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The Influence of Chromium Sources on Growth Performance, Economic Efficiency, Some Maintenance Behaviour, Blood Metabolites and Carcass Traits in Broiler Chickens

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Abstract: An experiment was conducted to study the effect of dietary supplemental chromium (Cr) source on growth performance, economic efficiency, blood metabolites and some maintenance behaviour in broiler chickens. A total of 225 one day old Cobb broiler chicks were used. Birds were divided into three experimental groups, each group into equal 5 subgroups (15 chicks/each subgroup). Broiler chickens fed on 3 experimental diets for six weeks; control diet (group I), control diet supplemented with Cr (0.5 ppm Cr/kg) either in the inorganic form (group II) and organic form (group III). The results indicated that body weight and its gain were significantly increased, while feed intake and total food conversion ratio weren't significantly different in the experimental groups. Nevertheless, there are significant differences between experimental diets in variable costs, total costs, return and net profit. Moreover, all behavioural traits were significantly affected by supplementation by chromium, where the ingestive behaviour was significantly higher in group supplemented by organic chromium and , the most of comfort behaviour was significantly higher in groups I and II. Glucose and cholesterol in blood were significantly affected by different sources of chromium. Although, the broilers fed organic form of chromium was superior to inorganic in growth performance parameters and some serum biochemical parameters, but the inorganic form of chromium showed the highest net profit in comparison with organic form and control group.

Key words: Chromium (Cr) · Performance · Economic · Behaviour · Broiler

INTRODUCTION

The most important part of raising chickens is feeding. Feeding makes up the major cost of production and good nutrition reflected in the bird's performance and its products [1]. In recent years, there has been considerable research interest in the utilization of organic chromium in animal feed. The chromium from organic complex, as chromium picolinate, chromium complexed with amino acids or Cr-enriched yeast is absorbed more efficiently, about 25-30 % more than inorganic compounds as chromium chloride, which is poorly absorbed (1-3%) regardless of doses or dietary chromium status [2]. Although NRC [3] didn't specify any recommendation for Cr in poultry diets, research reports suggested important nutritional and physiological roles for chromium [4]. The NRC recommends an amount of 300 µg/kg Cr for the diets of laboratory animals [5]. The supplementation of Cr in the livestock diet can improve animal metabolism due to its role as a co-factor in glucose tolerance factor, which

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increases the sensitivity of tissue receptors to insulin, resulting in increased glucose uptake by cells [6]; thus enhance performance and the composition of animal products [7]. Cr is also required for normal functioning of the β cells in the pancreas, preventing hyper responsiveness of insulin secretion to glucose stimulation, shown to be a protective factor against heart disease and achieving a regression of cholesterol induced arteriosclerosis in rabbits [8]. Small scale and semi-commercial poultry production is seen as a vital tool in reducing poverty and hunger in developing countries [9]. The well-being of poultry has been showed to play a significant role in level of production and hens are known to respond to stressful conditions [10]. The behavioural data as the indicator of well-being of animals have supplemented the evaluation of welfare and contributed to explain the more traditional data on production, health and economy [11].

MATERIALS AND METHODS

In this study, 225 one-day old Cobb broiler chicks were used (with an average weight 44 g) and obtained from commercial hatchery. The birds were randomly divided into 3 experimental groups, each group divided into equal 5 subgroups (15 chicks in each subgroup). The basal diet was formulated according to NRC [3] during starter period (0-3 wks; crude protein "CP" 23.20% and metabolized energy "ME" 3218 kcal/kg diet) and grower-finisher period (3-6 wks; CP 19.55% and ME 3218 kcal/kg diet). Physical and chemical compositions (%) of the experimental diets were mentioned in Table (1). Feed and water were provided ad-libitum. Feed ingredients and diets were analyzed for dry matter, crude protein, ether extract and ash according to procedures described by AOAC [12]. The analyzed values are in close agreement with the calculated values. The broilers fed on 3 experimental diets; control diet (group I), control diet supplemented with 0.5 ppm Cr/kg either in the inorganic form (group II) and organic form (group III). Organic Cr used is Bio-chrome (Cr enriched yeast. Products of Alltech, Inc. (Nicholasville, KY, USA).

Growth Performance Parameters: were recoded according to Amera *et al.*, [13], where, the birds were weighted at first day of age as one day-old weight and then live body weights were recorded, also feed residues and thus average feed intake were recorded daily. Body weight gain (BWG) and feed conversion ratio (FCR) were calculated over period of experiment.

Table 1: Physical and chemical composition (%) of the experimental diets

Ingredient	Starter (0-3 wks)	Grower-finisher (3-6 wks)
yellow corn	59.70	68.20
Soybean meal, 48%	24.30	19
Corn gluten, 60%	6	3.50
Fish meal, 65%	2.75	2.5
Soybean oil	3.50	2.8
Calcium carbonate	1.20	1.20
Calcium dibasic phosphate	1.50	1.50
Common salt	0.30	0.30
Premix[1]	0.30	0.30
DL-Methionine, 98%	0.20	0.12
Lysine, Hcl, 78%	0.15	0.18
Metabolized energy, Kcal/Kg	3218.35	3218.67
Crude Protein %	23.20	19.55
Ether extract %	8.01	8.20
Crude Fiber %	2.58	2.48

Economic Efficiency Measurements: I. Cost parameters: Were classified according to the methods implied by Ahmed [14] to:

- Total fixed costs (TFC): In this condition each chick took the same value of price of labor, litter, purchased chicks, veterinary medicaments, water and electrolyte, building and equipment depreciation [15].
- Total variable costs (TVC): It included feed price and feed additives costs.
- Total costs (TC): It is the summation of total fixed costs and total variable costs.

Returns Parameters:

- Total returns (TR) from chick sale = Body weight x kg price.
- Net Profit was calculated as = Total returns-Total costs

- Partial and collective measurement of the efficiency of feed additives, as according to Fardos [16].

Behavioural Traits: Birds used in this study were observed as scan samples [17] for 3 days / week throughout six weeks. Behavioural observation was in two observational periods; in the morning (7.00-11.00 am) and at afternoon (13.00-17.00 pm) for 8 hrs / week. The following behavioral parameters were observed and measured throughout the experiment; ingestive behaviour (feeding frequency and drinking frequency); comfort behaviour which includes preening, dust bathing, idling, resting, sleeping, wing and leg stretch behaviour [18].

The number of birds performing each of behaviour was recorded and the results were expressed as the percentage of birds performing the behaviour/total observed birds [19].

Blood Sampling and Biochemical Analysis: At the end of experiment, five birds were randomly selected from each group and slaughtered for collection of blood samples to determine some biochemical metabolites as glucose, total protein [20], albumin [21], globulin by subtracting the obtained albumin level from the total protein [22], cholesterol [23]. Serum aspartat-aminotransferase (AST) and alanine-aminotransferase (ALT) were determined by Reitman and Frankel [24].

Carcass Traits: The carcass was carefully eviscerated and split open to remove the gastrointestinal tract. Carcass weights were recorded. Organs weight such as liver, stomach, intestine and heart were separated and weighted. Recorded weights of part were expressed as percentage of respective live body weight [25].

Statistical Analysis: The obtained data in this study were statistically analyzed for variance ANOVA, LSD (Least significant difference) according to Snedecor and Cochran [26]. Differences among treatment means were compared using Duncan's multiple range tests [27]. Data were presented as mean ± SE and significance was declared at P < 0.05.

RESULTS

Table (2), showed that the final total body weight and body weight gain were significantly higher in group III, however, feed intake and FCR were unaffected by chromium sources. All economic measures were significantly differed among the groups, where the net profit was significantly higher in group II, as in Table (3). Table (4) showed that the ingestive behaviour was significantly higher in group III in compare with other groups. While the most forms of comfort behavior were significantly higher in groups I and II than groups III. The serum biochemical parameters as shown in Table (5)

Table 2: Effect of dietary chromium sources (inorganic and organic) on the overall performance of broiler chickens (Means ± SE)

The performance	Group I	Group II	Group III
Initial BW (g)	44.40±0.52	44.46±0.51	44.46±0.54
Final BW (g)	1953.34±4.71^{b}	1993.10±3.99^{a}	2012.53±16.08^{a}
Absolute Body gain (g)	1908.93±5.03^{b}	1948.64±3.72^{a}	1968.64±15.72^{a}
Total feed intake	3199.96±46.86	3197.20±40.58	3262.04±46.88
FCR	1.67±0.03	1.64±0.02	1.65±0.02

^{ab} Mean in the same row with different superscripts are significantly different at (P < 0.05).

Table 3: Economic measures of dietary chromium sources (inorganic and organic) of broiler chickens (Means ± SE)

Economical measures	Group I	Group II	Group III
Fixed costs (Piasters)	645.7	645.7	645.7
Total variable costs (Piasters)	1072.11±0.43^{c}	1080.65 ± 0.51^{b}	1118.19 ±3.74^{a}
Total costs (Piasters)	1717.81±0.43^{c}	1726.35±0.51^{b}	1763.89±3.74^{a}
Return (Piasters)	1806.84±1.67^{c}	1843.62±1.55^{b}	1859.92±0.74^{a}
Net profit (Piasters)	89.03±1.41^{b}	117.27±1.41^{a}	96.04±4.48^{b}
Total return / Total cost %	105.18±0.08^{b}	106.79±0.08^{a}	105.45±0.27^{b}
Total return / Total variable cost %	168.53±0.12^{b}	170.60±0.13^{a}	166.34±0.62^{c}
Net profit / Total cost %	5.18±0.08^{b}	6.79±0.08^{a}	5.45 ±0.27^{b}
Net profit /Total variable cost %	8.30±0.13^{b}	10.85±0.13^{a}	8.59±0.43^{b}
Feed additive cost/Total return %	………	0.1607±0.0001^{b}	0.4167±0.0002^{a}
Feed additive cost / Total cost %	………	0.1716±0.0001^{b}	0.4394±0.0009^{a}
Feed additive cost/Total variable cost %	………	0.2741±0.0001^{b}	0.6931±0.0023^{a}

^{abc} Mean in the same row with different superscripts are significantly different at (P < 0.05).

Table 4: The mean (± SE) of the frequencies of ingestive and comfort behaviour in broiler chickens under effect of dietary chromium sources (inorganic and organic)

Behavioural traits		Group I	Group II	Group III
Ingestive behaviour	Feeding	14.22±0.71[b]	17.33±0.25[a]	18.41±0.38[a]
(Frequencies / 8 hrs)	Drinking	3.24±0.14[b]	3.82±0.13[b]	3.99±0.08[a]
	Preening	5.02±0.17[b]	6.22±0.12[a]	5.29±0.11[b]
	Dust Bathing	0.11±0.02[c]	0.35±0.03[a]	0.26±0.02[b]
Comfort behaviour	Idling	0.20±0.02[a]	0.07±0.02[b]	0.08±0.02[b]
(Frequencies / 8 hrs)	Resting	22.84±0.24[c]	31.18±0.43[b]	38.55±0.38[a]
	Sleeping	13.62±0.59[b]	18.60±0.57[a]	18.77±0.24[a]
	Wing and Leg stretch	7.66±0.30[a]	7.66±0.30[a]	7.35±0.13[ab]

[abc] Mean in the same row with different superscripts are significantly different at ($P < 0.05$).

Table 5: Effect of dietary chromium sources (inorganic and organic) on serum biochemical parameters of broiler chickens (Means±SE)

Biochemical parameters	Group I	Group II	Group III
Glucose (mg / dl)	188.12±1.52[a]	182.16±2.11[a]	173.82±1.45[b]
Cholesterol (mg / dl)	137.11±1.68[a]	132.67±0.94[ab]	129.67±1.27[b]
Total protein (g / dl)	4.79±0.28	4.89±0.18	5.57±0.34
Albumin (g / dl)	1.88±0.15	1.90±0.16	2.09±0.08
Globulin (g / dl)	2.91±0.31	2.99±0.03	3.48±0.26
Ast (IU / dl)	45.63±2.81	46.30±2.16	45.24±2.47
Alt (IU / dl)	9.01±1.66	9.12±0.88	9.24±1.18

[ab] Mean in the same row with different superscripts are significantly different at ($P < 0.05$).

Table 6: Effect of dietary chromium sources (inorganic and organic) on carcass traits of broiler chickens (Means±SE)

Carcass traits (%)	Group I	Group II	Group III
Dressing	71.90 ± 2.09	69.54 ± 3.04	69.88 ± 0.51
Liver	2.58 ± 0.15	2.07 ± 0.19	2.15 ± 0.09
Stomach	2.11 ± 0.10	2.08 ± 0.11	1.95 ± 0.11
Intestine	3.70 ± 0.04	3.66 ± 0.02	3.66 ± 0.04
Heart	0.98 ± 0.07	1.11 ± 0.08	0.96 ± 0.03

revealed that the most parameters did not appear any significance differences among the groups; nevertheless the glucose and cholesterol were higher in control group with significant differences.

Statistical analysis of data on carcass traits relative to the live weight of broiler chickens is presented in Table (6). Carcass traits studied (dressing, liver, intestine and heart) wasn't significantly ($P > 0.05$) different for experimental groups compared with the control group.

DISCUSSION

Animal habitat consists of five essential elements: food, water, shelter, space and the arrangement of these elements. Although requirements differ in composition and quantity from species to species, all animals require these elements to survive [28]. At the 6th week, there was significant increase in the final body weight and BW gain of the experimental groups if compared with the control. There wasn't significantly different feed intake among the dietary treatments up to 6th weeks if compared with the control. Non significant differences in the total FCR among the dietary treatments if compared to the control group. Our growth performance results on broilers agreed with Sahin *et al*., Króliczewska *et al*., Toghyani *et al*. [29, 30, 31], in which these studies have reported that the use of organic or inorganic sources of chromium resulted in slightly better growth performance parameters in some poultry species. Due to insulin, glucose can be utilized by body cells and adequate amino acids enter the cells therefore muscle can be built [32].

On the other hand, studies have reported that the growth performance of some poultry species weren't affected by the source or level of chromium supplemented in the diets [7, 33, 34, 35, 36].

Economic Efficiency: as shown in Table 3. There are significant differences between experimental diets in variable costs, total costs, return and net profit. The organic chromium supplemented group showed the highest return and also the highest total costs while, the control group showed the lowest return and lowest total costs. While, inorganic chromium supplemented group showed the highest net profit followed by organic chromium supplemented group and the control group showed the lowest one. Collective efficiency measures revealed significant difference among the supplemented groups. The inorganic chromium supplemented group showed the highest value for total return / total cost, total return / total variable cost, net profit / total cost and net profit / total variable cost. Partial efficiency measures revealed significant difference among the supplemented groups. The inorganic chromium supplemented group showed the lowest value for feed additive cost / total return (%), feed additive cost / total cost (%) and feed additive cost / total variable cost (%) while organic chromium supplemented group showed the highest value of these measures.

The results in Table (4) indicated that the frequency of ingestive behaviour (feeding and drinking) was significantly affected, which maybe due to its relation to the positive effects on performance parameters can be related to role of chromium as an integral component of the glucose tolerance factor (GTF), which potentiates the action of insulin, one of the most important anabolic hormones [37]. The comfort behaviour patterns as indicator of animal welfare [38], where it measured by recordings of both behavioural and physiological parameters [39]. Thus, it may protein levels were significantly increased in-group I. prove beneficial effects on birds under stress as anti-stress factor [34] and reflect on the comfort behaviour.

The most of blood parameters (total protein, albumin, globulin, AST and ALT) as shown in Table (5) weren't significantly affected by supplementation by chromium. No difference in total protein among experimental groups was agreed with Sahin *et al*. [29], who found that supplemental chromium had no effects on serum total protein and urea levels in blood. On the other hand, other studies [34, 35, 36] cited that the total protein level was significantly higher in control group in compare to chromium groups. Even though, serum glucose and cholesterol in Table (5) were significantly lower in group III in compare to other groups. Our results agreed with Eseceli *et al*.; Hanafy; Suksombat and Kanchanatawe [35, 36, 40] in which were found that serum cholesterol levels of birds were decreased both by organic and inorganic chromium supplementation. Chromium supplementation may lead to decrease in serum cholesterol concentrations in Japanese quails [41] and laying hens [42]. Nevertheless, Yeşilbağ and Eren [34] found that serum cholesterol levels of birds weren't affected by chromium supplementation (organic and inorganic), while serum glucose levels were significantly increased inorganic. 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.

The obtained results (Table 6) revealed weren't significantly ($P > 0.05$) in the studied carcass traits for experimental groups compared with the control group. Similarly, Jackson *et al*. [33] reported no significant effect from dietary supplementation of Cr to broiler chickens. Supplementation of Cr increased carcass protein with a simultaneous reduction in the carcass fat content of the broiler chickens [43, 44]. This may be due to the potentiation of insulin action under the influence of Cr that might in turn have promoted the tissue uptake of protein or inhibitory effects on *in vitro* lipogenic activity in chick adipose tissue [43, 45].

CONCLUSION

The supplementation of broiler diets with organic chromium improved final total body weight and body weight gain. Moreover, it has positive effects on ingestive and the most of comfort behaviour. Even though, it caused significant lower values of total serum glucose and cholesterol. Thus, it's possible that the use of organic chromium instead of inorganic chromium in broiler diets may gave better results.

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