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Dietary supplementation of chromium yeast alone and in combination with antioxidants for designing broiler meat

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Abstract
The present study was carried out to evaluate the impact of dietary supplementation of chromium yeast alone and in combination with antioxidants for designing broiler meat. The experiment was performed in 180 Cob-400 straight run broilers chicks, distributed to four treatment groups viz. T_0, T_1, T_2 and T_3. Chromium was provided in the form of chromium yeast @ 0.5 mg Cr/kg (T_1) alone, Cr + 250 mg of ascorbic acid /kg (T_2) and Cr + 250 mg of vitamin E /kg (T_3) of diet. The results showed that best overall results in terms of lipid reduction and lean meat production were observed in chromium plus ascorbic acid supplemented group. In breast and thigh muscle, protein content was significantly ($P<0.01$) higher and fat content was significantly lower T_2 group. The value of total cholesterol in breast ($P<0.05$) and thigh ($P<0.01$) muscles were significantly reduced as compared to control group. Abdominal fat pad was reduced in all supplemented groups with the highest reduction in chromium plus ascorbic acid group implying a synergistic action between two. It is concluded that combination of chromium plus ascorbic acid offers great potential in designing the meat.

Keywords: chromium yeast, ascorbic acid, vitamin E, broiler, meat

Introduction

Chromium is an essential element required for normal carbohydrate, lipid and protein metabolism in humans and animals [1]. The primary role of chromium in metabolism is to potentiate the action of insulin through its presence in an organometallic molecule called glucose tolerance factor [2]. Metabolism of glucose in birds is considerably different from mammals while blood glucose concentration is much higher in birds and insulin levels are low [3]. Birds as compared to mammals are considered to be less sensitive to insulin and effect of chromium to enhance insulin sensitivity in mammals is well documented [4]. Poultry is reared in open side houses in most of the tropical countries like India which results in huge temperature variation in shed causing stress [5]. Heat or cold stress increase circulating concentrations of corticosterone in broilers and it is well documented that corticosterone reduces insulin sensitivity in broilers [6]. Though birds do not require any dietary vitamin source as they can synthesize vitamin C. Particular environmental stressors could alter ascorbic acid utilization or synthesis in poultry [7]. Since cooling of poultry houses (environment control) is very expensive thus methods are focused on nutritional modifications like search of new feed additives along with their different combinations to increase the performance of birds naturally [8].

Cardiovascular disease like coronary heart disease and atherosclerosis in humans is the second leading cause of death worldwide which are strongly related to dietary intake of cholesterol and saturated fat [9]. Saturated fat intake becomes more critical in human after the age of 50 where great caution is needed. Thus deceasing intake of cholesterol and saturated fats will be a choice of our health consciousssociety that too without compromising a lot on eating habits of economically growing society. Thus to produce more leaner meant naturally will be the demand of the future. Most of the studies indicate that dietary supplementation of chromium, ascorbic acid and vitamin E alone or in combination reduces environmental stress, enhances immune competence of chicken thus improve productivity [10, 11]. Serum triglycerides, total cholesterol, LDL cholesterol in serum as well as in meat were significantly reduced and HDL cholesterol was increased by dietary supplementation of chromium, ascorbic acid and vitamin

E alone or in combination improving meat quality [12]. The plasma/serum glucose levels were reduced by supplementation of chromium and vitamin C or vitamin E in broilers and laying hens [13,14]. Chromium supplementation increases protein percentage of breast and thigh muscle and decreases cholesterol level in muscle [15]. Thus chromium supplemented poultry meat may be lean and also give additional advantage by reducing low density lipoproteins. Studies show increase in protein percentage of breast and thigh muscle in broilers increased significantly on supplementation with chromium yeast [15]. In last few decades role of chromium in livestock and poultry nutrition has played an important role as research on nutrition is getting finer. Abdominal fat in poultry is considered as waste and unnecessary wastage of feed energy [10]. In various attempts to reduce this abdominal fat pad chromium supplementation has emerged as a promising source according to various studies conducted [11].

Chromium methionine supplementation in feed can improve laying performance largely because it alleviates harmful responses to stress conditions [31]. Serum triglycerides, very low density lipo- protein cholesterol, low density lipo-protein cholesterol were not significantly affected ($P<0.05$) by dietary treatments whereas total cholesterol concentration decreased in chicks fed chromium methionine compared to control [32]. Nevertheless, recent studies have obtained equivocal results in improved performance carcass measurement and blood parameters of broilers fed supplemental dietary chromium under either thermoneutral or heat stress condition [33].Variables such as management conditions including different stress factors, stressor severity and level of stress responses as dietary ingredients and nutrient content may influence the efficacy of a Chromium application in broilers [34]. Markedly increased blood glucose and total cholesterol concentrations during heat stress [35]. To more complicate matters, there is the observation that nutritionally relevant amounts of chromium in the diet seem to have no effects on plasma insulin levels in response to a glucose challenge in healthy Zucker lean rats [36]. Supplemental nano-chromium particles improved the retention of Zn, Fe, Ca, notably it increased the concentration of Chromium and calcium in the liver and also increased the number of lymphocytes in broiler chickens [37].Chromium propionate supplementation of a control diet containing 0.43 to 0.45mg chromium per kg enhanced insulin sensitivity [38]. Ferric reducing/ antioxidant power value was decreased in vitamin-C and chromium group by transport [39]. Supplementation of diets with antioxidant, especially vitamin-C and chromium is necessary to overcome the deleterious effects of heat stress on broilers performance [40].Supplemental dietary ascorbic acid was implicated in growth and improved colour of broiler meat [41]. Chromium content of the basal starter and finisher diet and drinking water is adequate to the normal requirement of broilers such as experimental conditions and supplementing of chromium may not be essential [42].

As per available literature ample work is done on chromium but work on chromium yeast in combination with other anti-oxidants to see any synergistic effect is very scanty. In view of the above, present experiment was designed to study the effect of dietary supplementation of chromium yeast alone and in combination with ascorbic acid and vitamin E on serum lipid profile, glucoseand muscle compositionof broilers.

Materials and Methods

One hundred eighty day old Cobb-400 broiler chicks were equally distributed into four treatment groups viz. T_0,T_1,T_2 and T_3. Each treatment group thus contained forty five chicks with three replicates of fifteen birds in each. Corn-soya based broiler mash (Table 1) was formulated as per BIS (1992) specifications to meet the nutrient requirements of broilers [29]. The standard starter mash (0 - 3 weeks) and finisher mash (4 - 6) were fed. Chromium was provided in the form of chromium yeast @ 0.5 mg Cr/kg (T_1) alone, Cr + 250 mg of ascorbic acid /kg (T_2) and Cr + 250 mg of vitamin E /kg (T_3) of diet. Blood samples were collected from randomly selected nine birds of each group (three from each replicate) at the end of 4th and 6th week. Serum was analyzed for glucose, triglycerides, total cholesterol, HDL cholesterol by semi auto analyzer using commercial kits supplied by Erba diagnostics and low density lipoprotein (LDL+VLDL) was calculated by indirect method. At the end of the experiment, three birds (one from each replicate) from each dietary treatment group were randomly selected and fasted for a period of twelve hours prior to slaughter then sacrificed. The birds were evaluated for carcass traits viz. dressed weight, cut-up part yields (breast, thigh), giblet yield (liver, heart and gizzard), organ weights (bursa and thymus) and abdominal fat weight were recorded and expressed as % of live weight. At the end of experiment breast and thigh muscle samples collected from carcass of each scarified birds (one from each replicate) from each dietary treatment group were subjected for analysis of moisture, protein, fat (ether extract) and total cholesterol content [28].

Ethical approval: The experiment followed the guidelines of the Institutional Animal Ethics committee.

Statistical analysis: The data generated throughout the experimental period was analyzed statistically by applying the Completely Randomized Design to study the effect of treatment on various parameters [16].

Results and Discussion

The data of serum glucoseof broilers are given in (Table 2). The average serum glucose values were found to be significantly ($P<0.05$) reduced in the treatment groups as compared to T_0 (control) group at 4th and 6th week. Reduction in serum glucose content in broilers due to the supplementation of organic chromium (T_1) as observed in the present study has also been reported [13,17]. T_2 group seemed to have the least values among the treated groups implying a synergistic effect between chromium and ascorbic acid [18]. The data of serum triglycerides in 4th and 6th week are presented in (Table 2) reveling that serum triglycerides were reduced significantly ($P<0.05$) in T_2 and T_3 group as compared to control group. Among the supplemented groups chromium yeast (T_1) varied non significantly but T_2 and T_3 varied significantly, implying a additive action of ascorbic acid / vitamin E on chromium for reducing serum triglyceridesand results were in agreement with [19].

The serum total cholesterol value from supplemented group were found significantly decreased (Table 2) as compared to T_0 (control) at both 4th and 6th week with the lowest in T_2 group. The findings of the present study are in accordance with [13, 15] who reported a reduction in serum cholesterol content due to the supplementation of organic chromium. However the combination of chromium yeast and ascorbic acid recorded lowest values for total cholesterol suggesting potentiated response of chromium in the presence of ascorbic acid, in agreement with [12]. The results of serum HDL cholesterolat 4th and 6th week are presented in (Table 2)

showing non-significant difference between the control and treatment groups. The findings of the present study are in accordance with [13, 20] but in contradiction with [21, 22] who reported increased serum HDL content due to chromium supplementation.

The serum low density lipoprotein LDL cholesterol in the supplemented group was significantly (Table 2) reduced as compared to T_0 (control) in both weeks and T_2 group recorded the lowest values of all. The result of the present study is in agreement with findings of [23] reported that reduced serum LDL cholesterol. The muscle total cholesterol values in supplemented groups showed significant differences in breast and thigh muscle cholesterol as compared to control group (Table 2). From the observations recorded, it can be inferred that, breast and thigh muscle cholesterol was significantly ($P<0.01$) decreased by dietary supplementation of chromium in the diet from chromium yeast and maximum reduction was seen in T_2 supplemented group. The findings of present study are in agreement with [24] who reported reduction in muscle cholesterol content due to the supplementation of organic chromium in broilers and the present study implies synergistic action of chromium and ascorbic acid to reduce muscle cholesterol.

The data of muscle, moisture, protein and fat are presented in (Table 3). The moisture content in of breast and thigh muscle was comparable in all treatment groups including control. However there was a significant increase in protein of breast and thigh muscle with highest in T_2 group followed by T_3, T_1 and T_0 respectively. The present findings are in agreement with [25, 26] who observed non-significant breast and thigh muscle moisture content in organic chromium supplemented broilers. The breast and thigh muscle protein content of supplemented T_2, T_1 and T_3 groups showed a relative increase over the control. This may be due to higher protein synthesis through improved amino acid uptake of muscular cells triggered by supplementation of chromium and synergistic action of ascorbic acid and protective action of vitamin E. A significant reduction in breast muscle and thigh muscle fat was seen in the treated groups in which T_2 group again recorded the lowest value followed by T_3 and T_1. The present findings are in close agreement with [15, 24, 27] observed a significant increase in protein content in breast and thigh muscle supplemented with organic chromium.

The data of weight of different organs and abdominal fat are presented in (Table 2). There was no significant difference observed in the total giblet weight but numerical increase in the control group was seen except in spleen were significant increase supplemented groups was found. The significant higher giblet weight in general and liver weight in particular observed in control group probably indicates its increased activity to meet the metabolic rate in the birds to combat stress. The results of the present findings are in agreement with [13, 15] reported the same results on supplementation of chromium in broilers

The mean spleen weight were significantly ($P<0.01$) increased in supplemented (T_2, T_3 and T_1) groups as compared to T_0 (control) group. Reduced spleen weight in the control group may be due to environmental stress, as adrenocortico tropic hormone (ACTH) and corticosterone administration decreased spleen weight because corticosterone eliminated growth of lymphoid organ such as the spleen.

Bursa and thymus weight percentage recorded showed non-significant effect in all experimental groups. The result of the present study is in agreement with [13, 15] who found spleen weight % increased in broiler supplemented with chromium from chromium picolinate and chromium yeast.

The mean abdominal fat percent were significantly ($P<0.05$) reduced in T_2, T_1 and T_3 supplemented groups as compared to (T_0) control group. The lower abdominal fat content in the chromium supplemented group may be due to chromium promote fat to be quickly hydrolyzed and provide energy and carbon source for amino acid and protein synthesis [30]. Lowest value of T_2 (CY + AA) can be attributed to the fact ascorbic acid for reduction spares chromium leading to more amino acid uptake and less fat formation.

Table 1: Composition of broiler mash (%)

Ingredients	Starter Mash	FinisherMash
Maize	56.2	62.5
Soybeanmeal	37.6	31.3
Vegetableoil	2.0	2.0
DCP	2.6	2.6
Calcite	1.0	1.0
Trace mineral mixture *	0.2	0.2
Salt	0.4	0.4
Othersupplement (g/100 kg)		
a) Vitaminpremix**	25	25
b) Methionine	155	34
c) Lysine	63	17
d) Choline Chloride	60	60
e) Maduramycin	50	50
f) Toxin binder	100	100

*1 Kg contains Mn 90 g; Zn 80 g; Fe 90 g; Cu 15 g; I 2.0 g and Se 300 mg.

**500 gm contains Vit.A 12; 50 MIU; Vit.D_3 2.80 MIU; Vit.E 30.00 g; Vit.K 2.00 g; Vit.B_1 2.00 g and Vit.B_2 2.00 g.

Table 2: Mean serum glucose and serum lipid profile of broilers from different treatment groups.

Particular	Week	Group			
		T_0	T_1	T_2	T_3
Triglycerides* (mg/dl)	4th	$76.21^{b}\pm3.09$	$67.26^{b}\pm2.20$	$57.19^{a}\pm2.51$	$61.3^{ab}\pm4.13$
	6th	$106.32^{b}\pm0.62$	$99.80^{b}\pm2.64$	$94.65^{a}\pm2.0$	$97.38^{a}\pm2.1$
Total cholesterol** (mg/dl)	4th	$99.95^{b}\pm1.72$	$90.65^{ab}\pm3.1$	$82.38^{a}\pm1.7$	$84.11^{a}\pm1.9$
	6th	$143.07^{c}\pm2.92$	$121.73^{b}\pm1.62$	$92.08^{a}\pm4.3$	$97.33^{a}\pm0.6$
HDL cholesterol (mg/dl)	4th	51.63±2.01	51.72±2.27	51.28±1.93	52.57±1.43
	6th	57.11±1.06	58.64±1.37	58.96±2.46	60.27±1.50
LDL cholesterol** (mg/dl)	4th	$48.32^{b}\pm9.7$	$38.93^{a}\pm4.30$	$31.10^{a}\pm2.07$	$31.54^{a}\pm0.83$
	6th	$85.96^{c}\pm3.97$	$63.09^{b}\pm1.61$	$33.12^{a}\pm6.10$	$38.06^{a}\pm1.79$
Glucose* (mg/dl)	4th	$149.20^{b}\pm5.59$	$136.25^{a}\pm4.22$	$130.30^{a}\pm2.95$	$141.90^{ab}\pm2.34$
	6th	$232.24^{b}\pm1.14$	$184.92^{a}\pm4.65$	$181.41^{a}\pm14.69$	$192.63^{a}\pm10.31$
Breast Muscle** Cholesterol (mg%)	6th	$76.34^{bc}\pm0.73$	$68.23^{b}\pm1.88$	$59.6^{a}\pm2.12$	$62.73^{ab}\pm1.73$
Thigh Muscle** Cholesterol (mg%)	6th	$105.42^{c}\pm1.05$	$97.71^{bc}\pm2.47$	$87.3^{a}\pm2.17$	$95.16^{ab}\pm2.43$

Mean bearing different superscripts (a,b,c) in row different significantly ($P<0.05$)*, ($P<0.01$)** and NS = Non-significant.

Table 3: Mean Muscle Moisture, Protein and Fat in broilers**.**

Parameters	T_0	T_1	T_2	T_3
Breast muscle moisture (%)	70.86±1.39	70.18±1.08	69.12±1.35	69.94±2.08
Thigh muscle moisture (%)	72.52±1.09	72.31±1.10	72.10±1.02	72.26±2.11
Breast muscle** protein (%)	23.31^{a}±0.19	24.26^{b}±0.08	25.54^{c}±0.05	24.75^{bc}±0.02
Thigh muscle** protein (%)	21.06^{a}±0.03	22.51^{b}±0.23	23.59^{c}±0.10	23^{bc}±0.10
Breast muscle** fat (%)	5.59^{b}±0.01	5.45^{a}±0.03	5.36^{a}±0.01	5.38^{a}±0.03
Thigh muscle* fat (%)	6.41^{b}±0.24	5.81^{a}±0.08	5.51^{a}±0.17	5.69^{a}±0.01

Mean bearing different superscripts (a,b,c) in row different significantly (P<0.05)*,(P<0.01)** and NS = Non-significant

Table 4: Mean carcass yield and organs weight of experimental broilers (% of live weight)

Parameters	T_0	T_1	T_2	T_3
Dressing*	73.38^{a}±0.13	73.42^{a}±0.07	73.82^{b} ±0.07	73.58^{ab}±0.03
Breast muscle*	22.58^{a}±0.27	23.39^{b} ±0.14	23.80^{b} ±0.15	23.76^{b} ±0.23
Thigh muscle*	6.18^{a} ±0.15	6.71^{a} ±0.46	7.78^{b} ±0.66	6.62^{a} ±0.61
Giblet	5.28±0.10	5.23±0.11	5.09±0.24	5.20±0.02
Heart	0.56±0.01	0.53±0.03	0.51±0.02	0.51±0.02
Liver	2.31±.08	2.38±0.01	2.55±0.10	2.51±0.11
Gizzard	2.39±0.01	2.30±0.06	2.03±0.24	2.18±0.06
Spleen	0.17^{a}±0.01	0.18^{b}±0.01	0.19^{c}±0.02	0.19^{c}±0.12
Bursa	0.26±0.02	0.26±0.02	0.29±0.01	0.29±0.03
Thymus	0.56±0.06	0.51±0.02	0.46±0.02	0.48±0.08
Abdominal fat*	1.41^{b} ±0.12	1.20^{b} ±0.06	0.82^{a} ±0.35	1.11^{a} ±0.02

Conclusion

It may be concluded from the results of the present study that supplementation of organic Cr alone or in combination with vitamin C or E significantly (P<0.01) reduced serum triglycerides, total cholesterol, LDL cholesterol and glucose in broilers. Best results in terms of cholesterol reduction were observed in chromium plus ascorbic acid supplemented group. With the combination of chromium and ascorbic acid more breast and thigh muscle meat was produced and lower abdominal fat in carcass. Chromium plus ascorbic acid offers great potential in designing the meat which will be a due demand in the future of health conscious society in terms of reducing total cholesterol and lean meat production. Moreover such feed additives increase the performance of birds naturally as they are usually under stress due to tropical environmental conditions.

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