Effects of Dietary Chromium Picolinate and Yeast Chromium on the Growth and Carcass Fat of Broilers

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(Received August 12, 1997)

Abstract Effects of two organic chromium (Cr), Cr picolinate and yeast Cr, on the growth and carcass quality of broilers were studied. One-week-old female Arbor Acres broiler chicks were group-fed a commercial diet for 7 days. After then, they were divided into five dietary groups of 20 chicks each, and supplied the experimental diets containing 21.5% crude protein (CP) and 3.10 kcal ME/g for 14 days, and then 18.3% CP and 3.20 kcal ME/g for 21 days. To above two basal diets 0, 200 or 400 ppb of Cr derived from Cr picolinate and yeast Cr were added. Body weight gain and feed intake were recorded weekly. At the end of the trial, chicks were sacrificed to determine abdominal fat and contents of crude fat, CP and moisture in the skin-off breast meat and skin-on drumsticks meat. Feed intake and body weight gain tended to decrease in the all of Cr supplemented diet groups, and yeast Cr (400 ppb) significantly suppressed weight gain ($P < 0.05$). Yeast Cr tended to have a greater negative effect on the body weight gain and feed intake than Cr picolinate. The abdominal fat, CP and moisture in the skin-on drumsticks meat and skin-off breast meat were not influenced by the dietary Cr levels. The crude fat in the skin-on drumsticks meat was not affected by dietary Cr levels, but that in the skin-off breast meat decreased proportionally with increasing Cr levels.

Anim. Sci. Technol. (Jpn.) 69 (3) : 247-252, 1998

Key words : Broiler chicks, Chromium picolinate, Depression of carcass fat, Growth, Yeast chromium

Excess chromium (Cr, more than 300 ppm) is toxic for chicken⁹, and there are no reports observed Cr deficiency in poultry. Therefore, Cr is not listed as an essential mineral in the current version of NRC (1994)¹³ and Japanese Feeding Standard for Poultry (1997)¹¹. However, it has been recognized that Cr reduces the fat accumulation without reducing the protein accumulation^{2,11,15}. Recently, it has been clarified that Cr elevates the activity of insulin *in vivo*¹¹, improves amino acid uptake by skel-

etal muscle cells⁸, and connects with fat metabolism¹¹. The growth of female turkey chicks is improved by feeding a diet containing Cr¹⁵. Addition of Cr to the diet resulted in the increased percentage of breast meat to total meat of turkeys². It has also been reported that Cr improves the immune function of beef cattle⁵ and milk cows⁴ raised under stressful conditions.

As a Cr source, organic Cr, Cr picolinate has recently been attracting considerable atten-

tion, because the carcass quality of pig is improved by the addition of Cr picolinate to the diet^{10,12,14}. Mooney *et al.*¹² reported that the pig fed a diet containing Cr picolinate from the beginning of the growth phase to the final growth yielded carcasses with a high muscle and a low fat. Although the fat content in poultry meat is less than in pork and beef, the abdominal and subcutaneous fat of broilers increase with advancing age. It is one of the most important problems to reduce these excess fat in broilers in the recent broiler industry. Until to date, a number of studies have been carried out concerning the effect of Cr picolinate on the quality of pig carcasses, but a few such studies have been published regarding broilers, in which the addition of Cr picolinate to the diet tended to reduce the carcass fat and increase the carcass protein of broilers^{7,8,17}. Yeast Cr was produced by fermentation with using brewer's yeast (*Saccharomyces*) and have ever been reported usefulness for beef cattle under stressful conditions⁵, but no reports have been published on the effects of yeast Cr on the quality of broiler carcass.

Therefore, the present study was undertaken to reconfirm the effects of Cr picolinate and to confirm the effects of yeast Cr on the growth and carcass fat of broilers.

Materials and Methods

Animals and experimental design

One-day-old female Arbor Acres broiler chicks were obtained from a commercial hatchery, and group-fed a commercial starter diet until 7 days of age. Chicks were weighed and allotted into five experimental dietary groups of 20 chicks each with similar average body weights. The selected chicks were fed the five experimental diets containing 0, 200 or 400 ppb Cr derived from Cr picolinate and yeast Cr in wire cages in an environmentally controlled windowless house ($22 \pm 2^\circ\text{C}$ and lights on all day) for following 35 days from 8 to 42 days of

age. Body weight and feed intake were recorded weekly throughout the experimental period. After measuring body weight of chicks at the end of the experiment, ten chicks were selected at random from each group, and killed by decapitation. Abdominal fat, skin-off breast meat (*M. pectoralis superficialis*) and skin-on drumsticks (mainly composed of *M. triceps surae*, *M. tibialis anterior* and *M. fibularis longus*) were collected.

Each meat sample was minced with a hand-operated mincer to small pieces to determine moisture, crude fat using a Soxhlet extractor with diethyl ether and crude protein (CP) by the semi-micro Kjeldahl method.

Diets

Table 1 shows the composition of two basal diets used for 7 to 21 and 22 to 42 days of age. The former contained 21.5% CP and 3.10 kcal ME/g, and the latter contained 18.3% CP and 3.20 kcal ME/g, respectively. The amounts of vitamins and minerals were adjusted to satisfy the requirements by NRC (1994)¹³. The amount of Cr derived from feedstuffs was negligible. As Cr sources, Cr picolinate (Prince Agri Products, Inc., USA) containing 400 mg Cr/kg, and yeast Cr (*Saccharomyces*; Alltech, Inc., USA) containing 1,000 mg Cr/kg were added to the both basal diets to be 0, 200, or 400 ppb as Cr.

Statistical analysis

The data were subjected to analysis of variance. The significance of differences was tested using Fisher's least significant difference. Statements of significance are based on $P < 0.05$ unless otherwise stated.

Results

The performance of broilers is summarized in Table 2. Body weight gain significantly decreased in the yeast Cr 400 ppb diet group compared with the control group. Feed intake tended to decrease in the all of Cr supplemented diet groups, except the Cr picolinate Cr 400 ppb diet group. Body weight

Dietary Chromium and Carcass Fat of Broilers

Table 1. Composition of basal diets (g/kg diet)

Ingredients	Starter (1 to 3 weeks)	Finisher (3 to 6 weeks)
Ground yellow corn	465.8	470.1
Ground sorghum	100.0	190.0
Wheat bran	15.2	20.4
Soybean meal	260.0	110.0
Canola meal	24.0	55.0
Corn gluten meal	9.0	10.0
Fish meal	30.0	48.0
Meat bone meal	41.0	45.0
Yellow grease	40.0	43.0
Calcium carbonate	6.0	3.0
Choline chloride	1.5	1.2
Dicalcium phosphate	2.0	—
Sodium chloride	1.9	1.6
DL-methionine	1.3	0.3
L-lysine · HCl	0.3	0.4
Vitamin mineral mixture*	2.0	2.0
Calculated analysis		
Crude protein (%)	21.5	18.3
Crude fat (%)	7.1	7.8
Calcium (%)	0.9	0.8
Available phosphorus (%)	0.45	0.47
ME (kcal/g)	3.10	3.20
Methionine (%)	0.50	0.39
Lysine (%)	1.17	0.96

* Provides per kilogram of diet : (IU) vitamin A, 5,000 ; (ICU) vitamin D₃, 1,000 ; (mg) d1- α -tocopherol acetate, 13 ; menadion, 0.8 ; thiamine nitrate, 2.3 ; riboflavin, 4 ; pyridoxine-HCl, 5 ; nicotinic acid amide, 36 ; D-pantothenic calcium, 12 ; folic acid, 0.56 ; cyanocobalamin, 0.01 ; d-biotin, 0.15 ; MnSO₄, 170 ; FeSO₄, 230 ; ZnSO₄, 121 ; CuSO₄, 22 ; Ca(IO₃)₂, 1.2 and MgCO₃, 694.

gain tended to be smaller in the Cr supplemented groups, and that in the yeast Cr groups was smaller compared to that in the Cr picolinate groups. Feed conversion ratio tended to increase in the Cr supplemented groups with increasing dietary Cr levels.

As shown in Table 3, no significant differences were found in abdominal fat content nor abdominal fat ratio to body weight among the all groups. None of the parameters in the skin-on drumsticks meat differed significantly by dietary Cr levels. The crude fat content of skin-off breast meat decreased with increasing dietary Cr levels, but there were no differences

caused by Cr sources. Although the moisture contents was not affected, the crude protein tended to increase with decreasing crude fat.

Discussion

When the diet containing Cr picolinate (200 ppb) was given to the pigs from a low weight stage, weight gain and feed intake were significantly suppressed⁹⁾. In an earlier study on the effects of Cr on growth of turkey, addition of inorganic Cr chloride (CrCl₃ · 6H₂O) to the diet resulted in the improvement of growth¹⁵⁾. In broilers it was reported that by addition of Cr picolinate to the diet the overall

Table 2. Effects of dietary chromium (Cr) picolinate and yeast Cr on weight gain, feed intake, and feed conversion ratio of broilers

Cr source	None	Cr picolinate		Yeast Cr		Pooled SE
Dietary Cr (ppb)	0	200	400	200	400	
Body weight						
Initial (g)	173	172	172	173	172	3
Final (g)	2,142 ^a	2,075 ^{ab}	2,080 ^{ab}	2,078 ^{ab}	2,011 ^b	31
Gain (g)						
7 to 21 days	650 ^a	638 ^{ab}	635 ^{ab}	645 ^{ab}	615 ^b	10
22 to 42 days	1,319 ^a	1,265 ^{ab}	1,273 ^{ab}	1,260 ^{ab}	1,224 ^b	22
7 to 42 days	1,969 ^a	1,903 ^{ab}	1,908 ^{ab}	1,905 ^{ab}	1,839 ^b	29
Feed intake (g)						
7 to 21 days	952	928	957	952	934	14
22 to 42 days	2,742	2,660	2,766	2,653	2,657	35
7 to 42 days	3,694	3,588	3,723	3,605	3,591	54
Feed conversion ratio (g/g)						
7 to 21 days	1.46	1.45	1.51	1.48	1.52	0.02
22 to 42 days	2.08	2.10	2.17	2.11	2.17	0.03
7 to 42 days	1.88	1.89	1.95	1.89	1.95	0.03

Each value is means for 20 chicks.

^{a-b} Means in the same row with different superscript letters are significantly different ($p < 0.05$).

Table 3. Effects of dietary chromium (Cr) picolinate and yeast Cr on abdominal fat and moisture, crude protein, crude fat content in skin-off breast and skin-on drumstick of broilers

Cr source	None	Cr picolinate		Yeast Cr		Pooled SE
Dietary Cr (ppb)	0	200	400	200	400	
Body weight (g/chick)	2,140	2,181	2,134	2,157	2,120	33
Abdominal fat content						
(g/chick)	55.8	61.6	56.0	64.3	52.3	4.2
(% of body weight)	2.61	2.83	2.63	2.89	2.47	0.24
Skin off breast						
Moisture (%)	74.2	74.0	73.9	74.1	74.1	0.4
Crude protein (%)	23.2	23.7	23.8	23.7	23.8	0.3
Crude fat (%)	1.36 ^a	1.08 ^b	1.01 ^b	1.07 ^b	0.97 ^b	0.09
Skin on drumstick						
Moisture (%)	70.5	70.9	71.9	71.2	71.2	0.6
Crude protein (%)	18.0	17.4	17.7	17.9	17.7	0.2
Crude fat (%)	10.4	10.3	9.1	9.8	10.0	0.7

Each value is means for 10 chicks selected randomly from 20 chicks.

^{a-b} Means in the same row with different superscript letters are significantly different ($p < 0.05$).

growth nor nutrient utilization were not improved, but carcass fat tended to decrease and carcass protein tended to increase^{7,8,17}. In this study, the growth of broilers tended to be de-

pressed by addition of Cr, and especially depressed significantly on the yeast Cr (400 ppb) diet. Although the amount of yeast added to the yeast Cr (400 ppb) diet was only 0.04% of

diet, some unknown factors contained in yeast might cause the depression of growth. The abdominal fat, which was used as an indicator fat accumulation, was unaffected by Cr supplementation. In the skin-off breast meat, the crude fat content was significantly lower in the broilers given diets containing Cr picolinate or yeast Cr than in the control group. The CP content tended to be increased by supplementation of Cr picolinate or yeast Cr. No differences of the crude fat, CP and moisture in the skin-on drumsticks were observed. Because much subcutaneous fat was contained in the skin-on drumsticks, they were not affected by dietary Cr levels. It might be possible that the depression of crude fat in the meat was masked by the large amount of subcutaneous fat.

In the present study, the addition of Cr picolinate or yeast Cr to the diet of broiler chicks suppressed fat accumulation in the breast meat. Mooney *et al.*¹²⁾ examined the carcass of pigs fed a diet containing Cr picolinate, and found that no difference in subcutaneous fat content between pigs fed the diets with or without Cr, but fat content in the carcasses which pigs fed diet with Cr was smaller. They attributed this difference to the depression of fat in muscles cells and intermuscular fat following the ingestion of Cr, and suggested the possibility that Cr enhances glucose or amino acid uptake by muscle cells¹²⁾. The depression of fat accumulation in the skin-off breast meat in present study corroborated their conclusion. The data were not presented here, the Cr contents in the liver and skin-off breast meat (*M. pectoralis superficialis*) of chicks fed the 400 ppb Cr diet were less than 0.3 ppm, the lowest value detected by diphenylcarbazide spectrophotometric method¹⁶⁾.

Whether or not there is a commercial merit of addition of Cr to the broiler diet depends on the future study, especially on the strain of chicken or the environmental condition to which chicks are exposed should be in-

vestigated.

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ブロイラーの成長および体脂肪に及ぼすピコリン酸クロムと 酵母クロムの影響

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ブロイラー雛に2種類の有機クロム、ピコリン酸クロムおよび酵母クロムを給与した場合の発育および屠体成分への影響を調べた。アーバーエーカー1週齢の雌雛、各区20羽を6週齢まで群飼した。給与飼料は1週齢から3週齢までは粗タンパク質21.5%、代謝エネルギー3.10 kcal/g、4週齢から6週齢までは粗タンパク質18.3%、代謝エネルギー3.20 kcal/gの基礎飼料を用い、ピコリン酸クロムおよび酵母クロムをクロムとして0, 200および400 ppbになるように添加した。体重および飼料摂取量は毎週記録した。試験終了時に屠殺して、腹腔内脂肪と皮なしの胸肉および皮付きのもも肉の粗脂肪含量、粗タンパク質含量、水分含量を測定した。クロム添加区では飼料摂取量および増体重ともに低下する傾向がみられ、特に酵母クロムの添加区(400 ppb)で増体重が有意に低下した。また、ピコリン酸クロムの添加区よりも酵母クロムの添加区の方が負の影響が大きかった。腹腔内脂肪および皮付きのもも肉と皮なしの胸肉の粗タンパク質含量および水分含量はクロム添加によって影響はうけなかった。皮付きのもも肉の粗脂肪含量はクロム添加の影響を受けなかったが、皮なしの胸肉の粗脂肪含量では飼料中のクロム含量が増加するにつれ低下した。

日畜会報, 69 (3) : 247-252, 1998