

Effect of Dietary Chromium Yeast on Thigh Meat Quality of Broiler Chicks in Heat Stress Condition

Majid Toghyani^{1*}, Abbas Ali Gheisari², Ali Khodami³, Mehdi Toghyani³, Mohammad Mohammadrezaei³ and Ramin Bahadoran¹

Abstract—This experiment was conducted to investigate the effect of different levels of dietary chromium yeast (Cr-yeast) on thigh meat quality of broiler chicks reared under heat stress condition. Two hundred and forty Ross male chickens in heat stress condition (33±3°C) were allocated to five treatments in a completely randomized design. Treatments were supplemented with 0 (control), 200, 400, 800 and 1200 µg kg⁻¹ Cr in the form of Cr yeast. Twelve chicks from each treatment were slaughtered at 42 d, to evaluate moisture, protein, lipid, pH and lipid oxidation of thigh meat. Protein, moisture, lipid and pH of thigh meat were not affected by supplemental Cr. Thigh meat lipid tended to decrease in broilers received 1200 µg kg⁻¹. Storage time increased lipid oxidation of meat (P<0.01). Lipid oxidation of thigh muscle for two days of storage were affected by supplemental Cr and decreased (P<0.05). Results of this study showed that dietary Cr-yeast supplementation improved the thigh meat quality of broiler chicks in heat stress condition.

Keywords—Broiler, Heat stress, Chromium yeast, Thigh meat quality.

I. INTRODUCTION

HEAT stress has long been recognized as having a detrimental effect on broiler production efficiency and meat yield [1,2].

Exposure to high ambient temperatures has been reported to cause undesirable changes in meat characteristics in broilers [3,4,5]. Trivalent Cr is an essential element in the animal body [6] and is involved in carbohydrate, lipid, protein and nucleic acid metabolic functions [7]. Cr is also a cofactor of insulin, promoting insulin activity [8] and enhancing amino acid uptake into muscular cells for protein synthesis [9]. Stress increased urinary excretion of Cr and may exacerbate a marginal Cr deficiency [10,11]. Dietary Cr supplementation has been reported to have a positive effect on meat quality [12,13] and carcass traits of broiler chicks in natural [14,15] or heat stress condition [16].

The aim of this study was to investigate the effects of

^{1*} Corresponding Author: Majid Toghyani, Department of Animal Science, Islamic Azad University, Khorasgan (Isfahan) Branch, Isfahan, Iran, E-mail: toghyani@hotmail.com

² Department of Animal Science, Isfahan Agricultural Research Center, Isfahan, Iran.

³ Young Researchers Club, Islamic Azad University- Khorasgan Branch, Isfahan, Iran.

different levels of Cr-yeast on the thigh meat quality of broiler chicks in heat stress condition.

II. MATERIALS AND METHOD

Two hundred and forty one-day-old commercial Ross male chicks were reared under heat stress condition. During the experiment, the mean value of daily temperature in the house was kept 33 ± 3 °C. Birds were randomly allotted by body weight to one of five treatments (four replicate pens of twelve chicks per pen) in a completely randomized design. Broiler chicks were housed in floor pens. Chicks were maintained on a 23 h light and 1 h dark schedule and allowed ad libitum access to experimental diets and water. The dietary treatments consisted of the basal diet supplemented with 0 (control), 200, 400, 800 and 1200 µg kg⁻¹ Cr of diet in the form of Cr yeast (contain 1000 mg/kg Cr). The birds were fed a corn-soybean meal starter diets until 21 d of age followed by a finishing diet from 21 to 42 day. 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 broilers by the National Research Council [17]. Cr contents were 3.45 and 3.96 mg kg⁻¹ in starting and finishing basal diets, respectively, as measured by atomic absorption spectrometer with a graphite furnace (Perkin-Elmer, AAnalyst 600, USA).

On day 42 of the trial, three broiler chicks from each pen were selected according to average body weight within the pen following a 12-h fasting, were weighed individually, killed and eviscerated (abdominal fat pad, liver, intestines, proventriculus, gall bladder, spleen, oesophagus and full crop). Some thigh muscles were immediately stored at -20 °C for assessing crude fat and crude protein, and others were stored individually in plastic bags at 4 °C in refrigerator for 2 and 6 days for analysis of meat lipid oxidation.

In order to determine the moisture content, the sample (5 g) was dried at 105°C for 24 h [18].

Intramuscular fat content was determined according to the AOAC (1990) (Soxhlet procedure). The sample was dehydrated (2 g) and subjected for 75 min to a 40–60°C petroleum ether circuit at 80 °C [18].

The crud protein was determined following the Kjeldahl method. At 12 h after slaughter the thigh muscle pH was measured with a Knick digital pH meter (Broadly Corp., Santa

Ana, CA, USA) after homogenization of 1 g of raw muscles for 30 s in 10 ml of 5 M iodoacetate [19].

Lipid oxidation was monitored by measuring Thio Barbituric Acid Reactive Substances (TBARS) using the method described by Strange et al [20].

Data were analyzed by analysis of variance procedures appropriate for a completely randomized design using the GLM procedures of SAS [21]. Significant differences ($P < 0.05$) among treatment means were determined using Duncan's new multiple range test.

TABLE I
 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
<i>Calculated composition</i>		
Metabolizable energy (Kcal/Kg)	3050	3200
Crude protein (%)	21.92	20
Calcium (%)	0.953	0.9
Available phosphorus (%)	0.429	0.35
Methionine + Cysteine (%)	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; pantothenic 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

III. RESULTS AND DISCUSSION

Effects of Cr supplementation on moisture, intramuscular fat and protein of thigh meat are summarized in Table 2. Dietary Cr had no effect on moisture and intramuscular fat content ($P > 0.05$). However, fat content tended to decrease at level of 1200 $\mu\text{g Cr kg}^{-1}$. Protein content of thigh muscle was also higher but not significantly ($P > 0.05$) in Cr supplemented groups compared with birds receiving no Cr supplementation. These results were similar to observation of Mooney and Cromwell [22] when pigs were fed by Cr picolinate or Cr chloride, tissue fat and moisture were not affected. However, Kim et al [23] reported in broiler chicks, supplementing the Cr picolinate in the diets decreased fat content of the carcass. The Cr has been found to exert inhibitory effects on in vitro lipogenic activity in chick and pig adipose tissue [23,24]. However Lambert and Jacquemin [25] reported insulin inhibits gluconeogenesis and depresses adipocyte lipolysis by reducing the activities of adenylate cyclase and hormone-sensitive lipase.

In the present study Supplemental Cr tended to increased muscle protein. Amayta et al. [12] observed an increase of the protein level in muscles of broilers fed a diet supplemented

with Cr in the form of Cr chloride or Cr yeast. Samanta et al. [13] reported meat protein accretion improved in broiler fed organic Cr under heat stress condition. Also increasing in protein levels in the carcass and liver of broilers given Cr picolinate were observed [14,23]. Cr has been shown to potentiate insulin action by enhancing its binding to the target cell receptors and also by improving its post receptor signaling. Insulin is known as primary hormone regulating glucose cellular absorption and utilisation. In chickens, insulin is also known to increase the protein synthesis, efficiency of amino acid transport and diminished protein degradation rate [26,27]. The mechanism of insulin action on protein metabolism is not clarified yet, but it was shown by Bigot et al.[28] that S6K1 in chickens, known as potent regulator of protein synthesis in mammals, is activated by insulin. The present investigation revealed that the effects of organic Cr is more than inorganic on meat quality. It has been reported in swine that supplementation of organic Cr utilized more efficiently than inorganic Cr sources [22,29].

Thigh muscle pH was not significantly influenced by the supplemental Cr (Table 2). In agreement with our results, increasing in muscle pH was reported in broilers [12] and pigs [30] fed Cr. However, Matthews et al.[31] observed the pH of loin muscle 24 h after slaughter was not affected by Cr in pig. Stress before slaughter can lead to increased muscle glycogen breakdown and glycolysis after slaughter, and then the increased muscle lactic acid lowers the pH of meat. The mechanism of dietary Cr to influence pH of the muscle after slaughter could be explained by the roles of Cr to reduction the stress-induced catecholamine secretion [13,16] and then inhibited glycogen breakdown and glycolysis.

The effects of supplemental Cr on lipid oxidation of thigh muscle are presented in Table 3. The results of oxidative stability of thigh meat stored under refrigerated conditions show that oxidation occurred slowly and followed a linear increase in oxidation with length of storage. The thigh meat of birds fed the Cr showed a reduction ($P < 0.05$) of TBARS values after four days of storage, especially in Cr at level of 1200 $\mu\text{g kg}^{-1}$. Oxidation of lipids is a major cause of deterioration in the quality of meat and can directly affect many meat characteristics such as flavor, color, texture, nutritive value and safety of the meat [32]. The balance between antioxidants and prooxidants and the composition of skeletal muscle influences the susceptibility of muscle lipids to oxidation [33]. In the present study, lipid oxidation was affected by supplemental Cr (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 [34]. It has been well recognized that insulin metabolism influences lipid peroxidation [35]. Cr is insulin cofactor, therefore postulated to function as an antioxidant [36]. According to antioxidant theory [37] when the concentrations of antioxidant vitamins (vitamin C and E)

TABLE II
EFFECTS OF DIETARY CR-YEAST ON MOISTURE, PROTEIN, LIPID AND PH OF CHICKEN THIGH MEAT

Parameter	Cr-yeast ($\mu\text{g kg}^{-1}$)					Significance
	Control	200	400	800	1200	
Moisture (%)	73.2	73.1	72.9	74.4	73.6	NS
Protein (%)	17.27	18.56	18.83	18.05	18.68	NS
Lipid (%)	5.96	5.64	6.17	6.83	4.91	NS
pH	6.17	6.06	6.28	6.21	6.19	NS

NS: Not Significance ($P>0.05$)

TABLE III
EFFECTS OF DIETARY CR-YEAST ON THE LIPID OXIDATION OF CHICKEN THIGH MEAT (MG MALONALDEHYDE/KG MEAT) FOLLOWING DIFFERENT REFRIGERATED STORAGE

Lipid oxidation	Cr-yeast ($\mu\text{g kg}^{-1}$)					Significance
	Control	200	400	800	1200	
Day 2	0.935	0.673	0.642	0.593	0.725	*
Day 6	1.418	1.341	1.442	1.487	1.160	*

*: $P<0.05$

decrease, lipid peroxidation increases in the plasma and tissues, leading to damage of cell membranes. Sahin et al.[38] reported supplemental Cr resulted in an increase in serum concentrations of vitamin C and E and decrease in malonaldehyde concentration in serum of heat-stressed broiler chicks. Preuss et al.[36] reported decreased hepatic TBARS formation upon supplementation of Cr picolinate and nicotinate in rats. Similarly, Anderson et al.[39] 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. It seems, studies on Cr and its effect on meat oxidative are scarce. However, Sahin et al.[40] reported, when Japanese quails were fed by Cr picolinate, malondialdehyde (MDA) concentration in serum decreased.

It was concluded from the present study that, supplementing the Cr-yeast in the broiler diets, influence the thigh meat quality in term oxidative stability in broiler chicks reared under heat stress condition

REFERENCES

- [1] M. O. Smith, and G. Teeter, "Influence of feed intake and ambient temperature stress on the relative yield of broiler parts," *Nutr. Reports Int.*, vol. 35, pp. 299-306, 1987.
- [2] M. A. R. Howlinder, and S. P. Rose, "Rearing temperature and the meat yield of broilers," *Br. Poult. Sci.*, vol. 30, pp. 61-67, 1989.
- [3] M. Aksit, S. Yalcin, S. Ozkan, K. Metin and D. Ozdemir, "Effects of temperature during rearing and crating on stress parameters and meat quality of broilers," *Poult. Sci.*, vol. 85, pp. 1867-1874, 2006.
- [4] S. Yalcin, A. Onenc, S. Ozkan, H. C. Guler and P. B. Siegel, "Meat quality of heat stressed broilers: Effects of thermal conditioning at pre- and -postnatal stages," in: Proc. 17th European Symposium. *Quality of Poultry Meat*, The Netherlands, 2005, pp. 265.
- [5] R. Yunis, and A. Cahaner, "The effects of naked neck (Na) and frizzle (F) genes on growth and meat yields of broilers and their interactions with ambient temperatures and potential growth rate," *Poult. Sci.*, vol. 78, pp. 1347-1352, 1999.
- [6] National Research Council, *The Role of Chromium in Animal Nutrition*. National Academy Press, CA: Washington, DC, 1997.
- [7] R. A. Anderson, and A. S. Kozlovsky, "Chromium intake, absorption and excretion of subjects consuming self-selected diets," *Am. J. Clin. Nutr.*, vol. 41, pp. 1777, 1985.
- [8] M. F. McCarty, "Homologous physiological effects of phenformin and chromium picolinate," *Medical Hypotheses.*, vol. 41, pp. 316-324, 1993.
- [9] H. Ohba, Y. Suzuki and H. Ohba, "Enhancement of ribonucleic acid synthesis by chromium (III)-bound chromatin," *J. Inorg. Biochem.*, vol. 27, pp. 179-188, 1986.
- [10] J. S. Borel, T. C. Majerus, M. M. Polansky, P. B. Mozer and R. A. Anderson, "Chromium intake and urinary Cr excretion of trauma patients," *Biol. Trace. Element Res.*, vol. 6, pp. 317-326, 1984.
- [11] R. A. Anderson, N. A. Bryden, M. M. Polansky, and P. A. Deuster, "Exercise effects on chromium excretion of trained and untrained men consuming a constant diet," *J. Appl. Physiol.*, vol. 64, pp. 249-252, 1988.
- [12] J. L. Amatya, S. Haldar and K. Ghosh, "Effect of chromium supplementation from inorganic and organic sources on nutrient utilization, mineral metabolism and meat quality in broiler chicks exposed to natural heat stress," *Anim. Sci.*, vol. 97, pp. 241-253, 2004.
- [13] S. Samanta, S. Haldar, V. Bahadur and T. K. Ghosh, "Chromium picolinate can ameliorate the negative effects of heat stress and enhance performance, carcass and meat traits in broiler chickens by reducing the circulatory cortisol level," *J. Sci. Food Agric.*, vol. 88, pp. 787-796, 2008.
- [14] T. L. Ward, L. L. Southern and S. L. Boleman, "Effect of dietary chromium picolinate on growth, nitrogen balance and body composition of growing broiler chicks," *Poult. Sci.*, vol. 72 (supp. 1): 37(Abstr.). 1993.
- [15] B. Debski, W. Zalewski, M. A. Galak and T. Kosla, "Chromium yeast supplementation of broilers in an industrial farming system," *J. Trace Element Medicine Biol.*, vol. 18, pp. 47-51, 2004.
- [16] K. Sahin, N. Sahin, M. Onderci, F. Gursu and G. Cikim, "Optimal dietary concentration of chromium for alleviating the effect of heat stress on growth, carcass qualities and some serum metabolites of broiler chickens," *Biol. Trace Element Res.*, vol. 89, pp. 53-64, 2002.
- [17] National Research Council, *Nutrient Requirements of Poultry*. 9th rev. ed. National Academy Press, CA: Washington, DC, 1994.
- [18] AOAC, *Official Methods of Analysis*. 15th ed. Association of Official Analytical Chemists, CA: Arlington, Virginia, 1990.
- [19] H. Korkeala, O. Maki-Petais, T. Alanko and O. Sorvettula, "Determination of pH in meat," *Meat. Sci.*, vol. 18, pp. 21-125, 1986.
- [20] E. D. Strange, R. C. Benedict, J. L. Smith and C. E. Swift, "Evaluation of rapid tests for monitoring alterations in meat quality during storage," *I. Intact meat. J. Food Protec.*, vol. 40, pp. 843-847, 1977.
- [21] SAS Institute Inc, *SAS/STAT User's Guide*: Version 6.06th ed. SAS Institute Inc, Cary, CA: North Carolina, 1997.

- [22] K. W. Mooney, and G. L. Cromwel, "Efficacy of chromium picolinate and chromium chloride as potential carcass modifiers in swine," *J. Anim. Sci.*, vol. 75, pp. 2661–2671, 1997.
- [23] Y. H. Kim, I. K. Han, Y. J. Choi, I. S. Shin, B. J. Chae and T. H. Kang, "Effects of dietary levels of chromium picolinate on growth performance carcass quality and serum traits in broiler chicks," *Asian-Aust J. Anim. Sci.*, vol. 9, pp. 341-347, 1996.
- [24] J. K. Min, W. Y. Kim, B. J. Chae, I. B. Chung, I. S. Shin, Y. J. Choi and K. Han, "Effect of chromium picolinate on growth performance, carcass characteristics and serum traits in growing-finishing pigs," *Asian-Aust J. Anim. Sci.*, vol. 10, pp. 8-14, 1997.
- [25] B. Lambert, and C. Jacquemin, "Inhibition of epinephrine induced lipolysis in isolated white adipocytes of aging rabbits by increased alpha-adrenergic responsiveness," *J. Lipid Res.*, vol. 20, pp. 208–216, 1979.
- [26] M. Sakhari, M. K. Jeacock and D. A. Shepherd, "Regulation of intracellular protein degradation in the isolated perfused liver of the chicken (*Gallus domesticus*)," *Comp. Biochem. Physiol.*, vol. 101, pp. 17–21, 1992.
- [27] M. J. Duclos, B. Chevalier, C. Goddard and J. Simon, "Regulation of amino acid transport and protein metabolism in myotubes derived from chicken muscle satellite cells by insulin-like growth factor-I," *J. Cell Physiol.*, vol. 157, pp. 650–657, 1993.
- [28] K. Bigot, M. Taouis and S. Tesseraud, "Refeeding and insulin regulate S6K1 activity in chicken skeletal muscles," *J. Nutr.*, vol. 133, pp. 369–373, 2003.
- [29] T. G. Page, L. L. Southern, T. L. Ward and D. L. Thompson, "Effect of chromium picolinate on growth and serum and carcass traits of growing-finishing pigs," *J. Anim. Sci.*, vol. 71, pp. 65, 1993.
- [30] J. O. Matthews, A. C. Guzik, F. M. Le Mieux, L. L. Southern and T. D. Bidner, "Effects of chromium propionate on growth, carcass traits, and pork quality of growing-finishing pigs," *J. Anim. Sci.*, vol. 83, pp. 858–862, 2005.
- [31] J. O. Matthews, A. D. Higbie, L. L. Southern, D. F. Coombs, T. D. Bidner and R. L. Odgaard, "Effect of chromium propionate and metabolizable energy on growth, carcass traits, and pork quality of growing-finishing pigs," *J. Anim. Sci.*, vol. 81, pp. 191–196, 2003.
- [32] D. J. Buckley, P. A. Morrissey and J. I. Gray, "Influence of dietary vitamin E on the oxidative stability and quality of pig meat," *J. Anim. Sci.*, vol. 73, pp. 3122–3130, 1995.
- [33] C. Lauridsen, D. J. Buckley and P. A. Morrissey, "Influence of dietary fat and vitamin E supplementation on a-tocopherol levels and fatty acid profiles in chicken muscle membranous fractions and on susceptibility to lipid peroxidation," *Meat Sci.*, vol. 46, pp. 9–22, 1997.
- [34] W. Mertz, "Chromium in human nutrition: A review," *J. Nutr.*, vol. 123, pp. 626-633, 1993.
- [35] D. D. Gallaher, A. S. Csallany, D. W. Shoeman and J. M. Olson, "Diabetes increases excretion of urinary malondialdehyde conjugates in rats," *Lipids*, vol. 28, pp. 663–666, 1993.
- [36] H. G. Preuss, P. L. Grojec, S. Lieberman and R. A. Anderson, "Effects of different chromium compounds on blood pressure and lipid peroxidation in spontaneously hypertensive rats," *Clin. Nephrol.*, vol. 47, pp. 325–330, 1997.
- [37] K. C. Klasing, *Comparative Avian Nutrition*. University Press, CA: Cambridge, pp. 277–299, 1993.
- [38] K. Sahin, N. Sahin and O. Kucuka, "Effects of chromium and ascorbic acid supplementation on growth, carcass traits, serum metabolites, and antioxidant status of broiler chickens reared at a high ambient temperature," *Nutr. Res.*, vol. 23, pp. 225-238, 2003.
- [39] R. A. Anderson, A. M. Roussel, N. Zouari, S. Majhoub, J. M. Matheau and A. Kerkeni, "Potential antioxidant effects of zinc and chromium supplementation in people with type 2 diabetes mellitus," *J. Am. College Nutr.*, vol. 20, pp. 212–218, 2001.
- [40] N. Sahin, K. Sahin, M. Onderci, M. Ozcelik and M. O. Smith, "In vivo antioxidant properties of vitamin E and chromium in cold-stress Japanese quails," *Arch. Anim. Nutr.*, vol. 57, pp. 207-215, 2003.