient in chromium, because the chromium content of plant products is low (Giri *et al*. 1990). National Research Council (NRC, 1989) has recommended an intake of 50 to 200 ppb of trivalent chromium for adult humans. However, an appropriate recommendation on the chromium requirement of poultry has not been made (NRC, 1994,1997).

The objectives of this study were to investigate the effects of different levels of chromium picolinate in on broiler performance and lipid oxidation in their breast and thigh muscles stored chilled for different periods.

Materials and methods

Two hundreds and forty one-day-old male broiler chicks (Ross 308) purchased from a commercial supplier were used in this experiment. On day 5, the chicks were individually weighed and randomly allocated to four treatment groups. Four replicate groups of fifteen birds with similar average initial weight and weight range were assigned to each of four treatments. The dietary treatments consisted of the basal diet supplemented with 0 (control), 500, 1000 and 1500 micro gram of Cr/kg of diet from chromium picolinate (contain 12.27% Cr). Respective amounts of chromium were first blended thoroughly with 10 g dicalcium phosphate in a mechanical blender, then was mixed with small amounts of the basal diets, after it with a larger amount of the basal diet until the total amount of the respective diets were homogeneously mixed. The birds were fed a maize-soybean meal starter diets until 21 d of age followed by a finishing diet from day 21 to day 42. Ingredients and chemical composition of the starter and finisher basal diets are shown in Table 1. The basal diets were formulated to meet or exceed the nutrient requirements of broiler chickens (NRC, 1994). Chromium contents were 3.45 and 3.49 ppm in starting and finishing basal diets, respectively, as measured by atomic absorption spectrometer with a graphite furnace (Perkin-Elmer, AAnalyst 600, USA).The diets and fresh water were provided *ad libitum*. Birds were kept in floor pens. During the experiment, house's temperature was measured four times a day (0600, 1200, 1800, and 2400). The mean value of daily temperature in the house was 33 ± 3 °C. The experiment was conducted between July 11th to Aug 20th.

Body weight was determined at 21 and 42 days of age. Feed consumption, weight gain and feed conversion were measured in different periods. At 42 d of age 3 broilers from each pen (12 chicks per treatment) were slaughtered and skinless and deboned breast and thigh meat were minced. The ground muscles were stored at 4 °C for 2 or 6 days. The extent of lipid peroxidation after refrigerated storage (2 and 6 days) was assessed by measuring thiobarbioturic acid reactive substances (TBARS) using the method described by Strange et al. (1987). TBRAS concentrations were expressed as mg malonaldehyde/kg meat.

The experiment data were analyzed using SAS statistical program (SAS,1997). General linear model was used to analyze variance, and significant differences (P<0.05) among treatment means were determined using Duncan's new multiple range test.

Table 1: Composition of the basal diets

Ingredients (%)	Starter	Finisher
Corn	51.88	56.19
Soybean meal, CP 44%	39.8	34.6
Soybean oil	4.47	5.75
Dicalcium phosphate	1.56	1.18
Calcium carbonate	1.22	1.35
Salt	0.4	0.35
Vitamin premix [1]	0.25	0.25
Mineral premix [2]	0.25	0.25
DL-Methionine	0.17	0.08
Calculated composition		
Metabolizable energy (Kcal/Kg)	3050	3200
Crude protein (%)	21.92	20
Calcium (%)	0.953	0.9
Available phosphorus (%)	0.429	0.35
Methionine + Cystine (%)	0.858	0.72
Lysine (%)	1.205	1.077
Chromium analyzed(ppm)	3.45	3.96

1- Vitamin premix contains followings in 2.5 kg: vitamin A, 9000000 IU; vitamin D3, 2000000 IU; vitamin E, 18g; vitamin k3, 2g; thiamine 1.8 g; riboflavin, 6.6 g; panthothenic acid, 10 g;vitamin B6, 3 g; vitamin B12, 15 mg; niacin, 30 g; biotin, 100 mg;folic acid, 1g; choline chloride, 250 g; Antioxidant 100 g.
2- Mineral premix contains followings in 2.5 kg: manganese, 100 g; zinc, 100 g; iron, 50 g; copper, 10 g; Iodine 1g; selenium 200 mg

Results

The effects of supplemental chromium on performance of broilers are summarized in Table 2. Chromium supplementation significantly ($P<0.05$) increased body weight of broilers either for 21 and 42 days of age. Supplement of 1500 ppb Cr to broiler diets significantly increased feed consumption at 5 to 21 and 5 to 42 days of age ($P<0.05$). Weight gain was significantly ($P<0.05$) increased in Cr supplemental groups. Feed conversion of broilers was not affected by different levels of supplemental Cr ($P>0.05$).

Table 2: Effect of supplemental chromium on performance of broilers

	Control (C)	Chromium supplemented levels (ppb)			SE
		500	1000	1500	
Body weight (g)					
21 days	671^{b}	696^{a}	693^{a}	702^{a}	6.2
42 days	2170^{b}	2258^{a}	2243^{a}	2263^{a}	24.2
Weight gain (g/d)					
5-21 days	37.8^{b}	39.1^{ab}	38.4^{ab}	39.4^{a}	.496
21-42 days	71.4^{b}	74.4^{a}	73.8^{a}	74.3^{a}	1.19
5-42 days	58.6^{b}	61^{a}	60.6^{a}	61.1^{a}	0.919
Feed intake (g/d)					
5-21 days	49.4^{b}	51.2^{ab}	51.1^{ab}	52.1^{a}	0.614
21-42 days	140.4	146.7	143	146	2.57
5-42 days	97.6^{b}	102.2^{ab}	100.3^{ab}	103.8^{a}	1.46
Feed : gain (g:g)					
5-21 days	1.31	1.31	1.33	1.32	0.025
21-42 days	1.97	1.97	1.94	1.96	0.057
5-42 days	1.66	1.67	1.65	1.70	0.041

$^{a-b}$ Means within the same row without common superscripts differ significantly ($P<0.05$).

Table 3 shows the effects of Cr supplementation on the lipid oxidation of thigh and breast meat . Tissue type (breast and thigh muscles) and storage time significantly influenced lipid oxidation ($P<0.05$). TBARs value or lipid oxidation (mg malonaldehyde/ kg meat) of thigh muscle in each storage time was higher than breast muscle ($P<0.05$). Overall TBARs values of the tissues, especially in thigh meat, significantly increased as their storage time increased from 2 to 6 days. It was also found that increasing dietary chromium supplementation, especially 1500 ppb Cr, significantly decreased lipid oxidation and TBARs value of thigh and breast muscle for 2d storage ($P<0.05$). On the 6^{th} days of storage, dietary Cr supplement not significantly tended to decrease lipid oxidation of breast and thigh muscles.

Table 3. Effects of chromium supplementation on the lipid oxidation of thigh and breast meat (mg malonaldehyde/kg meat) following different refrigerated storage

Treatments	Thigh		Breast	
	Day 2	Day 6	Day 2	Day 6
Control	0.860 a	1.46	0.492 a	0.438 ab
500 ppb Cr	0.558 b	1.45	0.326 b	0.442 ab
1000 ppb Cr	0.586 b	1.40	0.388 ab	0.529 a
1500 ppb Cr	0.552 b	1.31	0.318 b	0.413 b
SE	0.061	0.164	0.050	0.037

[a-b] Means within the same row without common superscripts differ significantly ($P<0.05$)

Discussion

In this study, supplemental chromium, particularly, at 1500 ppb of Cr from Cr picolinate increased body weight, weight gain and feed intake of broilers reared under heat stress condition (Table 2). It is well known that the growth rate and feed efficiency decrease when ambient temperature goes above the thermoneutral zone (Ensminger *et al.*, 1990) and decrease in growth rate was partly, the result of the decrease in feed intake (Hurwitz et al. 1980). In addition, stress increase chromium excretion (Anderson, 1994) and thus may exacerbate a marginal Cr deficiency or an increased Cr requirements. Similar to results of the present study, Sahin *et al*. (2002) reported that increase supplemental chromium (200, 400, 800 or 1200 µg/kg Cr picolinate) resulted in an increase in body weight, feed intake and feed efficiency in broilers reared under heat stress. Lien *et al*. (1999) reported that 1600 and 3200 µg/kg Cr picolinate supplementation in a broiler diets increased feed intake and improved live weight gain. Sahin *et al*.(2003) found that decrease in live weight gain and feed efficiency in broiler reared under heat stress was alleviated by dietary chromium and vitamin C supplementation.

The results of this study indicate that Cr supplementation decreased lipid oxidation of thigh and breast meat in two day storage time (Table 3). It is well known that Cr plays an important role as integral component of the glucose tolerance factor (GTF), which potentiate the action of insulin, and regulate fat metabolism (Mertz, 1993). It has been well recognized that insulin metabolism influences lipid peroxidation (Gallaher *et al*., 1993). Chromium (insulin cofactor) is, therefore, postulated to function as an antioxidant (Preuss *et al*., 1997). According to antioxidant theory (Klasing, 1993)**,** when the concentrations of antioxidant vitamins (vitamin C and vitamin E) decrease, lipid peroxidation increases in the plasma and tissues, leading to damage of cell membranes. Sahin *et al*. (2003) reported supplemental chromium and vitamin C resulted in an increase in serum concentrations of vitamin C and vitamin E and decrease in malonaldehyde concentration in serum. Preuss *et al*. (1997) reported decreased hepatic TBARS formation upon supplementation of chromium picolinate and nicotinate in rats. Similarly, Anderson *et al*. (2001) also reported the potential beneficial antioxidant effects of the individual and combined supplementation of Cr and Zn (30 mg/d of Zn as Zn gluconate or 400 microg/d of Cr as Cr pidolate or combined Zn/Cr supplementation) in Tunisian adult subjects with type 2 diabetes mellitus for 6 months. Research on

chromium and it's effect on meat oxidative are very limited and it seems that present study is the first study about it.

In conclusion, the results of this study indicate that supplemental chromium picolinate, especially at level of 1500 ppb in heat stress condition, improved performance and oxidative stability of thigh and breast meat of broiler during refrigerated storage.

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