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EFFECTS OF DIETARY CHROMIUM SUPPLEMENTATION ON GROWTH PERFORMANCE, CARCASS CHARACTERISTICS AND SOME BLOOD PARAMETERS OF BROILERS

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Abstract: *This study was conducted to determine the effects of supplemented five levels of chromium (Cr) as a chromium chloride ($CrCl_3$ $.6H_2O$) in broiler diets on performance, carcass characteristics, some blood parameters and economic efficiency of broilers. Two hundred forty one-day old male broiler (Arbor Acres) chicks were used and randomly assigned to 6 groups. The birds were fed either a control diet or the control diet supplemented with 10, 20, 30, 40 or 50 mg Cr/kg diet. The experiment lasted 7 weeks. The results obtained can be summarized as follows:*

Supplementing Cr at levels of 10, 20, 30, 40 and 50 mg Cr/kg diet increased significantly final body weight compared to the control group. There was significant increase in total body weight gain (0-7wks) in groups fed Cr supplemented diet at levels of 20, 30, and 40 mg Cr/kg diet compared to control. No significant differences in total feed consumption were observed for the whole experimental period (0-7wks). Feed conversion efficiency for the whole experimental period (0-7wks) was improved significantly of any Cr supplemented diet compared to control. The improvement in FCE averaged 5.93, 7.90, 4.81, 6.17 and 2.62%, of groups received Cr supplemented diets 10, 20, 30, 40 and 50 mg Cr/kg diet respectively compared to the control value. It was also shown that Cr supplementation tended to reduce mortality rate in broiler chicks.

Data of carcass characteristics showed a significant decrease ($P<0.05$) in liver weight in groups fed 20 mg or higher Cr/kg diet compared to the control group. No significant differences were observed between the treated groups received Cr supplemented diet and control group of both heart and spleen weights. Significant decreases of empty gizzard weight, giblets weight, giblets percentages, abdominal fat weight, subcutaneous fat weight, total body fat weight and percentages were observed in all groups received Cr supplemented diet compared with the control group. Significant *increases were observed in carcass weight, carcass percentages, meat yield (breast and legs) weight and percentages in all groups received Cr supplemented diet compared with the control group.*

Significant increases were observed in plasma total protein, total lipids and triglycerides in all groups received the Cr supplemented diet except for group received 10mg Cr/kg diet compared to control group. While plasma albumin and creatinine were not affected by Cr supplementation in diets. Also, significant decreases were observed in plasma glucose and total cholesterol in all groups received the Cr supplemented diets compared to control. Addition of Cr to control diet at levels of 10, 20, 30, and 40 mg/kg diet improved economic efficiency compared to control. These improvements in economic efficiency were 8.27, 10.89, 5.51 and 6.71% than the control value respectively.

These results indicate that the 20mg Cr/kg diet as $CrCl_3$ was the most effective for improving growth performance, carcass characteristics, and economic efficiency and reducing abdominal fat and cholesterol.

INTRODUCTION

There is a growing awareness of the beneficial role of trace elements, which may play in promoting health and growth. Chromium is intimately involved in lipid, carbohydrate and protein metabolism. Chromium is generally accepted to be the active component in glucose tolerance factor (GTF), which increases the sensitivity of tissue receptors to insulin, resulting in increased glucose uptake by cells (Mertz, 1969 and Sahin *et al*., 2001). Chromium, as an insulin potentiator, is therefore postulated to function as an antioxidant (Preuss *et al.,* 1997). In addition, chromium is thought to be essential for activating certain enzymes and for stabilizing proteins and nucleic acids (Linder 1991).

Chromium is found in all animal tissues and much of what is known about Cr comes from studies in humans, where the element decreases in tissues with increasing age. Beside age, various stresses can decrease the serum Cr level for example, pregnancy and infections as well, are metabolic, physical and even psychological stresses. In these situations, there is an increase in the excretion of Cr via the urine (Anderson *et al*., 1990).

The use of chromium has been suggested to have positive impacts on farm profitability, and many animal health benefits, including increased longevity; enhanced reproduction, improved immune response and lean carcass quality (Mooney and Cromwell,1997). Dietary chromium supplementation has been shown to positively affect growth rate and feed efficiency of growing poultry (Cupo and Donaldson 1987; Lien *et al*., 1999 and Sahin *et al.,* 2001).

Although many researchers have suggested that Cr should become a key ingredient in nutritional supplements, official bodies such as the USA National Research Council (NRC), animal nutrition subcommittees have not yet made final recommendations on minimum dietary Cr requirements for any farm animals or poultry species. Chromium is not currently considered an essential trace element for poultry, although this micronutrient may play a nutritional and physiological role. Moreover, the NRC has recommended 300µg Cr/kg diet for laboratory animals (NRC, 1995). Currently there are no NRC recommendations for Cr in poultry.

Therefore, the objective of this study was to evaluate the effects of chromium (chromium chloride, $CrCl_3$) supplementation at various levels on growth performance, carcass characteristics, some plasma metabolites, and economic efficiency of broilers.

MATERIALS AND METHODS

Birds:

Two hundred forty one-day old Arbor Acres male broilers chicks were obtained from Ismailia Misr Poultry Company and used for this study. Birds were housed in brooder batteries with raised wire floors at the Poultry Experimental Farm, Faculty of Agriculture, Suez Canal University. Chicks were weighed, wing banded and randomly allotted to six groups. Within each group, 40 chicks were divided randomly to four replicates of 10 chicks each. Diet and water were provided *ad-libitum*. Photoperiod was maintained at 24 hours light throughout the study, which lasted 7 weeks. Individual body weights and feed consumption per replicate were recorded weekly to calculate feed conversion efficiency (g feed consumed / g weight gain).

Experimental Diets:

Three types of basal diet were formulated to meet the nutritional requirements suggested by NRC (1994). The starter diet (0-3wks) containing 23% crude protein and 3200 Kcal ME/kg diet, followed by a grower diet (3-6wks) containing 20% and 3200 Kcal ME/kg diet, followed by finisher diet (6-7wks) containing 18% crude protein and 3200 Kcal ME/kg diet. The diet composition and its chemical analysis are shown in

(Table1). Dry matter, crude protein (Kjeldahl N X 6.25), crude fiber, ether extract, and ash were analyzed using the standard methods of the Association of Official Analytical Chemists (AOAC, 1995). Chromium was in the form of powdered salt of chromium chloride ($CrCl_3.6H_2O$).

In this experiment, five levels of chromium chloride were supplemented to the basal diet. The highest dose of chromium was calculated as 50% of the 1/10 of the tolerable amount, which is 1000 mg Cr/kg diet (NRC, 1980). Amounts of the $CrCI_3$ used were 51.2, 102.4, 153.6, 200.48 and 250.60 mg of $CrCI_3$/kg diet, equivalent to 10,20,30,40 and 50 mg Cr/kg diet.

Experimental Design:

Six experimental groups were used in this study; the first group was the control in which the chicks were fed the basal diet without chromium supplementation. Chicks were fed the basal diet supplemented with $CrCI_3$ of the aforementioned levels.

Carcass Characteristics:

At the end of the experiment (7 weeks old) five males were taken randomly from each group for slaughter test. Weights of liver, heart, spleen, empty gizzard, eviscerated carcass, meat (breast and legs), abdominal fat, subcutaneous fat and total body fat were recorded to the nearest gram. Giblets, carcass, meat (breast and legs), and total body fat weights were calculated as a percentage of live body weight.

Biochemical Parameters:

At 7^{th} weeks of age, blood samples were collected from five males in each group. Blood samples were collected from brachial veins into heparinzed tubes, centrifuged at 3000 rpm for 10 min. to separate plasma. Plasma samples were stored at $-20^{o}C$ until used for determination of total protein (Peter, 1968), albumin, (Doumas *et al.*1971), creatinine (Husdan, 1968), glucose (Keilin and Hartree, 1948), total lipids (Zollner and Kirsch, 1962) triglycerides (Fossati and Prencipe 1982), and cholesterol (Waston, 1960) by using available commercial kits Bio-Merieux, France.

Economic Efficiency

At the end of this work, the economical efficiency of the experimental diet was calculated from the input-output analysis based upon the differences in both growth rate and feeding cost as described by Bayoumi (1980).

Statistical Analysis

The data of body weight, body weight gain, feed consumption, feed conversion efficiency, slaughter test and blood parameters were statistically analyzed using one-way analysis of variance using SAS computer program (SAS, 1986). Differences among treatment means were tested using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Body Weight

The effects of supplementing different levels of chromium on weekly body weights for broiler chicks are shown in Table (2). There were significant increases (P < 0.05) in body weight of groups received 10 and 20 mg Cr/kg diet compared to control group at the first two weeks of age. Also, at the 3rd and 7th weeks of age there were significant increase (P<0.05) in body weight in groups received 10 up to 40 mg Cr/kg diet compared to control group and group fed 50 mg Cr/ kg diet. However, starting from 3 rd week of age and continued until the end of the study, chicks received the highest level of Cr (50mg Cr/kg diet) showed significant decrease (P< 0.05) in body weight compared with the other four groups of Cr supplementation. Similar to results of the present study Sahin *et al*. (2002a) reported that the broiler chicks fed diet supplemented with 200,400,800 or 1200 µg Cr/kg diet increased linearly body weight and improved feed efficiency.

The observed increase in body weight due to supplementing Cr confirmed the beneficial effects on physiological functions required for performance (Lukaski 1996). Also, this could be explained by the metabolic action of Cr on increasing protein deposition (Mooney and Cromwell, 1997 and Sahin *et al*., 2002b). Cr is involved in protein metabolism (NRC 1997) and is thought to have a role in nucleic acid metabolism because it increased amino acid incorporation into liver protein in vitro as observed by Weser and Koolman (1969).

The present results suggested that Cr supplementation up to level of 40 mg/kg diet tends to improve body weight, however, 20mg Cr/kg diet gave the highest body weight could be recommended as a suitable supplemental level for broiler diets.

Body Weight Gain

Significant increases (P<0.05) in body weight gain were observed in groups received 10 and 20 mg Cr/kg diet during 0-1wks of age compared to control group. In addition, a significant increase (P<0.05) in body weight gain was observed in group received 10mg Cr/kg diet during 1-2 wks of age compared to control group. While there were significant decreases in body weight gain of groups received 30 and 50 mg Cr/kg diet during 3-4wks of age compared to the control group. During the finishing period (6-7wks of age), there were significant increases in body weight gain observed in all treated groups compared to the control group. Regarding the entire experimental period (0-7wks) there were significant ($P<0.05$) increases in total body weight gain in groups received 20, 30 and 40 mg Cr/kg diet compared to control group. These increases in total body weight gain averaged 7.60, 7.37, and 7.40% respectively than control value (Table3). The observed increase in body weight gain of broilers chicks fed diet supplemented with Cr is in agreement with that reported by Lien *et al.* (1999) who concluded that dietary supplements of 1600 µg Cr/kg in broiler diets improved weight gain. Similar increase in body weight gain and improved feed conversion efficiency were observed in female turkey poults fed diets supplemented with Cr (Holoubek *et al.*, 1997). Chen *et al.* (2001) showed that 1mg Cr/kg diet supplementation significantly improved weight gain at 9-18 wks of age in turkey males.

Feed Consumption

Data for feed consumption are shown in Table (3). Significant increases ($P<0.05$) in feed consumption were observed in groups received 10, 20 and 40 mg Cr/kg diet compared to control group during 0-1wks of age. Also, a significant increase in feed consumption was observed in group received 30 mg Cr/kg diet compared to control group during the finishing period (6-7wks of age). While, no significant differences ($P<0.05$) were observed in feed consumption among different groups in the other experimental periods.

There were, no significant ($P<0.05$) effect due to Cr supplementation in total amount of feed consumption during the whole experimental period (0-7wks). Lien *et al.* (1999) and Sahin *et al.* (2002a) reported that increased supplemented Cr in broiler diets significantly increased feed consumption. However, Uyanik *et al.* (2002) reported that 20 mg/kg supplemental Cr in broiler diets resulted in 18.57% reduction in feed consumption. Increased supplemental chromium picolinate (CrPic) in laying Japanese quail diets increased feed intake (Sahin *et al.*, 2002b). Also, Chen *et al.* (2001) reported that turkey males received 1mg / kg Cr supplementation significantly increased feed intake at 9-18 wks of age.

Feed Conversion Efficiency (FCE)

Data for FCE are shown in Table (3). Groups received diet supplemented with 40 and 50 mg Cr/kg diet during 0-1wks of age scored the worst FCE compared to control group. Feed conversion efficiency was improved significantly of groups received diet supplemented with 20 and 30 mg Cr/kg diet during 2-3wks of age compared to the control group. While, group fed the highest level of Cr, scored the worst FCE compared to control group during 2-3wks and 3-4wks of age. During the finishing period (6-7 wks of age) as well as the whole experimental period (0-7wks) FCE was improved significantly ($P<0.05$) of groups received the Cr supplemented diet up to 50 mg Cr/kg diet compared to the control group. The improvement in the overall FCE averaged 5.93, 7.90, 4.81, 6.17, and 2.62 % compared to the control value respectively. Reports indicated that Cr supplementation to broiler diets significantly improved FCE (Steele and Rosebrough, 1981; Kim *et al.*1995 and Sahin *et al.* 2002a). Also, Uyanik *et al.* (2002) reported that 20 mg/kg supplemental Cr in broiler diets improved FCE by 16.77%.

The results suggested that Cr supplementation to broiler diets tended to improve growth performance .It was clear that 20 mg Cr/kg diet (102.4 mg CrI_3/kg diet) could be recommended as suitable supplemental level.

Mortality Rate

Mortality rates were 10.0, 4.0, 2.0, 7.5, 4.0, and 7.5 % in the control group and groups received Cr supplemented diet respectively .It was shown that mortality rates were decreased of groups received Cr supplemented diets up to 50 mg Cr/kg diet compared to control group. These results are in agreement with those reported by Hossain (1995) who found that 400-ppb Cr yeast in broiler diets resulted in lower mortality. Similar results were observed by Kim *et al.* (1996) who reported that mortality percentage was decreased as dietary Cr increased, when broiler chicks were fed diet supplemented with 0, 800, 1600 and 2400 µg CrPic/kg diet. The results of this study could be explained by the results of Uyanik *et al.* (2002) who reported that broiler chicks fed 20, 40, or 80 mg/kg Cr-supplemented diets for 44 day, increased lymphocyte counts, total antibody, IgG, and IgM titers. All levels of Cr increased the cell-mediated response to phytohemagglutinin. In the same respect Steele and Rosebrough, (1981)found that supplemented Cr in turkey poult diets increased rate of glucose utilization and immune response which explains the decreased mortality rate observed.

The present study showed that supplemental Cr decreased mortality of broilers and 20mg of Cr supplementation resulted in the lowest mortality rate.

Carcass Characteristics

Data of carcass characteristics are shown in Table (4). A significant decrease ($P<0.05$) in liver weight was observed in groups fed 20mg Cr/kg diet or more compared to control group. These results are contrary to those reported by Page *et al.*(1993) who found that liver weight was not affected by Cr supplementation .

No significant differences were observed between the treated groups received Cr supplemented diet and control group of both heart and spleen weights. Significant decreases ($P<0.05$) were observed of empty gizzard weight, giblets weight, giblets percentages, abdominal fat weight, subcutaneous fat weight, total body fat weight and percentages in all groups received Cr supplemented diet compared with the control group. This may be due to decreased tendency of fat deposition in the tissue.

Carcass weight, carcass percentages, meat yield (breast and legs) weight and percentages were significantly increased ($P<0.05$) in groups received Cr supplemented diet compared with the control group. Also, Cr supplementation to broiler diets significantly increased carcass weight and significantly decreased abdominal fat weight and fat percentages (Hossain, 1995; Hossain *et al*., 1998; Choct, 1999 and Sahin *et a*l., 2002a). Moreover, Ward et al. (1993) reported a tendency for 200ppb of CrPic. to increase protein percentage and decrease fat percentage of 3-wk old broiler chick carcass.

Blood Parameters

The effects of Cr supplementation in broiler diets on blood parameters are shown in Table (5). The statistical analysis of blood parameters of broiler chicks indicated a significant increase in plasma total protein levels with increasing dietary level of supplemental Cr compared to the control group. These results are in agreement with those reported by Sahin *et al.* (2002a), who observed that total protein concentration increased linearly with increasing level of Cr supplementation. Also, Uyanik *et al.*(2002) reported that 20 mg / kg supplemented Cr in broiler diets increased serum protein. In contrary to the present results, Chen *et al.* (2001) reported that dietary Cr supplementation at 1 or 3 mg Cr/kg diet to male turkey diets for 14 weeks did not significantly influence serum total protein compared to control.

Plasma albumin and creatinine levels did not show any significant changes due to dietary Cr supplementation. Chen *et al.* (2001) reported that dietary Cr supplementation at 1 or 3 mg Cr/kg diet to male turkey diets for 14 weeks did not significantly influence serum albumin compared to control, whereas 3 mg/kg Cr supplementation significantly increased creatinine concentration at 22 weeks of age. A significant (P<0.05) decrease in plasma glucose levels in all groups received Cr supplemented diet was noticed compared to control. Also, glucose concentrations decreased linearly when increased dietary Cr supplementation to broiler diets (Lien *et al.*1999, Sahin *et al.* 2002a and Uyanik *et al.*2002). Moreover, Cupo and Donaldson (1987) reported that Cr supplementation in broiler diets (20 mg Cr/kg diet) as $CrCl_3$ increased (16%) rate of glucose utilization in liver tissue, which explains the decrease in glucose levels obtained in this study.

Data obtained revealed a significant increase in plasma total lipid (P<0.05) by supplementing diets with Cr when compared to control. These data agreed with that reported by Anderson (1995), who found that Cr increased plasma total lipid concentration.

Concerning triglycerides, it was found that plasma triglycerides was significantly (P<0.05) increased in groups received Cr supplemented diet compared to the control. A similar effect due to Cr supplementation was reported by Riales and Albrink (1981) and Abraham *et al.* (1992).They demonstrated a tendency for triglycerides to rise by Cr supplementation but this was not significant. Chromium is generally accepted as the active component in the glucose tolerance factor (GTF), which increases the sensitivity of tissue receptors to insulin, resulting in increased glucose uptake by cells. Research suggests Cr involvement in carbohydrate metabolism including glucose uptake, glucose utilization for lipogenisis, and glycogen formation (Anderson *et al.,* 1991). It was hypothesized that increased glucose uptake should increase oxidation of glucose which would be otherwise converted to fatty acids and stored as triglycerides in adipose tissues.

Additionally, the results of this study showed a significant (P<0.05) decrease in plasma total cholesterol values in groups received Cr supplemented diet compared to the control. These results are in agreement with the results of Schroeder *et al.* (1970), Kim *et al.* (1995), Anderson (1999) and Sahin *et al.* (2002a) .They reported that increased supplemental Cr in broiler diets decreased cholesterol concentration.

Economic Efficiency (EE)

Economic evaluation study of broiler chicks fed the experimental diets are summarized in Table (6). Addition of Cr to control diet at levels of 10, 20, 30, and 40 mg/kg diet improved EE compared to control. These improvements in EE were 8.27, 10.89, 5.51 and 6.71% than the control value respectively. From economic stand point, it was clear that group received 20 mg Cr/kg diet recorded the best EE and group received 50 mg Cr/kg diet gave the lowest EE value compared to the control .

The results of the current study suggest that supplementation of chromium chloride ($CrCl_3.6H_2O$) in broiler diets especially at a level of 20 mg Cr/kg diet increased growth performance, improved feed conversion efficiency, increased meat yield (breast and legs) and provided the best economic efficiency than the control. There are other positive effects, including reduced abdominal fat pad, overall body fat and mortality rate. Chromium may be one of the most important trace minerals in broiler feed formulation in the new millennium.

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Table (1): Composition and chemical analysis of the experimental diets fed during starting, growing and finishing periods.

Ingredients (%)	Starter (0-3wks)	Grower (3-6wks)	Finisher (6-7wks)
Yellow corn ground	50.24	60.71	64.90
Soybean meal (44%)	33.00	25.70	26.03
Corn gluten	6.90	5.70	1.70
Sunflower oil	6.00	4.30	4.39
Dicalcium phosphate	1.70	1.40	1.01
Limestone	1.40	1.40	1.35
Sodium chloride	0.40	0.40	0.35
Vit. and min. Premix*	0.25	0.25	0.25
DL- methionine	0.11	0.04	0.02
L- lysine	--	0.10	--
Chemical composition %			
Dry matter	85.80	86.30	85.30
Crude Protein	22.90	20.09	18.10
Crude fat	2.99	2.83	2.80
Crude fiber	3.70	3.42	3.40
Ash	6.04	5.52	5.20
Calculated composition			
ME(kcal/Kg)	3200	3200	3200
Crude Protein %	23.00	20.00	18.00
C/P ratio	139.13	160.00	177.77
Calcium %	1.00	0.91	0.81
Phosphorous, available %	0.45	0.38	0.31
Lysine %	1.10	1.01	0.89
Methionine %	0.51	0.39	0.32
TSAA** %	0.93	0.78	0.69
Price of ton diet (LE),2002	**961.64**	**877.30**	**819.07**

* Composition of the vitamins and minerals premix
Each2.5 kg of vitamin and minerals mixture contain: 12,000,000 IU vitamin A; 2,000,000 IU D3'; I0g E; 1g K3; 1g BI; 5g B2; 1,500 mg B6; I0 mg B12; 10g pantothenic acid; 20g Nicotinic acid, 1g Folic acid; 50 mg Biotin; 500g choline chloride, 4g Copper, 300 mg Iodine; 30g Iron; 60g Manganese; 50 Zinc, and 100 mg Selenium.
**TSAA: Total sulfur amino acid

Table (2): Effect of supplementing different levels of chromium on weekly body weights (Mean ± SE) of broiler chicks.

week	Cr level mg/kg diet					
	0 (control)	10	20	30	40	50
0	46.55±1.6^{a}	47.94± 1.7^{a}	47.64±1.6^{a}	48.86±1.9^{a}	49.26±2.6^{a}	47.37±1.5^{a}
1	146.55±4.2^{b}	158.43±3.1^{a}	159.69±2.9^{a}	150.43±4.4^{a}	153.90±3.8^{ab}	149.71±2.7^{a}
2	365.84±9.4^{b}	397.92± 6.7^{a}	394.20±6.8^{a}	380.86±9.4^{ab}	385.87±9.3^{ab}	365.82±7.1^{b}
3	699.89±14.1^{b}	746.17±11.7^{a}	755.54 ±12.7^{a}	745.46±15.8^{a}	752.22±11.6^{a}	678.42±12.7^{b}
4	1094.97±17.7^{a}	1119.18±15.4^{a}	1136.78±19.5^{a}	1080.00±23.1^{a}	1111.54±14.4^{a}	1004.36±16.7^{b}
5	1504.17±24.3^{a}	1537.53± 24.6^{a}	1526.43±27.1^{a}	1490.07±28.6^{a}	1508.81±23.6^{a}	1406.15±26.2^{b}
6	1940.22±31.2^{a}	1952.97±32.5^{a}	1951.56±33.3^{a}	1900.19±31.9^{a}	1899.42±28.5^{ab}	1807.25±33.1^{b}
7	2242.78±37.4^{b}	2376.94 ± 42.4^{a}	2410.89±40.5^{a}	2407.04±42.5^{a}	2408.06±36.6^{a}	2291.77±44.5^{ab}

a-b Means within the same row having different superscripts are significantly different ($p < 0.05$)

Table (3): Weekly means ± SE of weight gain (WG) g, feed consumption (FC) g and feed conversion Efficiency (FCE) for the experimental chicks.

Weeks	Item	Cr level mg/kg diet					
		0	10	20	30	40	50
0- 1wks	W.G	100.00±5.1^{b}	110.49±2.3^{a}	112.05±2.2^{a}	101.57±2.9^{b}	104.64±8.01^{b}	102.34±2.3^{b}
	F.C	118.45± 6.6^{b}	131.09±2.3^{a}	132.49±1.5^{a}	122.63±2.2^{b}	129.28±6.0^{a}	126.26±3.4^{ab}
	F.C.E	1.185±0.04^{b}	1.186± 0.03^{b}	1.182±0.03^{b}	1.219±0.04^{ab}	1.235±0.06^{a}	1.234±0.05^{a}
1-2wks	W.G	219.29±7.3^{b}	239.49±5.6^{a}	234.51±0.7^{ab}	230.43±3.5^{ab}	231.97±8.8^{ab}	216.11±5.4^{b}
	F.C	309.08±9.0^{a}	325.74±5.8^{a}	319.23±2.7^{a}	311.08±3.4^{a}	319.91±8.3^{a}	306.78±5.7^{a}
	F.C.E	1.409± 0.01^{a}	1.360± 0.02^{a}	1.361±0.01^{a}	1.350± 0.02^{a}	1.379±0.03^{a}	1.420±0.03^{a}
2-3wks	W.G	334.05±7.7^{ab}	348.25±7.2^{a}	361.34±16.3^{a}	364.60±10.4^{a}	366.35±9.4^{a}	312.6±5.4^{b}
	F.C	519.16±29.8^{a}	529.19±7.7^{a}	502.79±8.4^{a}	509.87±25.3^{a}	542.90±3.3^{a}	510.26±13.9^{a}
	F.C.E	1.554± 0.02^{b}	1.520± 0.02^{b}	1.391±0.02^{c}	1.398±0.03^{c}	1.482±0.05^{ab}	1.632±0.02^{a}
3-4 wks	W.G	395.08±13.1^{a}	373.01±12.3^{a}	381.24±12.0^{a}	334.54±29.5^{b}	359.32±13.1^{ab}	325.94±13.8^{b}
	F.C	782.39±44.0^{a}	741.97±10.2^{a}	767.60±7.8^{a}	737.25±55.3^{a}	751.53±6.1^{a}	729.31±18.4^{a}
	F.C.E	1.980± 0.07^{b}	1.989± 0.03^{b}	2.013±0.06^{b}	2.204±0.0^{ab}	2.092±0.06^{ab}	2.238±0.05^{a}
4-5 wks	W.G	409.20±29.4^{a}	418.35±38.2^{a}	389.65±20.2^{a}	410.07±17.7^{a}	397.27±18.2^{a}	401.79±6.2^{a}
	F.C	863.74±43.6^{a}	856.27±50.1^{a}	827.57±35.2^{a}	899.21±50.4^{a}	870.06±24.3^{a}	877.24±16.8^{a}
	F.C.E	2.111± 0.05^{a}	2.047±0.07^{a}	2.124±0.03^{a}	2.193±0.03^{a}	2.190±0.05^{a}	2.183±0.1^{a}
5-6 wks	W.G	436.05±30.8^{a}	415.44±93.6^{a}	425.13±21.0^{a}	410.12±5.0^{a}	390.61±19.6^{a}	401.10±18.7^{a}
	F.C	1047.54±45.7^{a}	1005.19±33.6^{a}	979.49±25.7^{a}	1009.26±33.5^{a}	952.96±38.6^{a}	946.60±17.6^{a}
	F.C.E	2.402± 0.13^{a}	2.420± 0.02^{a}	2.304±0.05^{a}	2.461±0.07^{a}	2.440±0.07^{a}	2.360±0.07^{a}
6-7 wks	W.G	302.56±14.9^{c}	423.97±39.6^{b}	459.33±16.6^{ab}	506.85±9.9^{a}	508.64±32.6^{a}	484.52±11.07^{ab}
	F.C	1060.38±36.5^{b}	1098.89±56.4^{ab}	1129.36±44.9^{ab}	1213.53±26.0^{a}	1171.59±41.2^{ab}	1181.31±65.4^{ab}
	F.C.E	3.505±0.15^{a}	2.592±0.09^{b}	2.458±0.09^{b}	2.394±0.09^{b}	2.303±0.07^{b}	2.438±0.09^{b}
0-7 wks	W.G	2196.23±37.1^{b}	2329.0±67.1^{ab}	2363.25±47.5^{a}	2358.18±56.9^{a}	2358.8±59.8^{a}	2244.4±32.8^{ab}
	F.C	4700.74±53.6a	4688.34±101.4 a	4658.53±93.5 a	4802.83±104.1 a	4738.23±70.72 a	4677.76±107.5 a
	F.C.E	2.140±0.01^{a}	2.013± 0.03^{b}	1.971± 0.02^{b}	2.037±0.02^{b}	2.009±0.03^{b}	2.084±0.03^{b}

a - c Means within the same row having different superscripts are significantly different ($p < 0.05$)

Table (4): Effect of different levels of chromium on carcass characteristics (means±SE) of 7 wks old male broiler chicks.

Items	Cr level mg/kg diet					
	0	10	20	30	40	50
Live body weight, g.	2278.33±42.1	2353.33± 8.8	2447.33± 22.2	2363.33±28.9	2397.33±15.9	2295.67±52.3
Liver weight, g.	72.51±9.3^{a}	57.61±2.0^{ab}	44.51±5.5^{b}	50.58±3.6^{b}	48.60±2.1^{b}	50.37±2.1^{b}
Heart weight , g.	14.11±1.3^{a}	14.50±2.2^{a}	15.08±3.4^{a}	13.89±1.9^{a}	13.96±2.3^{a}	14.17±1.2^{a}
Spleen weight, g.	3.73±0.72^{ab}	3.98±0.4^{a}	2.93±0.2^{ab}	2.16±0.2^{b}	3.93±0.8^{a}	2.7±0.1^{ab}
Empty gizzard, g.	47.29±12.33^{a}	30.17±2.3^{b}	33.73±4.6^{b}	33.50±2.3^{b}	35.39±5.3^{b}	96.97±4.5^{b}
Giblets weight*,g.	135.74±12.3^{a}	106.26±1.4^{b}	99.25±10.9^{b}	97.46±3.2^{b}	101.18±6.8^{b}	96.97±4.5^{b}
Giblets %	5.96 ±0.48^{a}	4.52±0.04^{b}	4.06±0.43^{b}	4.12±0.11^{b}	4.39±0.27^{b}	4.23±0.23^{b}
Carcass weight**,g.	1591.67±30.0^{c}	1731.33±16.7^{ab}	1780.33±12.7^{a}	1744.33±33.9^{ab}	1743.6±17.1^{ab}	1687±39.6^{b}
Carcass %	69.86±0.12^{b}	73.57±0.9^{a}	72.75±0.3^{a}	73.80±0.6^{a}	72.74±0.7^{a}	73.48±0.05^{a}
Meat (breast and legs),g.	713.33±8.8^{b}	8+45.0±16.1^{a}	861.67±9.27^{a}	831.33±22.5^{a}	825.00±19.2^{a}	805.0±16.1^{a}
Meat (breast and legs) %	31.31±0.33^{b}	35.91±0.8^{a}	35.21±0.2^{a}	35.18±1.4^{a}	43.41±0.6^{a}	35.09±0.9^{a}
Abdominal fat, g.	54.30±7.3^{a}	24.32±2.8^{bc}	26.96±1.4^{b}	25.04±2.3^{bc}	12.07±0.7^{d}	14.62±3.2^{cd}
Subcutaneous fat, g.	100.33±5.49^{a}	18.76±6.4^{b}	3.33±0.9^{c}	10.33±3.8^{c}	7.00±0.6^{c}	9.67±3.8^{c}
Total body fat, g.	154.63±4.9^{a}	43.08±8.3^{b}	30.29±2.2^{bcd}	35.37±4.8^{bc}	19.07±0.5^{d}	24.28±0.8^{cd}
Total body fat %	6.79±0.2^{a}	1.83±0.4^{b}	1.24±0.1^{bcd}	1.50±0.2^{bc}	0.80±0.02^{d}	1.06±0.02^{cd}

a – d Means with different letters within each row are significantly different at $p < 0.05$

*Giblets (liver, heart, spleen and empty gizzard)

**Carcass weight = Eviscerated weight

Table (5): Effect of different levels of chromium on plasma total protein, albumin, creatinine, glucose, total lipids, triglycerides and cholesterol (means ± SE) of male broiler chicks.

Items	Cr level mg/kg diet					
	0	10	20	30	40	50
Total protein (g/dl)	3.60 ±0.02[b]	3.64±0.69[b]	4.61±0.56[a]	4.86±0.60[a]	5.20±0.58[a]	5.35±0.55[a]
Albumin (g/dl)	2.23±0.56[a]	2.55±0.56[a]	2.74±0.57[a]	2.86±0.52[a]	2.94±0.59[a]	2.97±0.57[a]
Creatinine (mg/dl)	0.98 ±0.19[a]	1.13±0.35[a]	1.03±0.19[a]	0.81±0.14[a]	0.75±0.16[a]	0.89±0.16[a]
Glucose (mg/dl)	268.33±4.4[a]	245.33±2.9[b]	233.67±3.1[bc]	219.3±11.5[bc]	196.6±17.4[cd]	173.00±15.8[d]
Total lipids (mg/dl)	4.25±0.57[b]	4.55±0.57[b]	6.83±0.62[a]	6.71±0.80[a]	7.12±0.55[a]	6.92±0.72[a]
Triglycerides (mg/d)	77.67±3.93[c]	78.33±0.88[c]	86.67±2.03[b]	87.00±1.53[b]	86.70±1.76[d]	94.33±2.33[a]
Cholesterol (mg/dl)	173.67±3.2[a]	159.67±3.1[b]	151.33±1.8[b]	147.33±1.7[b]	143.67±6.4[ab]	139.67±6.9[a]

a-d Means within the same row having different superscripts are significantly different ($p < 0.05$)

Table (6): Input-output analysis and economical efficiency of different dietary treatments.

Items	Cr level mg/kg diet					
	0	10	20	30	40	50
Average feed consumed (kg)	4. 701	4. 688	4. 659	4.803	4.738	4.678
Price/kg feed consumed (PT) [1]	88.109	88.555	88.856	89.138	89.700	90.006
Total feed cost (PT)	414.200	415.146	413.980	428.130	424.999	421.048
Average live Weight (kg)	2.243	2.377	2.411	2.407	2.408	2.221
Price/kg live Weight (PT) [2]	600.00	600.00	600.00	600.00	600.00	600.00
Total revenue (PT)	1345.80	1426.20	1446.60	1444.20	1444.80	1332.60
Net revenue (PT)	931.600	1011.054	1032.62	1016.07	1019.80	911.552
Economic efficiency (EE)[3]	2.249	2.435	2.494	2.373	2.400	2.165
Relative economic efficiency[4]	100	108.27	110.89	105.51	106.71	96.27

Price of 1 kg $CrCl_3$= 80 LE.

1. Total price of feed consumed at starting, growing and finishing periods / total feed consumed
2. According to the local market price at the experimental time (2002).
3. Net revenue per unit food cost.
4. Assuming the E.E. of control diet equals 100.

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الملخص العربي

تأثير إضافة الكروميوم للعليقة علي النمو وصفات الذبيحة وبعض قياسات الدم لكتاكيت التسمين

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أجريت هذه التجربة لدراسة تأثير إضافة ٥ مستويات من الكروميوم (كلوريد الكروميوم) في العلائق علي النمو و صفات الذبيحة و بعض قياسات الدم والكفاءة الأقتصاديه لكتاكيت التسمين. تم أجراء التجربة باستخدام ٢٤٠ كتكوت تسمين أربوايكرز(ذكور) عمر يوم قسمت عشوائيا إلى ٦ مجاميع كانت المجموعة الأولى منها كنترول و باقي المجاميع غذيت علي العليقة الكنترول مضافا إليها أحد مستويات الكروميوم التالية ١٠و٢٠ و٣٠ و٤٠ و٥٠ ملجم كروميوم/كجم عليقه علي التوالي. واستمرت التجربة لمدة سبع أسابيع.وكانت نتائج التجربة مايلي:

١. أوضحت النتائج زيادة معنوية في وزن الجسم في نهاية التجربة بالنسبة للكتاكيت المغذاة علي علائق مضاف أليها المستويات التالية من الكروميوم ١٠و٢٠ و٣٠ و٤٠ ملجم كروميوم/كجم عليقه بالمقارنة بالكنترول.

٢. كانت هناك تحسن معنوي في الزيادة في وزن الجسم المكتسب طول فترة التجربة للمجاميع المغذاة علي علائق مضاف إليها الكروميوم بمستويات ٢٠،٣٠،٤٠ ملجم كروميوم/كجم عليقه عند المقارنة بالكنترول.

٣. لم يكن هناك اختلاف معنوي في كمية الغذاء المستهلك طول فترة التجربة بين كتاكيت مجاميع الكروميوم التجريبية و المجموعة الكنترول.

٤. حدث تحسن معنوي في كفاءة تحويل الغذاء طول فترة التجربة في جميع المجاميع التجريبية بالمقارنة بالمجموعة الكنترول و كان التحسن بنسب ٥,٩٣ و٧,٩٠ و٤,٨١ و٦,١٧ و٢,٦٢ % من قيم الكنترول للمجاميع التجريبية المغذاة علي علائق مضاف إليها كروميوم بمستويات١٠، ٢٠ ،٣٠ ، ٤٠ ، ٥٠ ملجم كروميوم/كجم عليقه علي التوالي.

٥. أدى إضافة الكروميوم في جميع العلائق التجريبية إلى تقليل نسبة النفوق في كتاكيت التسمين بالمقارنة بالكنترول وأظهرت المجموعة المغذاة على٢٠ملجم كروميوم/كجم أقل نسبة نفوق(٢%).

٦. أوضحت نتائج صفات الذبيحة نقص معنوي فى وزن الكبد للمجاميع التجريبية المغذاة على ٢٠ملجم كروميوم أو أكثر/ كجم عليقة. كما كان هناك نقص معنوي لمجاميع الكروميوم في

وزن القونصة فارغة ووزن الحلويات والنسبة المئوية للحلويات ووزن دهن البطن ووزن الدهن تحت الجلد ووزن دهن الجسم الكلى والنسبة المئوية لدهن الجسم الكلي بالمقارنة بالكنترول. كما أظهرت النتائج زيادة معنوية في وزن الذبيحة و النسبة المئوية للذبيحة ووزن لحم الصدر والأفخاذ و النسبة المئوية للحم الصدر والأفخاذ بالمقارنة بالكنترول. كما لم يوجد اختلافات معنوية في وزن القلب والطحال بين المجاميع التجريبية والكنترول.

٧. كانت هناك زيادة معنوية في بلازما البروتين الكلي و الدهن الكلي و التراي جلسريد بين المجاميع التجريبية ماعدا المجموعة المغذاة على عليقة مضاف إليها ١٠ملجم كروميوم/كجم عليقه بالمقارنة بالمجموعة الكنترول بينما لم يتأثر البيومين البلازما والكرياتينين بإضافة الكروميوم إلى العلائق وكان هناك نقص معنوي في جلوكوز البلازما والكوليسترول الكلي في المجاميع التجريبية بالمقارنة بالكنترول.

٨. حدث تحسن في الكفاءة الاقتصادية للعلائق نتيجة لإضافة الكروميوم بالمستويات ١٠و٢٠ و٣٠ و٤٠ ملجم/كجم عليقه بالمقارنة بالكنترول. وهذا التحسن بنسبة ٨,٢٧ و١٠,٨٩ و ٥,٥١ و ٦,٧١%على التوالي.

أوضحت النتائج المتحصل عليها من هذه الدراسة أن استخدام الكروميوم في علائق كتاكيت التسمين بمعدل ٢٠ ملجم كروميوم/كجم عليقة كان الأكثر كفاءة في تحسين أداء الكتاكيت وصفات الذبيحة وتقليل وزن دهن الجسم والكوليسترول في الدم كما أدى إلى تحسين الكفاءة الأقتصاديه للعلائق.