Effects of dietary chromium polynicotinate supplementation on performance, fat deposition and plasma lipids of broiler chickens

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Abstract

The present study was conducted to determine the effect of chromium polynicotinate supplementation on performance, fat deposition and plasma lipids of broiler chickens. A total of 540 male broiler chicks (Cobb 500) were allotted to 6 dietary treatments. The dietary chromium polynicotinate levels were 0 (Control), 250, 500, 750, 1000 or 1250 µg/kg, respectively. At 10-28 days of age (grower phase), the 500 µg/kg concentration of chromium polynicotinate supplementation had a beneficial effect on feed intake and body weight gain of broilers (P<0.05). At 29-42 days of age (finisher phase), feed conversion ratio was decreased (P<0.05) in broilers fed with chromium polynicotinate supplement at levels of 250, 750, 1000 or 1250 µg/kg. Chromium polynicotinate did not affect the abdominal fat pad deposition. The results indicated that the 500 µg/kg level of chromium polynicotinate supplement decreased the plasma cholesterol concentration in the finisher phases. The chromium concentrations of 1000 and 500 µg/kg were more effective at grower and finisher phases, respectively (P<0.05). Plasma triglyceride was not affected by dietary chromium concentration. The results from this study suggest that supplementation of chromium polynicotinate improved growth performance and influenced blood cholesterol concentrations, but in this respect, there was no dose related effects.

Introduction

For many years, chromium has been considered by many nutritionists as an essential nutrient for animals and humans (NRC, 1997). Trivalent chromium is a well known essential trace element and is thought to have a primary role in activating insulin through the glucose tolerance factor (GTF) (Schwarz and Mertz, 1957). This element is also involved in carbohydrate, lipid, protein and nucleic acid metabolic function (Neri and Fring, 1973; Steele and Rosebrough, 1981; McCarty, 1991).

Research on animals has confirmed that organic chromium (Cr) sources provide more bioavailability (25 to 30%) than inorganic Cr sources, of which only about 0.5 to 3.0% is absorbed (Mowat, 1994). The National Research Council (1994) did not specify any requirement for Cr in poultry diets. Most poultry diets are mainly composed of plant origin ingredients, which are usually low in Cr (Giri et al., 1990). Young chicks can tolerate 500 mg Cr/kg diet (from soluble form, Cr2(SO4)3) without adverse effects (Chung et al., 1983). Body weight gain in young chicks was reduced by addition of 1,500 mg Cr/kg diet as Cr2(SO4)3 (Chung et al., 1983) or 2000 mg/kg diet as CrCl3 (Hill and Matrone, 1970). In general, dietary chromium supplementation has been shown to positively affect the growth rate, feed efficiency and carcass traits of broilers and turkeys (Cupo and Donaldson, 1983; NRC, 1997; Lien et al., 1999; Sahin et al., 2002; Debski et al., 2004). Others, however, have reported no positive effect on these same traits (Lian, 1993; Ward et al., 1993; Ward and Southern, 1995; Kim et al., 1996a,b; Anandhi et al., 2006). Researchers reported that Cr supplements may decrease carcass fat (Kim et al., 1996a) or plasma cholesterol (Press et al., 1990; Kitchalogen et al., 1995; Kim et al., 1996b) of broiler chickens. In the majority of the previous studies, chromium picolinate (Kim et al., 1996b), Cr yeast (Hossain et al., 1998) or CrCl3 (Uyanik et al., 2002) have been used, and there has been no research in broilers with chromium polynicotinate. The objective of the present study was to evaluate the effects of chromium polynicotinate supplementation on growth performance, abdominal fat and blood lipids in broiler chickens.

Materials and methods

For a 6-wk feeding trial, a total of 540 male broiler chicks (Cobb 500) were allotted to 6 dietary treatments. For the initial 10 d, the birds were raised with a commercial starter diet before allocation to experimental diets. A completely randomized design with 6 treatments replicated 3 times with 30 chicks per replicate was used. The dietary chromium polynicotinate (12.9% Cr, Acatris, Schouten, Belgium) levels were 0 (control), 250, 500, 750, 1000 or 1250 µg/kg, respectively. Basal experimental diets (mash) were formulated to contain 21 and 19% CP for grower (10-28 d) and finisher (29-42 d), respectively (Table 1). Chicks had ad libitum access to feed and water. The initial body weight of birds was recorded at 10 days of age. The body weight gain and feed intake were recorded at the end of the grower and finisher phases (28 and 42 d of age, respectively), and feed conversion ratio was calculated. At the end of the experiment, 18 chicks per treatment (6 per replicate) were randomly selected. Blood samples were obtained by jugular vein puncture and drawn into EDTA tubes. The blood samples were centrifuged at 2400 RCF for 15 min at 4°C, and plasma was collected and stored at 20°C for later analysis. Plasma cholesterol and triglyceride concentrations were determined using commercial kits (ZiestChem Diagnostics, Co) according to Loeffler and McDougald (1976), and Neri and Fring (1973) methods, respectively. Prior to slaughter, the feed was withdrawn for about 10 h. After blood collection, the birds were slaughtered, defeathered, processsed and eviscerated. Abdominal fat pad (including fat surrounding gizzard, bursa of Fabricius, cloaca & adjacent muscles) was removed, weighed individually and reported as a percent of carcass weight. Data were analyzed by one-way ANOVA to assess the significance of the effects of chromium polynicotinate. Then, Duncan’s multiple range test was performed to compare all means (SAS, Version 6.12). Differences were considered significant at P<0.05, unless otherwise stated.
Results and discussion

In this experiment no hazardous signs were observed in broilers receiving chromium in all doses. This was similar to previous reports (Steele and Rosebrough, 1981; Ahmad et al., 2004).

Effect of chromium polynicotinate on growth performance and abdominal fat pad of sampled broiler chickens are shown in Table 2. At 10-28 days of age (grower phase), the 500 µg/kg level of chromium polynicotinate supplementation had a beneficial effect on feed intake and body weight gain of broilers (P<0.05). However, no significant effects on feed conversion ratio and abdominal fat pad percentage were observed.

In the finisher phase of experiment (29-42 days of age), feed intake, body weight gain and abdominal fat pad percentage of broilers were unaffected, while feed conversion ratio was decreased (P<0.05) in broilers fed with chromium polynicotinate supplement at 250, 750, 1000 or 1250 µg/kg levels.

Table 1. Composition and calculated nutrient content of the grower and finisher basal diets of the experiment.

|                        | Grower (10-28 days of age) | Finisher (29-42 days of age) |
|------------------------|----------------------------|------------------------------|
| Chromium Polynicotinate, µg/kg | 0, 250, 500, 750, 1000 or 1250 |                               |
| Corn, %                | 47.97                      | 54.33                         |
| Soybean meal, %        | 41.46                      | 35.54                         |
| Sunflower oil, %       | 6.12                       | 5.86                          |
| Tallow, %              | 0.43                       | 0.27                          |
| Calcium carbonate, %   | 1                          | 1.01                          |
| Dicalcium phosphate, % | 1.83                       | 1.87                          |
| Salt, %                | 0.38                       | 0.38                          |
| Vitamin and mineral supplement*, % | 0.5                      | 0.5                            |
| DL-Methionine, %       | 0.33                       | 0.3                            |
| HCl-Lysin, %           | 0.19                       | 0.15                          |
| Metabolisable energy, kcal/kg | 3150                      | 3200                          |
| Crude protein, %       | 21                         | 19                            |
| Calcium, %             | 0.9                        | 0.9                            |
| Available phosphorous, % | 0.45                     | 0.45                           |
| Sodium, %              | 0.16                       | 0.16                           |
| Methionine, %          | 0.54                       | 0.49                           |
| Met+Cys, %             | 0.85                       | 0.78                           |
| Lysin, %               | 1.2                        | 1.05                           |

*Provided per kilogram: vitamin A, 4,000,000 U; cholecalciferol 900,000 U; vitamin E, 14,000 U; vitamin K3, 760 mg; vitamin B12, 2800 mg; vitamin B6, 1520 mg; vitamin B1, 7.8 mg; nicotinic acid, 18,000 mg; folic acid, 500 mg; pantothenic acid, 4000 mg; choline chloride, 190,000 mg; biotin, 65.3 mg; zinc, 16,000 mg; manganese, 12,800 mg; iron, 3200 mg; selenium, 44 mg; iodine, 320 mg.

Table 2. Effects of dietary chromium polynicotinate supplementation on performance traits of broiler chickens.

| Dietary chromium polynicotinate concentrations (µg/kg) | 10 to 28 days of age | 29 to 42 days of age | SEM |
|-------------------------------------------------------|----------------------|----------------------|-----|
|                                                       | Feed intake (g/bird/day) | Body weight gain (g/bird/day) | Feed conversion ratio | Abdominal fat pad* |
| 0                                                     | 84.6b                | 60.0b                | 1.41 | 2.04 |
| 250                                                   | 88.1ab               | 60.8ab               | 1.45 | 1.65 |
| 500                                                   | 90.7a                | 63.3a                | 1.43 | 1.65 |
| 750                                                   | 89.0ab               | 62.0ab               | 1.44 | 1.50 |
| 1000                                                  | 89.6ab               | 62.2ab               | 1.44 | 2.00 |
| 1250                                                  | 87.1ab               | 59.5b                | 1.46 | 1.52 |
| SEM                                                   | 0.63                 | 0.44                 | 0.06 | 0.08 |

|                                                       | Feed intake (g/bird/day) | Body weight gain (g/bird/day) | Feed conversion ratio |
| 0                                                     | 176.6                 | 89.4                 | 1.97a                 |
| 250                                                   | 174.0                 | 92.6                 | 1.87b                 |
| 500                                                   | 174.4                 | 91.6                 | 1.90ab                |
| 750                                                   | 176.7                 | 93.9                 | 1.88b                 |
| 1000                                                  | 177.2                 | 95.0                 | 1.88b                 |
| 1250                                                  | 172.0                 | 92.7                 | 1.85b                 |

SEM 0.86 0.78 0.09 0.1

a-b Means in a column with no common superscripts differ significantly (P<0.05). *Abdominal fat pad calculated as a percent of carcass weight.

Table 3. Effects of dietary chromium polynicotinate supplementation on plasma cholesterol and triglyceride concentrations of broiler chickens.

| Dietary chromium polynicotinate concentration (µg/kg) | 10 to 28 days of age | 29 to 42 days of age |
|------------------------------------------------------|----------------------|----------------------|
|                                                       | Plasma cholesterol concentration (mg/dL) | Plasma triglyceride concentration (mg/dL) | Plasma cholesterol concentration (mg/dL) | Plasma triglyceride concentration (mg/dL) |
| 0                                                    | 110.6b               | 25.3                 | 100.0b                 | 20.3                   |
| 250                                                  | 127.9b               | 25.9                 | 86.5b                  | 22.0                   |
| 500                                                  | 126.3b               | 24.1                 | 76.4b                  | 23.0                   |
| 750                                                  | 109.5b               | 26.0                 | 82.9b                  | 27.8                   |
| 1000                                                 | 101.7b               | 28.8                 | 92.6b                  | 23.6                   |
| 1250                                                 | 106.3b               | 26.3                 | 93.4b                  | 22.8                   |
| SEM                                                  | 3.2                  | 1.7                  | 2.6                    | 2.15                   |

SEM 0.7 0.4 0.1 0.1

a-b Means in a column with no common superscripts differ significantly (P<0.05).
The effect of chromium supplementation on growth performance and abdominal fat pad deposition in broiler chickens has been variable (NRC, 1997). The present research demonstrated that Cr supplementation improved feed intake, body weight gain and feed conversion ratio, but this performance traits showed variable responses to supplemental chromium polynicotinate at grower or finisher phases.

Some reports have indicated that Cr supplementation may improve body weight gain (Steele and Rosebrough, 1981; Sahin et al., 1998; Lien et al., 1999) and feed intake (Lien et al., 1999; Sahin et al., 2002), which is consistent with our results for birds fed with 500 µg chromium polynicotinate/kg at 10-28 days of age. Nevertheless, not all researches confirm positive effects of Cr supplement on growth performance in broilers (Kim et al., 1995; Kim et al., 1996a; Hossain et al., 1998).

Several researchers observed significant improvement in feed conversion ratio of broiler chickens by the addition of Cr supplement (Hossain et al., 1998; Lee et al., 2003). The results of current study indicate that chromium polynicotinate supplementation did not affect the feed conversion ratio of broilers from 10 to 28 days of age. This is in agreement with results obtained by Ward et al. (1993) with broiler chicks supplemented with Cr from Cr picolinate. Jackson et al. (2008) reported that Cr as chromium propionate improved feed conversion ratio of broilers in the later phases of growth, which is consistent with our results for chromium polynicotinate.

We found that supplemental Cr had no effect on abdominal fat pad content, which is consistent with those reported by (Ward et al., 1993, 1995). However, some authors have reported that in birds fed with Cr supplement, abdominal fat pad as a percent of carcass weight was reduced significantly (Kim et al., 1996b; Hossain et al., 1998; Lien et al., 1999). Debski et al. (2004) reported that Organic chromium supplementation decreased the meat’s fat and cholesterol content of broilers.

The concentrations of cholesterol and triglyceride in plasma of birds fed with chromium supplement is presented in Table 3. At the grower phase, the supplementation of 1000 µg Cr from chromium polynicotinate/kg decreased the plasma concentration of cholesterol (P<0.05), compared to the birds fed with 250 µg/kg Cr supplement. Whereas at the finisher phase, in birds fed with 500 µg/kg Cr supplement, plasma cholesterol concentration were decreased significantly (P<0.05), compared to control group. This finding is supported by the findings of Debski et al. (2004), who found the total cholesterol concentration in blood serum was significantly lower in birds fed on diet with Cr-yeast. In another study Kroliczewska et al. (2004) reported similar results that agreed with the present study. But Uyanik et al. (2002) observed that inorganic chromium (CrCl3·6H2O) did not affect serum cholesterol of broiler chickens.

Some reports have showed that plasma or serum triglyceride concentrations may be decreased in chickens fed Cr supplement (Bakhiet and El Badwi, 2007); however, our data indicate that chromium polynicotinate had no effect on plasma triglyceride concentrations.

Conclusions

The results from this study suggest that supplementation with chromium polynicotinate improved growth performance and influenced blood lipids concentrations, but in this respect there was no dose-related effects.

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