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NUTRIENT DIGESTIBILITY, CARCASS CHARACTERISTICS AND PLASMA METABOLITES IN KIDS FED DIETS SUPPLEMENTED WITH CHROMIUM METHIONINE

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ORIGINAL ARTICLE

ABSTRACT: *This study was carried out to evaluate the effects of different levels of chromium methionine (CrMet) on nutrient digestibility, carcass characteristics and plasma metabolites of male kids. Thirty-two male Mahabadi goat kids (average initial body weight (BW) = 22±2 kg, 4 months) were allocated in a completely randomized design with four treatments: 1) control (without Cr), 2) 0.5, 3) 1 and 4) 1.5 mg Cr as Cr-Met/animal/day. Diets were same (ratio of forage: concentrate was 30:70) except for top-dress addition of Cr-Met and fed in two equal meals (08.00 and 16.00h), Also orts collected before morning meal. Animals were kept in individual pens for 100 days. Kids were slaughtered at the end of the experiment and carcass characteristics determined. The results showed that dressing percentage was not affected by treatment, but, Cr supplementation reduced 10th rib back fat thickness by 30.30% ($P<0.01$), and tended to increase longissimus muscle area ($P<0.09$). Supplemental Cr increased percentage of neck ($P<0.05$) and proximal pelvic limb ($P<0.08$). Addition of different levels of Cr-Met failed to significantly effect on ($P>0.01$) the post-prandial changes in plasma levels of cholesterol, urea N, total protein, triglyceride and albumin, However, post-prandial of plasma glucose decreased by Cr ($P<0.05$). NDF and organic matter digestibility increased in the kids fed added dietary Cr compared with the control group. it was concluded that diet supplementation with chromium methionine could be improved nutrient digestibility, carcass characteristics and peripheral glucose utilization in goat kids.*

Key words: *Chromium-methionine, Mahabadi goat kid, Digestibility, Plasma metabolites, Glocuse*

INTRODUCTION

Trivalent chromium (Cr) is a structural component of a glucose tolerance factor (GTF) which potentiates the action of insulin; it is also an essential trace element for normal metabolism of carbohydrate, lipids, protein, and nucleic acids in humans and laboratory animals (Anderson et al., 1987; Abraham et al., 1991; Mertz, 1993). Dietary recommendation for Cr is not listed for most livestock species including goats. Nevertheless, supplementation of Cr in livestock diets may improve animal metabolism and enhance production performance and the quality of animal products (Spears, 1999). There is evidence to suggest that adequate absorption of Cr occurs only when the trace element is associated with a specific organic molecule (Evans, 1982). Consequently, many types of organic mineral complex have been developed and introduced to the market. Chromium methionine chelate is a newly developed organic mineral which is able to directly cross the intestinal cell membrane and be metabolized without any prior digestion since it was chelated with amino acid. Therefore, bioavailability of chromium methionine chelate is proposed to be higher than those of other organic chromium (Ohh and Lee, 2005). Research conducted with pigs showed that organic Cr supplementation increased loin eye area and decreased fat thickness (Page et al., 1993; Lindemann et al., 1995) as well as increasing the rate of lean and decreasing the rate of fat deposition (Boleman et al., 1995; Mooney and Cromwell, 1995). Kitchalong et al. (1995) reported Cr decrease fat thickness over the 10th rib in wether lambs. Bunting et al. (1994) reported lower plasma total cholesterol and higher glucose clearance rates in Holstein calves fed diet supplemented with CrPic. Studies of CrMet supplementation in goat kid are rare. Additionally, the dietary requirement and the exact level of supplementation of Cr need to be defined for livestock which are not exposed to any physical stress per se. In the present investigation, Mahabadi goat kids were supplemented with trivalent Cr as chromium methionine (CrMet) for 90 days. The objective of experiment was to determine the effect of adding different levels of organic Cr on nutrient digestibility, carcass characteristics and plasma concentrations of metabolites in growing goat kids.

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MATERIAL AND METHOD

Animals and dietary treatments

This study was done in Experimental Farm of Agriculture and Natural Resource Collage, university of Tehran, Karaj, Iran. Thirty-two male Mahabadi goat kids (initial age 4 months) were allocated by stratified randomization on the basis of body weight (22±2 kg) into four equal groups. Kids were individually penned and measurements were made on each kid. Kids were allowed ad libitum access to water and offered feed twice daily at approximately 0800 and 1700h for 100 days. Gradual adjustment to forage: concentrate ratio of 30:70 in TMR form. Diet took place over the 10 d quarantine period, and then kids were randomly assigned to one of four dietary treatments (n=8 per group) receiving supplementation of 0, 0.5, 1.0, and 1.5 mg Cr as Cr-Met [10% Cr and 90% Met (wt/wt); MicroPlex 1000, Zinpro, Inc., Eden Prairie, MN] once daily, top dressed with 50 g of ground barley for 90days. The basal diet (Table 1) was formulated for maximum growth and met or exceeded the requirements recommended by NRC (1985). The range of Cr levels was selected based on previous studies with goat (Haldar et al., 2009).

Table 1 - Ingredients and chemical composition of diet

Nutrient	% of DM	Chemical components		Macro mineral and micro mineral	
Alfalfa hay	16.49	DM (%)	80.78	Calcium (%)	0.89
Corn silage	8.32	NEL, Mcal/kg	2.41	Phosphorus (%)	0.48
Ground barley grain	50.65	CP (%)	13.5	Magnesium (%)	0.27
Soybean meal	2.21	NDF (%)	36.6	Sulfur (%)	0.28
Canola meal	4.55	Ether extract (%)	2.6	Zn (mg/kg dm)	219
Wheat bran	9.09	Ash (%)	9	Fe (mg/kg dm)	368
Wheat straw	5.19			I (mg/kg dm)	3
Carbonate Calcium	1.3			Mn (mg/kg dm)	216
Sodium bicarbonate	0.78			Cu (mg/kg dm)	54
Salt	0.52			Co (mg/kg dm)	1
Mineral-Vitamin Premix[1]	0.91			Cr (mg/kg dm)	0.83

[1]Containing vitamin A (250,000 IU/kg), vitamin D (50,000 IU/kg), and vitamin E (1,500 IU/kg), manganese (2.25 g/kg), calcium (120 g/kg), zinc (7.7 g/kg), phosphorus (20 g/kg), magnesium (20.5 g/kg), sodium (186 g/kg), iron (1.25 g/kg), sulfur (3 g/kg), copper (1.25 g/kg), cobalt (14 mg/kg), iodine (56 mg/kg), and selenium (10 mg/kg).

Metabolic challenge and sample analyses

A feeding challenge test was performed on day 75. The pre-feeding blood samples were collected from the jugular vein by jugular vein puncture into evacuated collection tubes containing sodium heparin at 0800 h after an overnight fast and then stored immediately on ice. The kids were fed and bled again 3h after feeding. Plasma samples were harvested by centrifuging at 3000 × g for 15 min and were stored at -20°C until analysis. Plasma samples were analyzed for glucose, triglyceride, total cholesterol, Urea N, total protein and albumin concentration using enzymatic method and appropriate kits (Pars-azmon Co., Tehran, Iran) and Clima Plus Analyzer (RAL, Madrid, Spain). The change (%) in the concentration of the serum metabolites over the basal value at 3 h post prandial was determined as well.

Carcass evaluation

At the termination of the trial, all of the lambs in each treatment group were weighed after 16 h of feed deprivation and slaughtered by Iranian traditional procedure (Nik-Khah, 1984) at the Meat Processing Facility of the Animal Sciences Department, University of Tehran. At slaughter, the head, hair and viscera were removed from carcass, hot carcass (for determination of dressing proportion) was collected, and the right and left halves of the carcasses were separated. Measurements of back fat depth and *longissmus* muscle area were made from right carcass tracings taken at the 10th rib. Carcass dressing proportion was calculated by the following formula: hot carcass weight divided by final live weight ×100. From the carcass, wholesale cuts including neck, proximal thoracic limb, proximal pelvic limb, steak-lumbar, and brisket-abdominal region were separated and weighed (Nik-Khah, 1984).

Diet and fecal samples collection and chemical analyses

Samples of the diet (TMR) and the orts were collected weekly in polyethylene sachets and pooled at monthly intervals. During the last 7 days of the experiment, fecal samples were collected every morning around feeding time. Faecal samples were pooled for each kids at the end of the collection period. Diet and fecal samples were analyzed for DM, organic matter (OM), crude protein (Kjeldahl N *6.25), ether extract, ash, and AIA content in accordance with the Association of Official Agricultural Chemists protocols (AOAC, 1990). All samples were analyzed for neutral detergent fiber (NDF) and acid detergent fiber (ADF) content according to procedures described by Van Soest et al. (1991) . AIA content was used as an internal marker to determine the apparent digestibility of Nutrient digestibility as reported by Van Keulen and Young (1977).

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Statistical Analysis

Data were analyzed as a completely randomized design using the General Linear Model (GLM) procedure of the statistical analysis software package (SAS Institute, 2002). Least-square means were computed and tested for differences by the Tukey's test. Differences of least squared means were considered to be significant at P <0.05, and that of (P <0. 01) was described as a trend.

RESULTS AND DISCUSSION

The effects of supplemental Cr on characteristics and percentage of wholesale cuts of the carcass are presented in Table 2. There is no significant effect of Cr on dressing proportion (%) compared to the control group (P>0.05) but, longissimus muscle area (LMA) had a trend to increased (LMA were 12.65, 13.96, 14.57, 15.24 control to 4, respectively; P= 0.09). Dietary CrMet supplementation reduced 10th rib back fat thickness by 30.30% (P<0.01). Among percentage of wholesale cuts of the carcass, neck (%) increased by addition of Cr to the diet (P < 0.05), whereas the percentage of brisket abdominal, steak-lumbar, Proximal thoracic limb and proximal pelvic limb were not affected by Cr supplementation (P>0.05; Table 4). kids fed 1.5 mg Cr tended to have higher proximal pelvic limb percentage (P=0.08). Our data indicate that Cr additives did affect lipid deposition and LMA. These results supported the findings of Lindemann et al. (1995), who observed that the addition of 200 ppb Cr reduced back fat and increased LMA of growing-finishing swine, and similar effects of Cr were also observed in pigs (Mooney and Cromwell, 1995; Wang and Xu, 2004; Wang et al., 2009). Kitchalong et al. (1995) reported a decrease in fat thickness over the 10th rib in wether lambs fed organic Cr, and no differences were detected for loin-eye area. On the contrary, Evock-Clover et al. (1993) indicated that Cr did not affect back fat or LMA in growing pigs, Yan et al. (2008) and Gentry et al. (1999) did not show any effect of Cr on dressing percentage, back fat and LMA in lambs. As the cofactor of insulin, Cr acts on carcass traits mainly by influencing insulin sensitivity, which closely relates to carbohydrate and protein metabolism (Anderson, 1998). The results of our research suggest that the chromium content in the test diet could not meet the requirements of fattening kids. Reports of carcass cuts in Cr supplementation studies have been rare. Mooney and Cromwell (1997) observed no differences in ham weight of pigs fed supplemental Cr (200g/kg) as CrPic, whereas Anderson et al. (1989) and Hossain et al. (1998) reported increase of breast yield in poultry fed supplemental Cr as CrCl3 (25 to 200 mg/kg) or high-Cr yeast (400g/kg). In the present study, among the wholesale cuts, percentage of neck and pelvic limbs increased by supplemental Cr. These results can be related to Cr effects on improving insulin sensitivity or cellular protein synthesis (Roginski and Mertz, 1969; Okada et al., 1982). Mostafa-Tehrani et al. (2006) reported supplemental Cr from CrNic or CrCl3 increased weights of proximal thoracic and pelvic fat-tailed ram limbs.

Table 2 - Effects of chromium methionine (CrMet) supplementation on carcass characteristics and percentage of wholesale cuts of the carcass in Mahabadi goat kids.

Item	Treatments*				SEM	Significance (p value)
	1	2	3	4		
Loin eye area (LMA,cm2)	12.65	13.96	14.57	15.24	0.70	*
Dressing percentage	41	39	43	39	1.30	NS
Fat thickness over 10^{th} rib, (mm)	3.30^{a}	2.88^{a}	2.63^{ab}	2.3^{b}	0.19	***
Neck (%)	9.66^{b}	10.07^{a}	11.17^{a}	9.96^{a}	0.35	**
Proximal thoracic limb (%)	22.97	22.47	21.92	21.66	0.44	NS
Proximal pelvic limb (%)	29.17	30.50	29.89	30.87	0.47	*
Steaks-lumbar (%)	21.58	20.99	20.78	21.61	0.56	NS
Brisket-abdominal region (%)	16.33	15.83	16.23	16.03	0.37	NS

*1= 0(control), 2= 0.5, 3= 1 and 4= 1.5 mg Cr/day/animal as chromium methionine (CrMet). Means in the same row with different superscripts differ significantly (p<0.05). *P < 0.1; ** P < 0.05; *** P < 0.01; NS = not significant.

Mean plasma glucose, triglyceride, total cholesterol, urea N, total protein and albumin at 0 and 3 h postprandial are shown in Table 3. Dietary Cr supplementation improved post-prandial utilization of glucose (P=0.026). Overall mean plasma glucose concentrations were lower (P<0.05) in the CrMet-fed kids than in those fed control (plasma glucose were 63.38, 58.11, 53.55and 51.81 mg/dL in 1m (control) to 4, respectively). All kids had higher (P<0.01) plasma triglyceride concentrations 3 h after feeding than after 16 h of feed deprivation. Following 16 h of feed deprivation, plasma triglyceride tended to decrease in kids fed 1 mg Cr day (P<0.01). Dietary treatment had no effect (P>0.01) on the post-prandial changes in plasma levels of cholesterol, urea N, total protein, triglyceride and albumin, but overall mean plasma cholesterol (P<0.06) and triglyceride (P<0.04) decreased, whereas urea N increased by CrMet (P=0.06). The 0 and 3 h, post-prandial plasma metabolite concentrations did not reveal any effect of Cr supplementation, and this was in partial agreement with the earlier findings (Kitchalong et al., 1995; Gentry et al., 1999). Haldar et al. (2007) observed that post-prandial serum levels of glucose and cholesterol decreased by dietary Cr supplementation from Cr chloride and Cr yeast in adult castrated male black Bengal goats. The 3 h postprandial plasma glucose indicated a better utilization of glucose after feeding. Overall mean plasma cholesterol and triglyceride levels revealed significant effect of Cr on lipid metabolism as did earlier workers (Bunting, et al. 1994; Kitchalong, et al. 1995; DePew et al., 1996; Subiyatno et al., 1996). Results from this study, therefore, support the suggestion that Cr supplementation has the potential to alter lipid metabolism (Riales and Albrink, 1981). The lower serum triglyceride at 0 h in agreement with the results of Page et al. (1993)

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and Wang et al. (2009), but different by several earlier works reporting little or no effect of supplemental Cr on serum triacylglycerol level (DePew et al., 1996; Besong et al., 2001).

Table 3 - plasma metabolite concentrations at 0 and 3 h post prandial in goat kids supplemented with different levels of chromium methionine (CrMet)

Measurements	Treatment 1					Significance (p value)		
	1	2	3	4	SEM	Diet	time	Diet*Time
Glucose(mg/dL)								
0 h	60.03	56.50	56.33	49.04	3.59	NS	NS	NS
3 h	66.72a	59.71ab	50.78b	54.58b	3.40	**	NS	NS
% change over 0 h value	11.16	8.64	-8.36	13.35	9.85	NS	NS	NS
Total cholesterol (mg/dL)								
0 h	71.06	54.94	69.79	59.90	7.86	NS	NS	NS
3 h	73.24	60.58	67.46	69.37	8.06	NS	NS	NS
% change over 0 h value	25.00	17.32	-0.40	28.36	10.01	NS	NS	NS
TG (mg/dL)								
0 h	36.25	39.04	32.52	36.70	1.34	*	***	NS
3 h	38.53	40.85	36.61	38.81	1.44	NS	NS	NS
% change over 0 h value	6.33b	5.33c	12.82a	5.71bc	0.35	***	NS	NS
Albumin,(g/dL)								
0 h	5.72	5.78	4.98	4.44	0.39	NS	*	NS
3 h	4.63	3.80	4.74	4.84	0.52	NS	NS	NS
% change over 0 h value	-18.17	-32.66	-3.46	12.38	13.12	NS	NS	NS
Urea N, (mmol/l)								
0 h	5.43	6.63	5.62	7.55	0.82	NS	NS	NS
3 h	5.51	5.53	6.18	6.96	0.39	NS	NS	NS
% change over 0 h value	7.45	-8.70	12.26	-4.01	8.47	NS	NS	NS
Total protein,(g/dL)								
0 h	7.32	7.19	6.23	7.44	0.45	NS	NS	NS
3 h	7.89	6.13	6.74	6.49	0.8	NS	NS	NS
% change over 0 h value	10.14	-22.04	7.25	-12.73	10.02	NS	NS	NS

[1]1= 0(control), 2= 0.5, 3= 1 and 4= 1.5 mg Cr /day/animal as chromium methionine (CrMet). Means in the same row with different superscripts differ significantly (p<0.05). For glucose: over all diet effect P = 0.02, For cholesterol: over all diet effect P = 0.06, For protein: over all diet effect P = 0.53. For triglyceride: over all diet effect P = 0.04, For albomin: over all diet effect P = 0.63, For Urea N: over all diet effect P = 0.06. *P < 0.1; ** P < 0.05; *** P < 0.01; NS = not significant

Table 4 - Effects of chromium methionine (CrMet) supplementation on DMI and apparent digestibility of nutrients diet in Mahabadi goat kids

Item	Treatments*				SEM	Significance (p value)
	1	2	3	4		
DMI kg/d	1.00	1.00	1.02	1.06	0.04	NS
Digestibility coefficients (%)						
DM	67.45	69.05	71.09	66.62	1.47	NS
OM	64.50	64.25	67.40	63.21	1.07	*
CP	59.42	57.72	61.19	57.12	1.74	NS
EE	48.14	57.21	61.06	57.44	3.25	NS
NDF	45.81b	46.50b	53.84a	48.46ab	1.58	***
ADF	67.31	64.53	70.50	67.49	1.86	NS

*1= 0(control), 2= 0.5, 3= 1 and 4) 1.5 mg Cr /day/animal as chromium methionine (CrMet). Means in the same row with different superscripts differ significantly (p<0.05). *P < 0.1; ** P < 0.05; *** P < 0.01; NS = not significant

Table 4 shows the effects of Cr supplementation on apparent digestibility of nutrients and dry matter intake (DMI). DMI were not affected (P>0.05) by Cr supplementation. This is consistent with research with pigs (Page et al., 1993; Amoikon et al., 1995; Lindemann et al., 1995), lambs (Samsell and Spears, 1989; Kitchalong et al., 1995; Forbes et al., 1998), and calves (Bunting et al., 1994; Mathison and Engstrom, 1995). In contrast, Moonsie-Shageer and Mowat (1993) did show improved DMI in calves supplemented with high-Cr yeast in a corn-silage diet, whereas Boleman et al. (1995) reported reduced DMI in pigs fed Cr tripicolinate from the growing to the finishing phase.

In the present study, dietary supplementation of CrMet had no effect on the digestibility coefficients of DM, CP, EE and ADF (P>0.05), whereas the apparent digestion rate of NDF was significantly improved in treated animals as compared with control (P<0.01). Kids fed 1 mg Cr tended to have higher OM digestibility (P = 0.06). Cr

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supplementation reportedly increased OM, DM and CP digestibility in Bengal goats (Haldar et al., 2009) and, Kornegay et al. (1997) reported improved DM digestibility in growing-finishing pigs fed chromium picolinate. In contrast, Kraidees et al. (2009) found that supplemental chromium levels from a Cr-yeast source had no effect on digestibility of nutrients in lambs.

CONCLUTON

The results of this experiment suggest that supplemental organically chelated chromium may decrease fat deposition and alter carcass quality in goat kids. Chromium supplementation as CrMet may be beneficial in improving some wholesale cuts such as neck or proximal pelvic limbs, and moreover CrMet may be a useful tool for improving digestion rate of nutrition and glucose utilization in animals even in a non-stressed management regime.

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