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Further Investigation Evaluating the Effect of Dietary Chromium Propionate and Yucca schidigera Supplementation in Finishing Pig Diets

J. T. Gebhardt
Kansas State University, Manhattan, jgebhardt@k-state.edu

J. C. Woodworth
Kansas State University, Manhattan, jwoodworth@k-state.edu

M. D. Tokach
Department of Animal Science and Industry, Kansas State University, mtokach@ksu.edu

See next page for additional authors

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Authors

J. T. Gebhardt, J. C. Woodworth, M. D. Tokach, J. M. DeRouchey, R. D. Goodband, J. A. Loughmiller, A. L. de Souza, M. J. Rincker, and S. S. Dritz

Further Investigation Evaluating the Effect of Dietary Chromium Propionate and *Yucca schidigera* Supplementation in Finishing Pig Diets[1,2]

J.T. Gebhardt, J.C. Woodworth, M.D. Tokach, J.M. DeRouchey, R.D. Goodband, J.A. Loughmiller,[3] A.L. de Souza,[3] M.J. Rincker,[4] and S.S. Dritz[5]

Summary

A total of 2,430 pigs (PIC 359 × 1050; initial BW = 64.6 lb) were used to evaluate the effects of dietary chromium propionate (Cr; KemTRACE Cr, Kemin Industries, Des Moines, IA) and a *Yucca schidigera*-based extract (Micro-Aid; DPI Global, Porterville, CA) on growth performance of finishing pigs housed in commercial conditions. Pigs were placed in balanced, mixed-gender pens (27 pigs per pen), blocked by average pen BW, and randomly assigned to treatment. Diets were corn-soybean meal-based and were formulated in 5 dietary phases to meet or exceed NRC[6] requirement estimates. Dietary treatments were fed for the full duration of the study and were arranged in a 2 × 3 factorial with 14 pens per treatment. Main effects included chromium (0 or 200 ppb added Cr), and *Yucca schidigera* extract (0, 62.5, or 125 ppm active ingredient). For the overall study, a marginally significant (linear; $P \leq 0.072$) Cr × *Yucca schidigera* interaction was observed for ADG and ADFI. Pigs fed *Yucca schidigera* without added Cr had similar ADG and ADFI; however, pigs fed added Cr had increased ADG and ADFI as *Yucca schidigera* increased from 62.5 to 125 ppm. Added Cr had no effect on F/G ($P > 0.05$). Increasing *Yucca schidigera* resulted in a marginally significant poorer (quadratic; $P = 0.057$) F/G. The main effect of added *Yucca schidigera* on final BW (quadratic; $P = 0.012$) resulted in pens which were supplemented with 62.5 ppm having the lowest final BW. Carcass characteristics, including HCW, loin depth, backfat, percentage lean, and percentage yield, were not influenced by added Cr ($P \geq 0.278$). Added *Yucca schidigera* did not influence loin depth, backfat, percentage lean, or percentage yield ($P \geq 0.152$). In summary, adding Cr propionate along with *Yucca schidigera* led

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[3] Kemin Industries, Des Moines, IA.

[4] DPI Global, Porterville, CA.

[5] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

[6] NRC. 2012. Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington D.C.

to modest changes in performance, with the greatest benefit observed with 200 ppb Cr and 125 ppm (active ingredient) *Yucca schidigera*.

Introduction

Addition of Cr in growing and finishing pig diets was recently summarized in a meta-analysis, and results indicated potential benefits of Cr supplementation including improved ADG, F/G, carcass percentage lean, and LM area along with a reduction in backfat thickness.[7] However, a great deal of variation in responses among studies has been observed, thus further evaluation in a commercial setting is necessary. Previous research by our group in field-based research settings has shown mixed results;[8,9] reinforcing the lack of a clear response, especially in production settings. In addition, the NRC[6] does not provide an estimate for biological requirement in swine, indicating further evaluation is warranted.

Yucca schidigera-based extracts have been used to control nitrogenous gaseous emissions in a variety of livestock, including poultry, swine, beef, and dairy cattle, through its saponin characteristics.[10] Research evaluating the effects of *Yucca schidigera* supplementation in poultry is more extensive than swine, and would suggest an improvement in F/G.[11] Research related to the impact of *Yucca schidigera* on blood metabolites in swine is currently very limited, and there is little research evaluating potential interactions between Cr and *Yucca schidigera*-based feed additives. However, in one previous experiment, inclusion of supplemental Cr in addition to *Yucca schidigera* did not result in any synergistic effects, but *Yucca schidigera* supplementation resulted in a marginally significant increase in overall ADFI, while added Cr increased backfat depth and reduced percentage lean.[7] Therefore, the objective of this experiment was to further determine the effects of Cr supplementation at increasing levels of a *Yucca schidigera*-based extract on growth performance and carcass composition of pigs housed in a commercial environment.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at a commercial research-finishing site in southwest Minnesota. Two identical barns were used for this study. The barns were naturally ventilated and double-curtain-sided. Each pen (18 ×

[7] Sales, J., and F. Jancik. 2011. Effects of dietary chromium supplementation on performance, carcass characteristics, and meat quality of growing-finishing swine: A meta-analysis. J. Anim. Sci. 89: 4054-4067.

[8] Gebhardt, J. T., J. C. Woodworth, M. D. Tokach, J. M. DeRouchey, R. D. Goodband, J. A. Loughmiller, and S. S. Dritz. 2016. Determining the influence of KemTRACE Cr and/or Micro-Aid on growth performance and carcass composition of pigs housed in a commercial environment. *Kansas Agricultural Experiment Station Research Reports*: Vol. 2: Iss. 8. https://dx.doi.org/10.4148/2378-5977.1312.

[9] Gebhardt, J. T., J. C. Woodworth, M. D. Tokach, J. M. DeRouchey, R. D. Goodband, J. A. Loughmiller, and S. S. Dritz. 2016. Influence of chromium dose and feeding regimen on growth performance and carcass composition of pigs housed in a commercial environment. *Kansas Agricultural Experiment Station Research Reports*: Vol. 2: Iss. 8. http://dx.doi.org/10.4148/2378-5977.1312.

[10] Colina, J.J., A.J. Lewis, P.S. Miller, and R.L. Fischer. 2001. Dietary manipulation to reduce aerial ammonia concentrations in nursery pig facilities. J. Anim. Sci. 79: 3096-3103.

[11] Sahoo S.P., D. Kaur, A.P. Sethi, A. Sharma, and M. Chandra. 2015. Evaluation of *Yucca schidigera* extract as feed additive on performance of broiler chicks in winter season. Veterinary World 8(4): 556-560.

10 ft) was equipped with a 4-hole stainless steel feeder and cup waterer for ad libitum access to feed and water and allowed approximately 6.6 ft^2/pig. Feed additions to each individual pen were made and recorded by a robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN).

A total of 2,430 pigs (PIC 359 × 1050; initial BW = 64.6 lb) were used to evaluate the effects of dietary supplementation of chromium propionate (Cr; KemTRACE Cr, Kemin Industries, Des Moines, IA) and *Yucca schidigera*-based extract (Micro-Aid; DPI Global, Porterville, CA) on growth performance of finishing pigs housed in commercial conditions. Pigs were placed in balanced, mixed-gender pens (27 pigs per pen), blocked by average pen BW, and randomly assigned to treatment. Diets were corn-soybean meal-based and were formulated in 5 dietary phases to meet or exceed NRC[6] requirement estimates within phase. Dietary treatments were fed for the full duration of the study and were arranged in a 2 × 3 factorial. Main effects included added Cr (0 and 200 ppb added Cr from Cr propionate; KemTRACE Cr, Kemin Industries, Des Moines, IA), and *Yucca schidigera* extract (0, 62.5, and 125 ppm, Micro-Aid; DPI Global, Porterville, Ca). All diets were manufactured at a commercial feed mill (New Horizon Feeds, Pipestone, MN; Table 1) and were fed in meal form.

Samples of the complete feed were taken from feeders at the beginning and end of each phase. Subsamples of each diet were then submitted for proximate analysis (Ward Laboratories, Inc., Kearney, NE) and Cr analysis (University of Guelph Agriculture & Food Laboratory; Guelph, ON). Pens of pigs were weighed and feeder measurements were recorded approximately every 14-d and at dietary phase changes, first marketing, and conclusion of the trial to determine ADG, ADFI, and F/G. The 3 largest pigs per pen were selected and marketed on d 95 and 98 in barns 1 and 2, respectively, following the routine farm protocol with no carcass data collected on these animals. At the conclusion of the trial, the remaining animals were given a tattoo corresponding to pen number and were transported to a commercial packing facility (JBS Swift and Company; Worthington, MN) for processing and carcass data collection. Carcass measurements taken at the plant included HCW, backfat, percentage carcass lean, and loin depth. Percentage yield was calculated by dividing HCW by mean pen live weight collected at the research facilities prior to transport to harvest facility for the corresponding pen.

Data were analyzed as a randomized complete block design using the GLIMMIX procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. Weight block was included in the model as a random effect, which also accounted for the barn pigs were housed in. Linear and quadratic interactive effects were evaluated in the statistical model, as well as the main effect of added Cr and linear and quadratic effects of increasing *Yucca schidigera*. Backfat, loin depth, and percentage lean were adjusted to a common carcass weight using HCW as a covariate. Results were considered significant at $P \leq 0.05$ and marginally significant between $P > 0.05$ and $P \leq 0.10$.

Results and Discussion

Proximate analysis of diets did not yield significant differences from formulated values (Table 2). Chromium analysis yielded a significant amount of variability, with analyzed values ranging from 660 to 2,400 ppb. Total Cr content within corn-soybean meal diets can vary significantly, ranging from 750-3,000 ppb.[6] Thus, while variable, analyzed values are within reasonable variation.

Increasing *Yucca schidigera* inclusion in the grower period (65 to 201 lb BW) resulted in a marginally significant (quadratic, $P = 0.093$; Table 3) decrease, then increase in ADG, with the poorest gain observed in pigs fed diets with 62.5 ppm *Yucca schidigera* and the best gain observed in pigs fed 125 ppm. This resulted in a marginally significant Cr × *Yucca schidigera* interaction (linear, $P = 0.100$) for BW at the end of the grower period with BW being similar across *Yucca schidigera* treatments when Cr was not included in the diet, but was increased when *Yucca schidigera* increased from 62.5 to 125 ppm in diets containing Cr. Inclusion of Cr or *Yucca schidigera* had no effect on ($P >$ 0.10) on ADFI or F/G during the grower period.

During the finishing phase (201 to 272 lb BW), pigs fed added *Yucca schidigera* had decreased (quadratic, $P = 0.018$) ADG, with the poorest ADG observed in pigs fed 62.5 ppm *Yucca schidigera*. There was no evidence of differences ($P > 0.10$) among pigs for ADFI observed within the finishing period. Feed efficiency worsened (linear, $P = 0.034$) in pigs fed increasing *Yucca schidigera*. Added Cr during the finishing period did not influence ($P > 0.10$) ADG, ADFI, or F/G.

The main effect of added *Yucca schidigera* on final BW (quadratic, $P = 0.012$) resulted in pigs fed diets with 62.5 ppm having the lowest final BW. For the overall data, a marginally significant (linear, $P = 0.072$) Cr × *Yucca schidigera* interaction was observed for ADG and ADFI, where pigs fed added *Yucca schidigera* without added Cr did not differ, but when Cr was included, ADG and ADFI increased as *Yucca schidigera* increased from 62.5 to 125 ppm. This resulted in a marginally significant (linear, $P = 0.058$) Cr × *Yucca schidigera* interaction for final BW, where increasing *Yucca schidigera* without Cr reduced final BW, but when Cr was added, BW increased as *Yucca schidigera* increased from 62.5 to 125 ppm. Increasing *Yucca schidigera* supplementation resulted in a marginally significant increase, then decrease (quadratic, $P = 0.057$) in F/G. Chromium supplementation alone did not influence overall growth performance ($P \geq 0.299$).

Carcass characteristics, including HCW, loin depth, backfat, percentage lean, and percentage yield, were not influenced by added Cr ($P \geq 0.278$). Inclusion of *Yucca schidigera* at 62.5 ppm resulted in the lowest HCW (quadratic, $P = 0.012$), but did not influence loin depth, backfat, percentage lean, or percentage yield ($P \geq 0.152$).

In summary, supplementation of Cr propionate along with *Yucca schidigera* led to modest changes in performance with the greatest benefit observed when adding 200 ppb Cr and 125 ppm *Yucca schidigera*. Adding Cr alone did not influence growth performance or carcass characteristics. With regards to *Yucca schidigera* level, growth performance was optimized when adding 125 ppm.

Table 1. Diet composition (as-fed basis)

	Dietary phase[1]				
Item	1	2	3	4	5
Ingredient, %					
Corn	55.04	63.03	68.13	71.29	79.82
Soybean meal, 46.5% CP	22.80	14.97	9.89	6.71	8.21
DDGS[2]	20.00	20.00	20.00	20.00	10.00
Calcium carbonate	0.95	0.98	0.90	0.93	0.85
Monocalcium phosphate, 21% P	0.25	0.08	0.10	0.08	0.20
Salt	0.35	0.35	0.35	0.35	0.35
L-Lys HCl	0.38	0.39	0.40	0.41	0.33
DL-Met	0.02	- - -	- - -	- - -	- - -
L-Thr	0.05	0.04	0.05	0.06	0.07
L-Trp	- - -	0.01	0.02	0.02	0.01
Phytase[3]	0.01	0.01	0.01	0.01	0.01
Vitamin/trace mineral premix	0.15	0.15	0.15	0.15	0.15
KemTRACE Cr[4]	+/-	+/-	+/-	+/-	+/-
Micro-Aid[5]	+/-	+/-	+/-	+/-	+/-
Total	100	100	100	100	100

continued

Table 1, *continued*. Diet composition (as-fed basis)

	Dietary phase[1]				
Item	1	2	3	4	5
Calculated analysis[6]					
Standardized ileal digestible (SID) amino acids, %					
Lys	1.06	0.89	0.78	0.71	0.65
Ile:Lys	62	60	59	58	58
Leu:Lys	149	158	166	173	166
Met:Lys	30	29	30	31	30
Met and Cys:Lys	55	56	58	60	59
Thr:Lys	61	60	61	63	65
Trp:Lys	18.3	18.1	18.0	18.0	18.0
Val:Lys	69	69	69	69	69
Total Lys, %	1.23	1.04	0.92	0.84	0.76
ME, kcal/lb	1,505	1,511	1,514	1,516	1,514
NE, kcal/lb	1,102	1,125	1,139	1,148	1,158
SID Lys:ME, g/Mcal	3.19	2.67	2.34	2.12	1.95
SID Lys:NE, g/Mcal	4.36	3.59	3.11	2.81	2.55
CP, %	20.5	17.5	15.6	14.4	12.9
Ca, %	0.52	0.48	0.43	0.43	0.42
P, %	0.48	0.41	0.39	0.37	0.37
Available P, %	0.32	0.27	0.27	0.26	0.25
STTD P, %[7]	0.35	0.30	0.29	0.28	0.28

[1] Diets were fed in a 5-phase feeding program formulated to 60 to 100, 100 to 150, 150 to 200, 200 to 240, and 240 to 280 lb BW ranges.

[2] DDGS = dried distillers grains with solubles.

[3] Optiphos 2000 (Huvepharma, Sofia, Bulgaria) provided an estimated release of 0.11% available P.

[4] KemTRACE Cr (0.04% Cr from chromium propionate; Kemin Industries Inc., Des Moines, IA) was added at 0 or 1.0 lb/ton (200 ppb added Cr) at the expense of corn.

[5] Micro-Aid (DPI Global, Porterville, CA.) was added at 0, 2, or 4 lb/ton at the expense of corn to provide 0, 62.5, and 125 ppm *Yucca schidigera*, respectively.

[6] NRC, 2012. Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington D.C.

[7] Standardized total tract digestible P.

Table 2. Chemical analysis of diets, phase 1-5 (as-fed basis)[1,2]

Added Cr, ppb[3]:	0			200		
Yucca schidigera, ppm[4]:	0	62.5	125	0	62.5	125
Phase 1						
DM, %	89.8	89.4	89.7	89.9	89.7	89.6
CP, %	20.7	21.7	21.6	21.3	20.6	21.5
Ether extract, %	3.4	3.7	3.4	3.3	3.6	3.7
Crude fiber, %	2.1	2.4	2.5	2.0	2.1	2.6
Cr, ppb	1,700	2,200	2,100	2,400	1,700	2,400
Phase 2						
DM, %	89.7	89.9	90.0	89.7	90.3	89.7
CP, %	19.2	18.7	19.7	19.5	19.6	19.1
Ether extract, %	3.8	3.6	3.6	3.6	3.9	3.7
Crude fiber, %	2.1	2.1	2.9	2.8	3.4	2.8
Cr, ppb	1,700	1,400	1,500	1,200	1,200	1,700
Phase 3						
DM, %	89.6	89.4	89.3	89.0	88.9	89.7
CP, %	16.2	16.1	16.0	16.1	15.0	15.6
Ether extract, %	3.8	3.7	4.0	3.9	4.0	3.9
Crude fiber, %	2.5	2.7	2.9	2.6	2.6	2.4
Cr, ppb	920	800	660	970	1,700	1,000
Phase 4						
DM, %	89.4	90.0	89.8	89.0	89.6	89.6
CP, %	16.8	17.7	18.4	15.9	15.7	17.9
Ether extract, %	3.9	3.6	3.7	3.8	3.9	3.8
Crude fiber, %	2.5	3.3	3.3	3.2	2.1	2.5
Cr, ppb	640	1,400	1,400	1,200	790	1,200
Phase 5						
DM, %	88.8	90.4	89.0	89.9	89.2	88.9
CP, %	13.9	13.8	14.2	12.7	13.9	14.9
Ether extract, %	3.5	3.8	4.0	3.6	4.0	4.2
Crude fiber, %	2.4	1.9	2.4	1.8	2.6	2.4
Cr, ppb	1,400	1,300	970	1,100	1,100	1,200

[1] A composite sample was collected from feeders within treatment and phase, subsampled, and submitted to Ward Laboratories (Kearney, NE) for proximate analysis and to University of Guelph Agriculture & Food Laboratory (Guelph, ON) for Cr analysis.

[2] Diets were fed in a 5-phase feeding program formulated to 60 to 100, 100 to 150, 150 to 200, 200 to 240, and 240 to 280 lb BW ranges.

[3] KemTRACE Cr (0.04% Cr from Cr propionate; Kemin Industries Inc., Des Moines, IA) was added at 0 or 1.0 lb/ton (200 ppb added Cr) at the expense of corn.

[4] Micro-Aid (Distributor's Processing, Inc.) was added at 0, 2, or 4 lb/ton at the expense of corn to provide 0, 62.5, and 125 ppm *Yucca schidigera*, respectively.

Table 3. Effects of added Cr propionate and *Yucca schidigera* on finishing pig growth performance and carcass characteristics[1]

Added Cr, ppb:[2]	0			200				Probability, $P <$				
									Yucca schidigera		Cr × *Yucca schidigera*	
Yucca schidigera, ppm:[3]	0	62.5	125	0	62.5	125	SEM	Cr	Linear	Quadratic	Linear	Quadratic
BW, lb												
Initial	64.5	64.6	64.6	64.6	64.5	64.6	0.94	0.991	0.965	0.885	0.902	0.679
End grower	201.5	200.5	200.3	200.6	199.3	202.3	2.02	0.971	0.797	0.109	0.100	0.254
Final	273.8[a,b]	270.2[c]	271.3[b,c]	273.1[a,b,c]	271.1[b,c]	275.4[a]	1.84	0.167	0.936	0.012	0.058	0.723
Grower (phases 1-3)												
ADG, lb	1.98	1.96	1.96	1.97	1.95	1.99	0.020	0.945	0.682	0.093	0.166	0.265
ADFI, lb	4.83	4.82	4.80	4.78	4.80	4.87	0.052	0.936	0.448	0.734	0.105	0.656
F/G	2.45	2.46	2.45	2.43	2.47	2.45	0.035	0.954	0.528	0.127	0.529	0.511
Finisher (phases 4-5)												
ADG, lb	1.96	1.89	1.92	1.95	1.92	1.96	0.048	0.167	0.509	0.018	0.237	0.576
ADFI, lb	6.54	6.44	6.53	6.46	6.52	6.60	0.082	0.601	0.232	0.252	0.162	0.326
F/G	3.36	3.42	3.42	3.33	3.40	3.38	0.054	0.120	0.034	0.110	0.884	0.769
Overall (phases 1-5)												
ADG, lb	1.97[a,b]	1.94[c]	1.95[b,c]	1.96[a,b,c]	1.94[b,c]	1.98[a]	0.028	0.299	0.976	0.007	0.072	0.649
ADFI, lb	5.41[a,b]	5.37[a,b]	5.40[a,b]	5.36[b]	5.39[a,b]	5.46[a]	0.042	0.686	0.202	0.377	0.071	0.783
F/G	2.76	2.78	2.78	2.74	2.79	2.77	0.042	0.450	0.071	0.057	0.788	0.394
Carcass characteristics[4]												
HCW, lb	205.7	202.5	204.6	204.9	203.8	206.5	2.31	0.315	0.774	0.012	0.183	0.668
Loin depth, in.	2.61	2.59	2.61	2.62	2.60	2.57	0.031	0.353	0.206	0.648	0.196	0.422
Backfat, in.	0.65	0.64	0.65	0.66	0.64	0.66	0.012	0.409	0.819	0.152	0.811	0.851
Lean, %	56.73	56.85	56.79	56.65	56.79	56.50	0.226	0.278	0.787	0.267	0.482	0.642
Yield, %	75.17	74.95	75.42	75.02	75.15	75.00	0.744	0.426	0.568	0.542	0.472	0.155

[1] A total of 2,430 finishing pigs (PIC 359 × 1050; initial BW = 64.6 lb) were used in a five-phase finisher study with 27 pigs per pen and 14 replications per treatment. Treatment diets were fed for the full duration of the trial and were formulated to 60 to 100, 100 to 150, 150 to 200, 200 to 240, and 240 to 280 lb BW ranges.

[2] KemTRACE Cr (0.04% Cr from Cr propionate; Kemin Industries Inc., Des Moines, IA) was added at 0 or 1.0 lb/ton (200 ppb added Cr) at the expense of corn.

[3] Micro-Aid (DPI Global, Porterville, CA) was added at 0, 2, or 4 lb/ton at the expense of corn to provide 0, 62.5, and 125 ppm *Yucca schidigera*, respectively.

[4] Backfat, percentage lean, and loin depth were analyzed by adjusting for a common HCW.

[a,b,c] Means lacking common superscripts differ ($P < 0.05$).