Improving the breast meat quality and carcass characteristics of heat-stressed broilers by feeding chromium supplementation

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In this experiment 240 one-day-old male broilers (Ross 308) in heat stress condition (33±3°C) were allocated to four treatments in a completely randomized design. Treatments were supplemented with 0 (control), 500, 1000 or 1500 ppb chromium (Cr) in the form of Cr nicotinate. Twelve chicks from each treatment were slaughtered at 42 d, carcass and abdominal fat pad were removed, and weighed. Breast meat was skinless, deboned and some muscles from the breast were immediately stored at −20 °C for assessing intramuscular fat and crude protein content, and others were stored individually in plastic bags at 4 °C in refrigerator for 2 and 6 days to measure malonaldehyde and tyrosine value as the indicator of lipid peroxidation (oxidative stability) and proteolysis, respectively. At 12 h after slaughter the breast muscle pH was determined. Chromium supplementation increased carcass yield and protein content of meat ($P<0.01$). Moisture, intramuscular fat content pH and meat proteolysis were not affected by supplemental Cr. Storage time increased lipid peroxidation and proteolysis of breast meat ($P<0.01$). Supplemental Cr decreased abdominal fat content and lipid oxidation of breast muscle for 2 days of storage ($P<0.05$).

Key words: broiler; heat stress; chromium; carcass characteristics; meat quality

Introduction

Heat stress has long been recognized as having a detrimental effect on broiler production efficiency and meat yield (Howlinder and Rose, 1989). Exposure to high ambient temperatures has been reported to cause undesirable changes in meat characteristics in broilers (Yunis and Cahaner, 1999; Yalcin et al., 2001). Trivalent chromium (Cr) is a well known essential trace element for human and animals (Schwartz and Mertz, 1959). Cr is a component of an oligopeptide low molecular-weight Cr-binding substance, chromodulin, functioning as a part of the insulin signalling auto-amplification mechanism (Vincent, 2000). This element is also involved in carbohydrate, lipid, protein and nucleic acid metabolic function (Ohba et al., 1986). Environmental stress increased urinary excretion of chromium (Anderson, 1994) and may exacerbate a marginal Cr deficiency.

Dietary Cr supplementation has been shown to positively affect meat quality (Amayta et al., 2004) and carcass traits (Debski et al., 2004) of broilers and pork quality (Mathewes et al., 2003). Nevertheless, recommendations regarding the dietary inclusion level of Cr in diets of livestock including poultry are yet to be finalized (NRC, 1994). Moreover, poultry diets are composed mostly of ingredients from plant origin, which are low in Cr (Giri et al., 1990).

The present experiment was conducted with broiler chickens receiving either no Cr supplementation or different levels of Cr nicotinate. The objective of this study was to assess the effects of these supplemental Cr on breast meat quality and carcass characteristics of broiler chicks reared under heat stress condition.

Materials and methods

Two hundred and forty one-day-old male broiler chicks (Ross 308) reared under heat stress condition. During the experiment, the mean value of daily temperature in the house was 33 ± 3 °C. Birds were randomly allotted to four treatments (four replicate pens of fifteen chicks in each treatment) in a completely randomized design. Broilers allowed *ad libitum* access to experimental diets and water. The dietary treatments consisted of the basal diet supplemented with 0 (control), 500, 1000 and 1500 micro gram of Cr/kg (ppb) of diet in the form of chromium nicotinate (contain 12.25% Cr). 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. The basal diets were formulated to meet or exceed the nutrient requirements of broilers by the National Research Council (1994). Chromium contents were 3.51 and 4.52 ppm in starting and finishing basal diets, respectively, as measured by atomic absorption spectrometer with a graphite furnace.

On day 42 of the trial, three broilers from each pen were selected according to average body weight within the pen following a 12-h fasting, were weighed individually, killed and carcass and abdominal fat removed, weighed and expressed as percentage of live weight. Some muscles from the breast were immediately stored at −20 °C for assessing crude fat and crude protein content, and others were stored individually in plastic bags at 4 °C in refrigerator for 2 and 6 days for analysis of meat proteolysis and lipid oxidation.

Moisture, intramuscular fat and crud protein were determined using the AOAC (1990) procedure. At 12 h after slaughter the breast and thigh muscle pH was measured with a digital pH meter after homogenization of 1 g of raw muscles for 30 s in 10 ml of 5 M iodoacetate (Korkeala et al., 1986). Lipid oxidation was monitored by measuring Thio Barbioturic Acid Reactive Substances (TBARS) using the method described by Strange et al. (1977). The extent of meat proteolysis was evaluated by measuring free tyrosine content following the method of Pearson (1968).

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.

Results

The effects of Cr supplementation on carcass yield and abdominal fat are shown in Table 1. Chromium supplementation increased significantly ($P<0.01$) carcass yield and decreased abdominal fat content of broiler chicks. Protein content in breast muscle of broilers received supplemental Cr significantly increased ($P<0.05$). Breast muscle pH values not significantly tended to increase in Cr supplemented groups. Moisture and intramuscular fat content of breast meat were not affected by Supplemental Cr.

Table 1. Effects of different levels of Cr nicotinate on the carcass characteristics and breast meat quality of broiler chicks

	Control	Chromium chloride (ppb)			SE
		500	1000	1500	
Carcass yield*	71.9 [b]	73.5 [a]	73.1 [a]	73.5 [a]	0.305
abdominal fat*	2.41 [a]	2.02 [b]	1.68 [c]	1.67 [c]	0.114
Moisture (%)	72.83	73.15	73.96	73.25	0.454
Protein (%)	20.72 [b]	23.5 [a]	22.58 [a]	23.08 [a]	0.379
Lipid (%)	0.994	1.18	1.09	1.21	0.268
pH	5.73	5.83	5.83	5.89	0.074

[a-b] Means within the same row without common superscripts differ significantly ($P<0.05$).
*: Percentage of live weight

Table 2 shows the effect of different levels of Cr nicotinate on the lipid oxidation and proteolysis of breast meat following different refrigerated storage. Storage time significantly influenced lipid oxidation and proteolysis of breast meat ($P<0.01$). TBARs value or lipid oxidation (mg

malonaldehyde/kg meat) and tyrosine value or proteolysis (mg tyrosine/kg meat) significantly increased as their storage time increased from 2 to 6 days. It was also found that increasing dietary chromium supplementation, especially 1000 and 1500 ppb Cr, significantly decreased lipid oxidation and TBARs value of breast muscle for 2 d storage ($P<0.05$). On the 6th days of storage, dietary Cr supplement not significantly tended to decrease lipid oxidation. Proteolysis of breast muscle was not affected by Supplemental Cr.

Table 2. Effects of different levels of Cr nicotinate on the lipid oxidation (mg malonaldehyde/kg meat) and proteolysis (mg tyrosine/kg meat) of breast meat following different refrigerated storage

Treatments	Lipid oxidation		Proteolysis	
	Day 2	Day 6	Day 2	Day 6
Control	0.492 [a]	0.563	153	246
500	0.356 [ab]	0.461	146	253
1000	0.264 [b]	0.442	157	246
1500	0.305 [b]	0.431	152	243
`SE	0.023	0.053	6.64	10.18

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

Discussion

The present study revealed that Cr supplementation increased carcass yield and protein content and decreased abdominal fat but intramuscular fat was not affected (*Table 1*). In accordance with our results, increasing carcass yield and decreasing abdominal fat content in broilers has been reported for diets supplemented with Cr (Sahin et al., 2002; Debski et al., 2004). However, results have been variable (NRC, 1997). In broiler chickens, supplementation of 100 to 400 ppb Cr increased carcass protein with a simultaneous reduction in the fat content of the carcass. Accretion of protein in the carcass was perhaps due to the potentiation of insulin action under the influence of Cr that might in turn have promoted the tissue uptake of protein (Kim et al., 1996).

The results of this study indicate that Cr supplementation decreased lipid oxidation of breast meat in two days storage time (*Table 2*). 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 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 in Tunisian adult subjects with type 2 diabetes mellitus for 6 months. Research on chromium and it effect on meat oxidative are very limited and it seems that present study is the first study about it.

From these results, it is concluded that supplemental Cr improved carcass traits and meat quality in terms of protein content and oxidative stability of breast meat in broiler chicks reared under heat stress condition.

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