EFFECTS OF SOURCE AND LEVEL OF ADDED CHROMIUM ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWING-FINISHING PIGS [1,2]

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Summary

A growth trial was conducted to evaluate the effects of added chromium nicotinate (CrNic) on growth performance and carcass composition of growing-finishing pigs (80 to 230 lb) and to compare 200 ppb of CrNic and chromium picolinate (CrPic). Few statistical responses were observed for growth performance, carcass characteristics, or serum chemistry profiles. These data suggest no beneficial responses to supplemental chromium in diets for growing-finishing barrows and gilts.

(Key Words: Growing-Finishing Pigs, Chromium Nicotinate, Growth, Carcass Quality.)

Introduction

Chromium is a trace mineral that is involved actively in the metabolism of carbohydrates, lipids, proteins, and nucleic acids in the body. Chromium is most widely recognized as a potentiator of the actions of insulin. In animal studies, Cr supplementation is reported to increase rate and efficiency of gain and degree of muscling and decrease fat deposition. Chromium also is thought to improve the immune status in stressed animals. Several forms of Cr have been evaluated in swine studies, including yeast cultures, chromium chloride, and CrPic, which has received the most attention in the scientific literature. Recent chromium work with human subjects has suggested that CrNic may be more biologically available than CrPic. For these reasons, a feeding trial was designed to evaluate the efficacy of CrNic supplementation and to compare growth performance and carcass characteristics of pigs fed equal concentrations of CrNic and CrPic.

Procedures

A total of 144 crossbred barrows and gilts (initially 80.7 lb) was used in the growth trial. Pigs were blocked on the basis of initial weight, sex, and ancestry and randomly allotted to dietary treatments with six replications per sex per treatment.

All diets were fed in meal form (Table 1). Barrows and gilts were fed separate diets within each phase to more accurately meet changes in their lysine requirements. All diets contained .1% L-lysine•HCl. Diets were fed in three phases (80 to 130, 130 to 180, and 180 to 230 lb BW), and diets were changed when the average weight of pigs in a pen reached the upper limit of the weight interval. Chromium was added to the basal diets at 50, 100, 200, or 400 ppb Cr as CrNic or 200 ppb Cr as CrPic. The Cr additions first were prepared as a 20-lb premix and

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then blended with the other dietary ingredients to ensure proper mixing.

Pigs were housed in an environmentally controlled finishing barn with two pigs in each 5-ft × 5-ft totally slatted-floored pen. Pigs were allowed ad libitum access to feed and water through one single-hole self-feeder and a nipple waterer.

Pigs were weighed every 2 weeks to determine ADG, ADFI, and feed efficiency (F/G). The day before slaughter, blood samples were taken from each pig to determine serum Cr concentrations after a 3-h fast. Blood samples were pooled for each pen and stored frozen until the analyses were conducted.

Pigs were slaughtered when the average weight of pigs in a pen reached 230 lb. Standard carcass measurements; visual analyses of the longissimus for coloring, marbling, and firmness; drip loss; and Minolta colorspectrometry (Hunter L*, a*, and b*) were taken for each pig 24-h postmortem (drip loss at 48-h postmortem).

Data were analyzed as a randomized complete block. The pen was the experimental unit for all calculations. The trial was analyzed as two separate experiments (one for barrows and one for gilts) because of the different lysine levels fed to barrows and gilts. Because of the unequal spacing of dietary chromium concentrations, a regression model was fit to the data. Thus, the REG procedure of SAS was used to determine the linear and quadratic effects of supplementation with CrNic, whereas the GLM procedure of SAS was used for the single degree of freedom contrast between pigs fed 200 ppb CrNic and 200 ppb CrPic and between pigs fed the control diet and the diet containing 200 ppb CrPic. No covariates were used in the statistical model for the carcass analyses because of the similar ending test weight of all pigs.

Results and Discussion

Growth Data. From 130 to 180 lb, increasing CrNic tended (linear, P = .09) to decrease ADG in barrows (Table 2). This resulted in an overall (80 to 230 lb) tendency for decreased ADG (linear, P = .09) for pigs fed increasing CrNic. Otherwise, neither source of Cr nor level of increasing CrNic had an effect (P>.10) on ADG, ADFI, or F/G for any of the growth intervals or the total trial.

Neither source of Cr nor level of increasing CrNic had any effect (P>.20) on gilt growth performance during any of the growth intervals or over the entire trial. Although not compared statistically, gilts fed 50 ppb Cr as CrNic grew on average 7% faster and converted feed to gain approximately 5% better than did control gilts.

Carcass Characteristics. Other than a quadratic response (P = .10) in last lumbar backfat, neither source of Cr nor level of increasing CrNic had any effect (P>.10) on carcass characteristics for barrows (Table 4).

Gilts fed increasing levels of CrNic had greater first rib fat depths (linear, quadratic, P<.05; Table 5) than control gilts. Chromium source affected (P = .05) longissimus muscle visual color, with gilts fed 200 ppb CrPic having a darker colored longissimus muscle than gilts fed 200 ppb CrNic. Drip loss percentage in gilts was increased (P = .02) with increased CrNic supplementation. An explanation for this response is not readily apparent, because Cr has no known function with membrane permeability. The effects of supplemental Cr on longissimus muscle quality were not consistent.

Serum Analysis. Source of Cr affected barrow serum Cr levels (Table 6), with barrows fed CrPic having a higher (P = .05) concentration than CrNic-supplemented barrows. Neither source of Cr nor level of increasing CrNic had an effect (P>.10) on gilt serum Cr concentrations (Table 6).

General. Differences between pigs fed the control diets or the diets containing 200 ppb CrPic were few. Barrows fed 200 ppb CrPic grew slower (P = .02) from 180 to 230 lb BW. Gilts fed 200 ppb CrPic ate more feed (P = .04) from 130 to 180 lb BW. Gilts fed the control diet had more marbled longissimus muscle (P = .02) and a higher drip loss (P = .07) than pigs fed the 200 ppb CrPic diet. Barrows fed 200 ppb CrPic had a higher (P = .03) serum Cr level than pigs fed the control diet.

Dietary chromium is absorbed from the GI tract, converted to trivalent Cr upon entry into the bloodstream, and rapidly taken up into the tissues. Because the blood and tissue levels of Cr are not in equilibrium, serum values may not be good indicators of Cr status. Any Cr not used or stored by the tissues is excreted back to the blood for excretion from the body via the urine. Thus, 24-hr urinary Cr measurements may be better indicators of Cr stores than serum Cr levels are.

Two small assays were undertaken later to help explain some of the serum Cr differences noted herein and in an earlier nursery trial with CrNic and CrPic. First, 20 finishing weight pigs from a commercial farm in Northeast Kansas were bled for serum Cr analysis. This farm had never fed Cr through any of their barns. The mean value for these pigs was 11.17 ± 3.63 nmol/L of Cr (data not shown). This value is considerably lower than that for the control pigs not fed Cr in the present experiment. These results could indicate a difference in Cr content of the dietary ingredients. The diets fed on this farm were typical grain-soybean meal-based diets, but they were not assayed for Cr content.

Secondly, analysis of such diets not containing supplemental Cr indicated that background Cr levels range well into the ppm range (data not shown). No work has been conducted to define the bioavailability of this background Cr. Even if only a small fraction is bioavailable, the high levels could mask any potential treatment responses, especially when dietary inclusion levels are only in the low-to-mid ppb range.

In conclusion, supplemental Cr (either as CrNic or CrPic) had no beneficial effects on growth performance or carcass characteristics of growing-finishing pigs. Because of consistent numerical improvements in ADG and F/G with gilts fed 50 ppb Cr as CrNic, further research should be conducted to evaluate lower concentrations of CrNic in diets fed to finishing gilts. These results further suggest that the responses to supplemental Cr may be related directly to the level of background Cr already present in the diet.

Table 1. Composition of Basal Diets (As-Fed Basis)[a]

	Period I[b]		Period II[c]		Period III[d]	
Ingredient, %	Barrows	Gilts	Barrows	Gilts	Barrows	Gilts
Corn	70.09	66.52	78.02	74.46	83.65	80.08
Soybean meal, 46.5% CP	24.77	28.39	17.47	21.09	12.02	15.64
Soybean oil	2.00	2.00	2.00	2.00	2.00	2.00
Monocalcium phosphate	1.15	1.09	.80	.73	.65	.59
Limestone	1.06	1.07	.88	.89	.85	.86
Vitamin/trace mineral premix	.35	.35	.25	.25	.25	.25
Salt	.35	.35	.35	.35	.35	.35
Antibiotic[e]	.13	.13	.13	.13	.13	.13
L-Lysine•HCl	.10	.10	.10	.10	.10	.10
Total	100.00	100.00	100.00	100.00	100.00	100.00

[a]Graded levels of Cr were added to the basal diets to achieve levels of 50, 100, 200, or 400 ppb Cr. [b]Period I diets were fed from 80 to 130 lb BW and were formulated to contain .70% total Ca, .60% total P, and either 1.00% (barrows) or 1.10% (gilts) lysine. [c]Period II diets were fed from 130 to 180 lb BW and were formulated to contain .55% total Ca, .50% total P, and either .80% (barrows) or .90% (gilts) lysine. [d]Period III diets were fed from 180 to 230 lb BW and were formulated to contain .50% total Ca, .45% total P, and either .65% (barrows) or .75% (gilts) lysine. [e]Provided 100 g/ton tylosin.

Table 2. Growth Performance of Barrows Fed Graded Levels of Chromium[a]

	CrNic					CrPic		Probability		
Item	0	50	100	200	400	200	CV	Lin.[b]	Quad.[b]	Cont.[c]
80 to 130 lb BW										
ADG, lb	2.37	2.50	2.27	2.27	2.42	2.30	8.46	.15	.14	.23
ADFI, lb	5.53	5.75	5.40	5.56	5.54	5.34	7.73	.78	.82	.95
F/G	2.34	2.31	2.38	2.44	2.30	2.33	6.81	.14	.12	.13
130 to 180 lb BW										
ADG, lb	2.62	2.54	2.35	2.44	2.45	2.40	8.87	.09	.14	.96
ADFI, lb	7.33	7.38	6.92	7.08	7.02	6.88	8.40	.32	.45	.86
F/G	2.81	2.91	2.96	2.90	2.89	2.87	8.38	.46	.47	.92
180 to 230 lb BW										
ADG, lb[d]	2.37	2.39	2.27	2.27	2.08	2.29	9.15	.54	.88	.14
ADFI, lb	7.80	7.97	7.41	7.74	7.41	7.90	8.17	.70	.95	.37
F/G	3.30	3.34	3.26	3.44	3.57	3.46	8.68	.82	.76	.44
80 to 230 lb BW										
ADG, lb	2.45	2.49	2.30	2.32	2.33	2.34	6.98	.09	.18	.93
ADFI, lb	6.89	7.03	6.58	6.79	6.66	6.71	7.20	.51	.68	.64
F/G	2.81	2.83	2.86	2.92	2.86	2.87	5.19	.16	.22	.48

[a]Values are means for two pigs/pen and six replications/treatment.
[b]Contrasts refer to the linear and quadratic comparisons of CrNic supplementation.
[c]Contrast refers to the comparison of supplementation with 200 ppb CrNic against that of 200 ppb CrPic.
[d]Control differs from 200 ppb CrPic (P = .02). All other contrasts between the control diets and diets containing 200 ppb CrPic were nonsignificant (P>.10).

Table 3. Growth Performance of Gilts Fed Graded Levels of Chromium[a]

	CrNic					CrPic		Probability		
Item	0	50	100	200	400	200	CV	Lin.[b]	Quad.[b]	Cont.[c]
80 to 130 lb BW										
ADG, lb	2.05	2.25	2.12	2.14	2.10	2.21	6.45	.47	.41	.65
ADFI, lb	4.88	5.16	5.07	4.85	4.85	5.08	5.17	.94	.68	.99
F/G	2.39	2.30	2.40	2.27	2.31	2.29	4.96	.32	.45	.59
130 to 180 lb BW										
ADG, lb	2.18	2.34	2.20	2.02	2.10	2.14	9.39	.27	.47	.54
ADFI, lb[d]	6.10	6.16	6.12	5.71	5.73	6.20	5.35	.19	.51	.92
F/G	2.83	2.65	2.78	2.83	2.75	2.90	8.65	.87	.86	.57
180 to 230 lb BW										
ADG, lb	2.14	2.23	2.15	2.08	2.06	2.18	10.74	.77	.98	.86
ADFI, lb	6.35	6.91	6.61	6.47	6.29	6.91	6.77	.58	.35	.50
F/G	3.01	3.13	3.09	3.13	3.06	3.17	8.79	.47	.47	.67
80 to 230 lb BW										
ADG, lb	2.11	2.27	2.15	2.07	2.08	2.17	7.03	.66	.90	.86
ADFI, lb	5.78	6.08	5.94	5.68	5.63	6.06	4.01	.77	.70	.71
F/G	2.76	2.68	2.76	2.75	2.70	2.79	5.91	.79	.72	.60

[a]Values are means for two pigs/pen and six replications/treatment.
[b]Contrasts refer to the linear and quadratic comparisons of CrNic supplementation.
[c]Contrast refers to the comparison of supplementation with 200 ppb CrNic against that of 200 ppb CrPic.
[d]Control differs from 200 ppb CrPic (P = .04). All other contrasts between the control diets and diets containing 200 ppb CrPic were nonsignificant (P>.20).

Table 4. Carcass Characteristics of Barrows Fed Graded Levels of Chromium[a,b]

	CrNic					CrPic		Probability		
Item	0	50	100	200	400	200	CV	Lin.[c]	Quad.[c]	Cont.[d,e]
Shrink loss, %	2.70	2.59	2.54	2.39	2.39	2.30	15.50	.16	.34	.96
Backfat, in:										
First rib	1.50	1.52	1.59	1.52	1.51	1.53	5.34	.40	.34	.89
Tenth rib	.94	.96	.98	.90	.93	.90	11.79	.64	.73	.55
Last rib	.76	.78	.81	.75	.73	.77	9.15	.61	.40	.57
Last lumbar	.72	.75	.82	.75	.70	.71	11.16	.18	.10	.29
Average[f]	.99	1.01	1.07	1.01	.98	1.00	6.46	.29	.17	.49
LMA, in^2	5.27	5.20	4.97	5.01	5.30	5.37	7.97	.14	.11	.24
Lean %[g]	49.88	49.24	48.73	49.66	49.98	50.54	4.05	.62	.51	.79
Dressing %	72.07	72.24	71.22	72.09	72.75	71.30	1.63	.42	.24	.34
Visual color[h]	2.42	2.38	2.71	2.46	2.58	2.33	12.64	.53	.66	.50
Firmness[h]	2.63	2.63	3.21	2.75	2.58	2.63	19.10	.25	.19	.58
Marbling[h]	2.71	2.67	3.13	2.92	2.75	2.63	17.75	.20	.19	.57
Hunter L*[i]	52.75	53.42	50.33	51.96	53.60	53.66	5.55	.18	.12	.34
Hunter a*[i]	11.48	11.28	11.59	12.41	12.47	11.86	12.85	.41	.68	.94
Hunter b*[i]	7.73	7.88	7.16	8.14	8.53	8.18	19.36	.93	.67	.67
Hue angle[i]	45.70	48.28	40.82	43.52	46.86	47.34	12.71	.15	.13	.32
Saturation index[i]	13.86	13.77	13.63	14.87	15.12	14.43	14.56	.62	.92	.84
A:B ratio[i]	1.52	1.44	1.63	1.59	1.47	1.48	8.72	.10	.07	.13
Drip loss, %	3.33	3.92	2.25	2.85	4.49	3.73	61.56	.28	.17	.19

[a]Values are means for two pigs/pen and six replications/treatment.
[b]Carcass length (mean = 31.74 in) and muscle score (mean = 2.51) were not affected (P>.20) by dietary treatment.
[c]Contrasts refer to the linear and quadratic comparisons of CrNic supplementation.
[d]Contrast refers to the comparison of supplementation with 200 ppb CrNic against that of 200 ppb CrPic.
[e]All contrasts between the control diets and diets containing 200 ppb CrPic were nonsignificant (P>.15).
[f]Average backfat is the average of the first and last rib and last lumbar fat depths.
[g]Lean percentage was derived from NPPC equations.
[h]Scoring system of 1 to 5: 2 = grayish pink, traces to slight, or soft and watery; 3 = reddish pink, small to modest, or slightly firm and moist; and 4 = purplish red, moderate to slightly abundant, or firm and moderately dry for color, firmness, and marbling, respectively.
[i]Means were derived from three sample readings per loin. Measures of dark to light (Hunter L*), redness (Hunter a*), yellowness (Hunter b*), red to orange (hue angle), or vividness or intensity (saturation index).

Table 5. Carcass Characteristics of Gilts Fed Graded Levels of Chromium[a,b]

	CrNic					CrPic		Probability		
Item	0	50	100	200	400	200	CV	Lin.[c]	Quad.[c]	Cont.[d]
Shrink loss, %	2.20	2.45	2.28	2.25	2.39	2.40	16.61	.96	.88	.54
Backfat, in:										
First rib	1.40	1.46	1.49	1.52	1.46	1.50	6.61	.03	.04	.27
Tenth rib	.77	.80	.80	.78	.75	.82	10.72	.73	.55	.54
Last rib	.69	.71	.73	.69	.69	.69	10.48	.96	.87	.88
Last lumbar	.65	.70	.69	.71	.71	.70	12.01	.33	.47	.95
Average[e]	.91	.96	.97	.97	.95	.97	8.01	.20	.23	.65
LMA, in^2	5.93	5.70	6.04	5.78	6.09	5.59	8.10	.74	.57	.26
Lean %[f]	53.46	52.40	52.84	52.60	54.05	51.60	3.27	.35	.21	.16
Dressing %	72.02	72.04	72.66	73.09	72.24	72.81	1.20	.02	.02	.10
Visual color[g]	2.50	2.63	2.46	2.42	2.63	2.58	6.86	.15	.09	.05
Firmness[g]	2.92	3.04	2.96	2.75	2.75	2.79	12.10	.52	.81	.99
Marbling[g,h]	2.88	2.46	2.79	2.46	2.46	2.58	11.65	.17	.37	.99
Hunter L*[i]	51.18	50.65	51.90	51.02	52.05	49.85	4.32	.99	.82	.43
Hunter a*[i]	11.41	10.87	10.06	11.04	11.84	10.86	9.91	.14	.06	.21
Hunter b*[i]	7.47	6.91	6.86	7.17	7.69	6.81	13.46	.32	.18	.36
Hue angle[i]	43.71	42.71	46.71	42.83	43.63	40.23	10.75	.85	.80	.77
Saturation index[i]	14.00	12.89	12.19	13.19	14.13	12.41	9.96	.10	.05	.22
A:B ratio[i]	1.55	1.58	1.49	1.62	1.56	1.69	9.22	.72	.75	.47
Drip loss, %[j]	2.19	2.17	2.38	3.00	3.56	2.04	52.01	.51	.94	.47

[a]Values are means for two pigs/pen and six replications/treatment. [b]Carcass length (mean = 32.15 in) and muscle score (mean = 2.53) were not affected (P>.20) by dietary treatment. [c]Contrasts refer to the linear and quadratic comparisons of CrNic supplementation. [d]Contrast refers to the comparison of supplementation with 200 ppb CrNic against that of 200 ppb CrPic. [e]Average backfat is the average of the first and last rib and last lumbar fat depths. [f]Lean percentage was derived from NPPC equations. [g]Scoring system of 1 to 5: 2 = grayish pink, traces to slight, or soft and watery; 3 = reddish pink, small to modest, or slightly firm and moist; and 4 = purplish red, moderate to slightly abundant, or firm and moderately dry for color, firmness, and marbling, respectively. [h]Control diet differs from diets containing 200 ppb CrPic (P = .02). [i]Means were derived from three sample readings per loin. Measures of dark to light (Hunter L*), redness (Hunter a*), yellowness (Hunter b*), red to orange (hue angle), or vividness or intensity (saturation index). [j]Control diets differ from diets containing 200 ppb CrPic (P = .08). All other contrasts between the control diets and diets containing 200 ppb CrPic were nonsignificant (P>.15).

Table 6. Serum Chromium Levels of Pigs Fed Graded Levels of Chromium[a]

	CrNic					CrPic		Probability		
Item	0	50	100	200	400	200	CV	Lin.[b]	Quad.[b]	Cont.[c]
Barrows:										
Chromium[d,e]	49.78	57.60	48.05	50.72	65.65	64.28	22.08	.48	.21	.05
Gilts:										
Chromium[d]	45.45	46.80	50.98	41.42	45.25	63.85	16.63	.71	.83	.42

[a]Values represent the pooled results of two pigs/pen and six replications/treatment. All pigs were bled following a 3-h fast. [b]Contrasts refer to the linear and quadratic comparisons of CrNic supplementation. [c]Contrast refers to the comparison of supplementation with 200 ppb CrNic against that of 200 ppb CrPic. [d]Chromium values are expressed as nmol/L. [e]Control diets differ from diets containing 200 ppb CrPic (P = .03). All other contrasts between the control diets and diets containing 200 ppb CrPic were nonsignificant (P>.20).