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Effect of chromium propionate and fat source on growth, carcass traits, and meat quality in swine and the effect of chromium propionate on growth and carcass traits in broilers

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EFFECT OF CHROMIUM PROPIONATE AND FAT SOURCE ON GROWTH, CARCASS TRAITS, AND MEAT QUALITY IN SWINE AND THE EFFECT OF CHROMIUM PROPIONATE ON GROWTH AND CARCASS TRAITS IN BROILERS

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ABSTRACT

Three experiments were conducted to determine the effects of the chromium propionate (CrProp) in swine and poultry diets. Two broiler experiments, each utilizing 1,460 Ross X Ross broilers, were conducted to evaluate the effects of 0, 200, 400, or 800 ppb CrProp on growth performance and carcass traits in 0 to 42 and 0 to 49 d-old broilers. In Exp. 1, 400 ppb Cr decreased ($P < 0.10$) ADG and G:F in the grower phase, but mortality was reduced ($P < 0.10$) in broilers fed 200 ppb or 800 ppb Cr. In the finisher phase, G:F was increased ($P < 0.10$) in broilers fed all dietary levels of Cr, and mortality was reduced ($P < 0.10$) in broilers fed 200 and 400 ppb Cr. Chromium did not affect the overall growth data or carcass traits. In Exp. 2, CrProp did not affect growth performance. The results indicated that Cr as CrProp improved G:F in the later phases of growth and reduced mortality in Exp. 1 but not in Exp. 2. In Exp. 3, 108 crossbred Yorkshire gilts were used to examine the effects of 0 or 200 ppb CrProp on iodine value, fatty acid profile of fat, growth, carcass traits, and pork quality from gilts fed tallow or choice white grease (CWG). Chromium decreased ($P < 0.03$) 10^{th} rib back fat and increased ($P < 0.02$) percent muscle. Gain:feed was increased ($P < 0.003$) and ADFI decreased by fat addition. Fat increased hot carcass weight ($P < 0.07$) and dressing percent ($P < 0.02$). Average back fat, 9^{th} rib CL, and total loss were decreased ($P = 0.02$ to 0.04) by tallow. Belly width was increased ($P < 0.08$) by tallow, but belly bending on both the teatline and scribe side were increased ($P = 0.004$ to 0.01) by CWG. Iodine values on belly and loin samples were increased ($P < 0.001$) by CWG. Overall, Cr affected BF and percent muscle and the inclusion of tallow decreased ($P = 0.03$ to 0.09) belly and loin iodine value further than CWG or no added fat.

CHAPTER 1

INTRODUCTION

For many years, Cr has been considered by many nutritionists as an essential nutrient for animals and humans (NRC, 1997). Chromium is thought to have a primary role in activating insulin through the glucose tolerance factor (GTF; Schwarz and Mertz, 1959). Chromium is naturally found in the form of Cr^{+3}. Chromium propionate (KemTRACE Chromium, Kemin Industries Inc., Des Moines, IA) is made from a fractional distillation method that requires chromic oxide, propionic acid, and sodium hydroxide that yields sodium propionate as a precipitant. KemTRACE chromium propionate (CrProp) is a bioavailable, organic source of chromium for swine. It is a dry product with a Cr concentration of 0.04%.

The NRC (1997) published a summary of recent research on the effect of Cr on poultry and swine productivity. Research with Cr and swine is somewhat extensive. The NRC summarized the results of 31 publications on Cr and swine and reported that the response to Cr was inconsistent, but that Cr may improve growth performance and carcass traits. The effect of Cr on carcass traits is more consistent than the effect of Cr on growth performance. Research with poultry is more limited. The NRC (1997) summarized a total of 19 publications, 12 on growth performance and 7 with laying hens. Some of these publications were with quail and turkeys. As with swine, the responses have been variable; however improvements in growth, carcass traits, and egg production have been reported.

The vast majority of the research with Cr in swine and poultry has been with $CrCl_3$ or with chromium picolinate (CrPic). Recently, CrProp has been permitted for use in swine diets in the US and Canada. The research with CrProp in swine and poultry is more limited than with $CrCl_3$ or CrPic. Therefore, the purpose of this research was to evaluate the effect of CrProp on growth and carcass traits of swine and poultry. Two experiments with broilers were conducted and one experiment with growing finishing pigs was conducted.

CHAPTER 2

THE EFFECT OF CHROMIUM AS CHROMIUM PROPIONATE ON GROWTH AND CARCASS TRAITS OF BROILERS

Introduction

Organic Cr has been approved for use in swine in the US. Organic Cr is not currently approved for use in poultry, and there has been much less research with Cr in poultry than with Cr in swine. Because of the positive effect of organic Cr on reproductive traits of swine (Lindemann et al., 1995, 2004), some of the research with Cr in poultry has been with laying hens. Sahin et al. (2002a,b) reported that CrPic increased egg production and egg production efficiency in laying hens and quail. Research with Cr in poultry also has been conducted to evaluate growth and carcass traits. Rosebrough and Steele (1981) reported that Cr as $CrCl_3$ increased growth and feed efficiency in turkeys fed a low CP diet. In a similar study with broilers, Kim et al. (1995a) reported that G:F ratio was improved and that carcass fat was decreased by 200 ppb Cr as CrPic in low CP diets. Lien et al. (1999) also reported an increase in growth and a decrease in carcass fat in broilers fed diets supplemented with 1,600 ppb of CrPic. However, Kim et al. (1996a,b) reported that 800, 1,600, and 2,400 ppb Cr as CrPic had no effect on BW gain, feed intake, or G:F but Cr decreased carcass fat and mortality. Lee et al. (2003) reported that Cr as CrPic increased feed efficiency in 0 to 3 wk broilers. Sahin et al. (2002b) reported that Cr as CrPic increased growth performance and carcass traits in heat stressed broilers. However, this affect may be due to the stress on the animals. Ward et al. (1993) reported that Cr as CrPic had no effect on growth performance or carcass traits. Debski et al. (2004), fed Cr enriched yeast and reported no growth response, but they observed an increase in breast weight and a decrease in mortality.

Most of the previous research with Cr has been with CrPic or $CrCl_3$, and there has been no research in broilers with CrProp.

Therefore the objective of this research was to evaluate the effects of CrProp on growth performance and carcass traits in 0 to 42 d commercial broilers as well as growth performance in 0 to 49 d commercial broilers.

Materials and Methods

The procedures related to animal care used in this experiment were approved by the Louisiana State University Agricultural Center Institutional Animal Care and Use Committee.

General

Two similar experiments were conducted to determine the effects of dietary CrProp on growth performance and carcass traits in 0 to 42 and 0 to 49 d-old commercial Ross x Ross broilers. Each experiment was conducted with 1,460 broilers (House of Raeford, Gibsland, LA). The experiments consisted of four treatments that were replicated seven times (four male and three female) with either 50 male or 55 female broilers per pen. On day 0, chicks were sexed and randomly assigned to 28 (1.5 x 3.0 m) pens. The broilers were housed at the Louisiana State University Poultry farm in one room of a ventilated tunnel house equipped with cool cells and fans. All pens contained litter top-dressed with 10 cm of clean wood shavings. Broilers had ad libitum access to feed in mash form and water for the duration of the experiment. Lighting was via incandescent lights. The lighting program consisted of the first 3 d of full light, followed by 16 h of natural/artificial light and 8 h of near dark. The birds were conditioned to the dark over a 3 d period starting on the 4th d gradually going from full light on the 3rd d to 4-foot-candels on the 7th d. Mortalities were recorded daily and the weights of the dead birds were used to adjust ADG, ADFI, and G:F. The chicks were brooded between 31° and 32° C the 1st wk and the temperature was lowered gradually each week until 24° to 27° C was achieved. The three phase feeding program consisted of a starter, grower, and finisher diet. The diets (Table 2.1) were corn-soybean meal (C-SBM) based. The starter period, diets were formulated to provide 3,035 kcal/kg ME, 0.89% Ca, 0.45% nonphytate P (nPP), 1.25% total Lys, and 0.94% TSAA.

Table 2.1. Percentage composition of diets for 42 and 49 d growth trial [a]

Ingredient	Starter	Grower	Finisher
Corn	55.72	59.38	66.56
Soybean meal (47.5%)	36.00	31.97	25.93
Tallow	3.41	4.09	3.44
Monocalcium phosphate	1.55	1.34	1.19
Limestone	1.26	1.18	1.41
BMD + 3 nitro [b]	0.50	0.50	-
Salt	0.50	0.50	0.50
Mineral premix [c]	0.25	0.25	0.25
DL–Methionine	0.24	0.22	0.18
Choline chloride [d]	0.14	0.14	0.14
Biocox [e]	0.03	0.03	-
Ethoxyquin [f]	0.10	0.10	0.10
Vitamin premix [g]	0.05	0.05	0.05
L-Lysine·HCl	0.05	0.05	0.05
Sand [h]	0.20	0.20	0.20
Calculated composition			
Crude protein, %	22.39	20.73	18.39
ME, kcal/kg	3,035	3,117	3,155
Lys, %	1.25	1.14	0.98
TSAA, %	0.94	0.88	0.78
Thr, %	0.84	0.77	0.68
Trp, %	0.30	0.27	0.23
Ca, %	0.89	0.82	0.80
Nonphytate P, %	0.45	0.40	0.36

[a] Actual analysis for the diets with 0, 200, 400, and 800 ppb added Cr were 2,620, 2,750, 3,070, and 3,320 ppb in the starter diets; 2,250, 2,330, 2,790, and 2,820 ppb in the grower diets; 2,010, 2,600, 2,530, and 2,350 ppb in the finisher diets.
[b] Bacitracin methylene disacicylate + 3-nitro-4hydroxyphenylarsonic acid from Nutra Blend, Neosha, MO.
[c] Provided the following per kilogram of diet: Fe, 50 mg; Mn, 100 mg; Cu, 7 mg; Se, 0.15 mg; Zn 75mg; I, 1mg, as ferrous sulfate monohydrate, manganese sulfate, copper sulfate, sodium selenite, zinc sulfate, ethylenediamine dihydriodide, respectively with calcium carbonate as the carrier.
[d] Contains 600,000 mg/kg of choline.
[e] Biocox provided 132.3 g/kg of salinomycin sodium (Roche, Parsippany, NJ).
[f] Quinguard brand Ethoxyquin provided 66.6% 6-ethoxyl-1, 2 dihydo-2, 2, 4-trimethylquinone (Novus International).
[g] Provided the following per kilogram of diet: vitamin A, 8,000 IU; vitamin D_3, 3,000 IU; vitamin E, 25 IU; vitamin K, 1.5 IU; riboflavin, 10 mg; pantothenic acid, 15 mg; niacin, 50 mg; vitamin B_{12}, 0.02 μg; biotin, 0.1 μg; folic acid, 1 mg, pyridoxine, 4 mg, thiamin, 3 mg.
[h] Sand will be replaced by CrProp for Diets 2, 3, and 4.

For the growing period, diets were formulated to provide 3,117 kcal/kg ME, 0.82% Ca, 0.40% nPP, 1.14% total Lys, and 0.88% TSAA. For the finishing period, diets were formulated to provide 3,155 kcal/kg ME, 0.80% Ca, 0.36% nPP, 0.98% total Lys, and 0.78% TSAA.

Experiment 1

This experiment was conducted to evaluate the effect of CrProp on growth performance and carcass traits in 0 to 42-d-old commercial broilers. Chromium propionate was included in the diet to provide 0, 200, 400, or 800 ppb Cr. Average initial and final BW were 37 and 2,136 g, respectively.

Carcass Traits. After final BW were taken, six broilers from each pen were randomly selected and tagged. The broilers were then fasted for 12 h on d 42 and then transported to the Louisiana State University Food Processing and Technology Pilot Plant. The broilers were killed by severing the jugular vein. The birds were then scalded, defeathered, and eviscerated. The fat pad was removed and the weight was recorded before the carcasses were chilled in an aerated chill tank. The carcasses were chilled approximately 30 min, removed, allowed to drain, and chill weight was recorded. The breast from each carcass was removed and the individual breast weight was recorded as chilled breast weight. After the chilled breast weight was recorded, the breasts were placed in a poultry meat tray that contained two absorbent pads. Each tray was then sealed and held at 4 to 6° C for 24 h, after which breast weight was recorded to determine drip loss (DL).

Cook Loss. Twenty-four hours after determining DL, cook loss (CL) was determined. Three breasts per replication were individually vacuum packaged in plastic bags and heated in an agitating water bath at 85° C for 50 min. After cooking, breasts were blotted dry, allowed to remain at room temperature for 15 min, and then weighed. Cook loss was determined by taking the difference between the weight before and after cooking. Twenty-four hours after determining

CL, shear force (SF) was determined by shearing three, 3 cm cubes from each breast. Each cube was evaluated using a HD 250 Instron (Texture Technologies Corporation, Scarsdale, NY) fitted with a Warner-Bratzler shearing device with a load cell capacity of 25 kg and a cross-head speed of 100 mm/min.

Experiment 2

This experiment was similar to Exp. 1, except only growth performance data were collected and the study was conducted for 0 to 49 d. Average initial and final BW were 36.5 and 2,147 g, respectively.

Statistical Analysis. Data were analyzed as a completely randomized design using the GLM procedure of SAS (SAS Institute, Inc. Cary, NC, 1992). Contrast statements appropriate for unevenly spaced treatments were used to determine treatment differences. The pen of chicks served as the experimental unit for all data. The model included treatment and sex. There were no treatment x sex interactions, so this effect was removed from the model.

Results

Experiment 1

Growth Performance. In the grower phase, 400 ppb Cr decreased (quadratic, $P < 0.10$) ADG and G:F, but mortality was reduced (cubic, $P < 0.10$) in broilers fed 200 ppb or 800 ppb Cr. In the finisher phase, the 400 ppb Cr treatment increased (quadratic, $P < 0.10$) G:F in broilers, and mortality was reduced (quadratic $P < 0.10$) in broilers fed 200 and 400 ppb Cr (Table 2.2). There was no significant effect of Cr on growth performance in the starter phase or in the overall growth performance.

Carcass Traits. Chromium supplementation did not affect carcass traits in broilers (Table 2.3).

Experiment 2

Chromium supplementation did not affect growth performance in Exp. 2 (Table 2.4).

Table 2.2. The effect of chromium propionate on growth performance of 42 d-old broilers, Experiment 1 [a]

Item	Control	200 ppb Cr	400 ppb Cr	800 ppb Cr	SEM
Starter (d 0 to 14)					
ADG, g	20.27	20.04	20.02	19.92	0.24
ADFI, g	28.77	29.61	28.64	28.95	0.52
G:F, g:g	0.705	0.684	0.682	0.691	0.008
Mortality, %	0.14	0.57	0.57	0.71	0.21
Grower (d 15 to 36)					
ADG, g [b]	63.58	63.49	62.47	64.15	0.52
ADFI, g	102.85	103.53	102.71	104.53	0.99
G:F, g:g [b]	0.618	0.613	0.608	0.613	0.003
Mortality, % [c]	0.43	0.00	0.29	0.00	0.14
Finisher (d 37 to 42)					
ADG, g	65.96	69.15	68.82	66.46	1.79
ADFI, g	158.05	159.71	158.27	157.03	2.22
G:F, g:g [b]	0.416	0.433	0.435	0.423	0.008
Mortality, % [b]	0.29	0.00	0.00	0.71	0.26
Overall (d 0 to 42)					
ADG, g	49.53	50.04	49.49	49.98	0.55
ADFI, g	90.60	90.97	89.33	91.48	1.30
G:F, g:g	0.556	0.560	0.549	0.555	0.006
Mortality, %	0.86	0.57	0.86	1.43	0.41

[a] Data are means of seven replications, except for ADFI and G:F for the starter phase. The number of replications for ADFI and G:F for the 0, 200, 400, and 800 ppb Cr were 5, 5, 2, and 7 respectively. Initial and final BW were 37 and 2,136 g, respectively. Values are adjusted for mortality.

[b] Quadratic ($P < 0.10$).

[c] Cubic ($P < 0.10$).

Table 2.3. The effect of chromium propionate on carcass characteristics and meat quality of 42 d-old broilers, Experiment 1 [a]

Item	Control	200 ppb Cr	400 ppb Cr	800 ppb Cr	SEM
Live wt., kg	2.12	2.11	2.13	2.11	0.04
Eviscerated wt., kg	1.52	1.51	1.54	1.52	0.03
Chill wt., kg	1.55	1.53	1.57	1.54	0.03
Fat pad wt., g	26.44	24.57	28.73	25.79	2.13
Fat pad as percentage of live wt.	1.25	1.18	1.35	1.24	0.09
Fat pad as percentage of chill wt.	1.71	1.62	1.84	1.70	0.13
Carcass yield, % [b]	71.78	71.34	72.09	71.97	0.45
Moisture gain due to chill, % [c]	1.95	1.77	2.09	1.81	0.17
Breast wt. as percentage of live wt.	14.26	14.10	14.60	14.18	0.20
Breast wt. as percentage of chill wt.	19.48	19.43	19.83	19.32	0.25
Drip loss, % [d]	0.62	0.59	0.69	0.70	0.11
Cook loss, % [e]	24.93	24.98	25.58	25.74	0.65
Shear force, kg [f]	6.77	7.05	6.89	7.04	0.33

[a] Data are means of seven replicates of six broilers per replicate pen. Average initial and final BW were 37 and 2,136 g, respectively. The growth trial lasted 42 d. The broilers were processed on d 43 after a 12 h fast.
[b] Carcass yield was calculated as follows: eviscerated weight / live weight *100.
[c] Moisture gain was calculated as follows: [(chill weight - eviscerated weight) / eviscerated weight] *100.
[d] Moisture loss was calculated as follows: [(24-h breast weight - initial breast weight) / initial breast weight] *100.
[e] Cook loss was determined by cooking in an 85° C water bath for 50 min, then blotting and weighing (breasts were allowed to cool for 15 min).
[f] Shear force determined on three 3 cm cubes.

Table 2.4. The effect of chromium propionate on growth performance of 49 d-old broilers, Experiment 2 [a, b]

Item	Control	200 ppb Cr	400 ppb Cr	800 ppb Cr	SEM
Starter (d 0 to 14)					
ADG, g	23.05	23.05	23.47	23.59	0.25
ADFI, g	33.82	33.41	33.90	33.37	0.42
G:F, g:g	0.682	0.691	0.693	0.692	0.009
Mortality, %	1.89	1.95	2.16	3.06	1.15
Grower (d 15 to 35)					
ADG, g	54.34	53.98	55.62	55.43	0.98
ADFI, g	95.49	95.27	97.26	97.26	1.38
G:F, g:g	0.568	0.566	0.571	0.569	0.004
Mortality, %	1.12	1.12	0.57	0.83	0.53
Finisher (d 36 to 49)					
ADG, g	42.42	42.36	41.96	43.24	1.21
ADFI, g	118.51	118.07	119.24	121.18	1.88
G:F g:g	0.357	0.358	0.352	0.357	0.007
Mortality, %	3.01	1.66	2.83	2.21	0.85
Overall (d 0 to 49)					
ADG, g	41.69	41.52	42.19	42.37	0.67
ADFI, g	85.17	84.94	86.20	86.62	1.04
G:F, g:g	0.489	0.489	0.489	0.489	0.003
Mortality, %	6.03	4.73	5.56	6.10	1.31

[a] Data are means of seven replications with an initial and final BW of 37 and 2,147 g, respectively. Values are adjusted for mortality.
[b] There were no significant effects ($P > 0.10$).

Discussion

The effect of Cr on growth performance and carcass traits in broilers has been variable (NRC, 1997), and our results agree with this variability. Our research showed that Cr supplementation improved some aspects of growth performance in one experiment but not in another. Our results and the review by the NRC (1997) regarding the variability of Cr supplementation agree with recent publications. Lee et al. (2003) reported that CrPic had no affect on growth, but feed efficiency was improved. Sahin et al. (2002b) reported that Cr as CrPic improved growth performance of broilers during heat stress, but this response may be due to the stress. Lien et al. (1999) reported that 1,600 ppb Cr as CrPic improved gain in broilers. However, Kim et al. (1996a,b) reported no effect of Cr as CrPic on growth performance in broilers.

Our data suggest that Cr had no effect on carcass traits or meat quality in broilers. However, Lien et al. (1999) and Kim et al. (1996b) reported that fat deposition was decreased in broilers fed 1,600 ppb or 200 and 400 ppb Cr as CrPic, respectively.

Our data also suggest that Cr has positive effects on mortality in broilers. Similarly, Kim et al. (1996b) reported that Cr as CrPic reduced mortality in broilers, and Debski et al. (2004) reported that mortality was reduced in broilers fed Cr as Cr enriched yeast.

In summary, our data and the data in the literature suggest that Cr may improve growth performance, carcass traits, and mortality in some instances but not in others. More extensive research is needed to determine the effect of Cr on growth performance, carcass traits, and mortality in broilers.

CHAPTER 3

THE EFFECT OF CHROMIUM PROPIONATE ON GROWTH PERFORMANCE, CARCASS TRAITS, MEAT QUALITY, IODINE VALUE, AND FATTY ACID PROFILE OF FAT FROM GILTS FED DIETS WITH TALLOW OR CHOICE WHITE GREASE

Introduction

Chromium supplementation to diets for swine has proven to be beneficial, but the responses are inconsistent. Although, supplemental levels as well as form vary, some reports indicate that Cr has beneficial effects on specific growth and carcass responses (NRC, 1997). Much of the research with Cr has been conducted with Cr tripicolinate or $CrCl_3$. Recently, CrProp has been allowed in diets for swine. Matthews et al. (2001a) supplemented Cr as either CrPic or CrProp at 200 ppb and reported no effects on growth performance or carcass traits. Subsequently, studies by Matthews et al. (2003, 2005) reported that 200 ppb Cr as CrProp did not affect growth performance or carcass traits; however, CrProp had positive effects on some aspects of pork quality. Shelton et al. (2003) reported that CrProp had no effect on growth performance but had positive effects on some carcass traits in one experiment but not in another.

Production of leaner pigs by the industry has led to unfavorable carcass traits such as thin, soft pork bellies, which produce a lower-quality product. Iodine value (IV) is a measure of the degree of unsaturation of a fat, and therefore is an indicator of fat firmness. A relative high degree of saturation is essential for maximizing the quality of pork bellies. Averette Gatlin et al. (2002) reported that an increase in dietary beef tallow decreased iodine value (IV) and PUFA levels in fat. Averette Gatlin et al. (2003) supplemented diets with 5% choice white grease (CWG), which had been chemically hydrogenated to decrease its IV, and reported that chemical hydrogenation of CWG improved pork belly quality without altering growth performance.

Chromium supplementation to the diet has been shown to increase insulin sensitivity and glucose clearance (Amoikon et al., 1995; Matthews et al., 2001d).

This increased insulin sensitivity may increase the efficiency of glucose utilization, and it may make more dietary energy available to the pig. If this occurs, then the pig may have more glucose available for de novo fatty acid synthesis. Fatty acids synthesized by the pig are more saturated than the fat in typical pig diets (Stahly, 1984). Thus, Cr supplementation may affect the fatty acid profile of fat stores in the pig, and this may be the reason for the observed improvement in some aspects of pork quality.

Therefore, the purpose of this research was to investigate the effect of Cr as CrProp on growth performance, carcass traits, meat quality, and the fatty acid profile of fat from pigs fed no supplemented dietary fat, CWG, or tallow.

Materials and Methods

The procedures related to animal care used in this experiment were approved by the Louisiana State University Agricultural Center Institutional Animal Care and Use Committee.

General

One hundred-eight crossbred Yorkshire gilts were randomly selected and allotted to six dietary treatments in a randomized complete block design on the basis of BW, and allotted from within block to a 2 X 3 factorial arrangement of treatments. The arrangement consisted of two levels of Cr supplementation (0 and 200 ppb in the form of CrProp) and three dietary fat sources (no added fat, CWG, or tallow). Each treatment was replicated six times with three pigs per replicate pen. The experiment was replicated in time with three replicates conducted each time. Dietary treatments were: 1) corn-soybean meal (C-SBM) diet with no added fat; 2) C-SBM diet with 4% added tallow; 3) C-SBM diet with 4% added CWG; 4) Diet 1 + 200 ppb Cr as CrProp (Kem-TRACE Chromium; Kemin Industries, Inc.) ; 5) Diet 2 + 200 ppb Cr; 6) Diet 3 + 200 ppb Cr (Table 3.1). A four-phase grower-finisher feeding program was used.

Table 3.1. Percentage composition of basal diets (as fed basis)

Item	Grower			Finisher 1			Finisher 2			Finisher 3		
	Basal	4% tallow	4% CWG	Basal	4% tallow	4% CWG	Basal	4% tallow	4% CWG	Basal	4% tallow	4% CWG
Ingredient												
Corn	72.03	65.66	65.53	77.05	70.95	70.83	81.19	75.29	75.19	86.26	80.62	80.53
Soybean meal, (48% CP)	25.02	27.21	27.34	20.26	22.22	22.33	16.26	18.02	18.11	10.96	12.46	12.53
Limestone	1.03	1.04	1.04	0.96	0.97	0.97	0.89	0.89	0.89	0.92	0.92	0.93
Monocalcium phosphate	0.73	0.87	0.88	0.54	0.67	0.67	0.47	0.60	0.60	0.67	0.81	0.81
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin premix[a]	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Trace mineral premix[b]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Sand/chromium propionate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Tallow	----	4.00	----	----	4.00	----	----	4.00	----	----	4.00	----
Choice white grease	----	----	4.00	----	----	4.00	----	----	4.00	----	----	4.00
L-Lys·HCl	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
L-Thr	0.02	0.03	0.03	0.02	0.03	0.03	0.02	0.03	0.03	0.01	0.02	0.02
DL-Met	----	0.02	0.02	----	----	----	----	----	----	----	----	----
L-Trp	----	----	----	----	----	----	----	----	----	0.01	0.004	0.004
Calculated composition												
ME, kcal/kg	3,315	3,480	3,490	3,326	3,491	3,502	3,332	3,498	3,508	3,327	3,492	3,502
True digestible amino acids												
Lys, %	0.94	0.99	0.99	0.83	0.87	0.87	0.73	0.76	0.76	0.59	0.62	0.62
TSAA, %	0.54	0.57	0.57	0.50	0.50	0.50	0.46	0.46	0.47	0.41	0.41	0.41
Thr, %	0.60	0.62	0.63	0.53	0.55	0.56	0.47	0.49	0.50	0.39	0.41	0.41
Trp, %	0.18	0.19	0.19	0.16	0.17	0.17	0.14	0.14	0.14	0.11	0.12	0.12
Ca, %	0.61	0.64	0.64	0.54	0.57	0.57	0.49	0.51	0.52	0.52	0.54	0.54
P, %	0.53	0.55	0.56	0.47	0.49	0.49	0.44	0.46	0.46	0.46	0.48	0.48
Crude fat, %	3.56	7.38	7.38	3.61	7.43	7.43	3.65	7.48	7.48	3.69	7.52	7.52

[a]Vitamin premix provided the following per kilogram of diet: vitamin A, 8,267 IU; vitamin D_3, 2,480 IU; vitamin E, 66 IU; menadionine (as menadione pyrimidinol bisulfite complex), 6.2 mg; riboflavin, 10 mg; Ca D-pantothenic acid, 37 mg; niacin, 66 mg; vitamin B12, 45µg; D-biotin, 331µg; folic acid, 2.5 mg; pyridoxine, 3.31 mg; thiamine, 3.31 mg; and vitamin C, 83 µg.

[b]Trace mineral premix provided the following per kilogram of diet: Zn, 127 mg; Fe, 127 mg; Mn, 20 mg; Cu, 12.7 mg; and I, 0.80 mg, as zinc sulfate, ferrous sulfate, manganese sulfate, copper sulfate, and ethylenediamine dihydriodide, respectively, with calcium carbonate as the carrier.

[c] Recommended AA concentrations were established for gilts gaining 350 g of lean gain/day for the weights 31.5, 54.5, 77.5, and 101.5 kg, which resulted in ratios of 3,511, 4,031, 4,598, and 5,629 kcal of ME to true digestible Lys for the grower, finisher 1, finisher 2, and finisher 3 feeding phases, respectively.

Nutrient requirements for the four phases met or exceeded the NRC (1998) recommended AA concentrations were for gilts gaining 350 g of lean gain/day for BW of 31.5, 54.5, 77.5, and 101.5 kg, which resulted in ratios of 3,511, 4,031, 4,598, and 5,629 kcal of ME to true digestible Lys for the grower, finisher 1, finisher 2, and finisher 3 feeding phases, respectively. True digestible Trp, Thr, and TSAA, were set as a ratio to true digestible Lys, total P was set as a ratio to ME and Ca was set as a ratio to total P; all from NRC (1998; Table 3.2). Treatment diets were in mash form and were provided for *ad libitum* consumption along with water. Gilts were placed on a common diet upon entering the grower facility. The dates for the phase changes are in Table 3.3. Gilts and feed were weighed at the initiation and conclusion of the study as well as at each phase change for calculation of ADG, ADFI, and G:F. Gilts were housed in 1.8 x 2.4-m pens in an enclosed facility with slated floors during the grower phase and in a curtain-sided building with 1.5 × 3.0-m pens and concrete slotted floors during the finisher phases.

Carcass Evaluation. At the termination of both trials, two pigs from each pen were randomly selected for slaughter. Pigs were transported to the Louisiana State University Agricultural Center Meats Laboratory where they were killed by exsanguination after electrical stunning. Conventional carcass data (LM area, 10^{th} rib back fat thickness, carcass length, muscle score, and dressing percentage) were taken on the left side of the carcass after a 20-h chill at 2°C. Values from total body electrical conductivity (TOBEC); (Model MQI-27: Meat Quality Inc., Springfield, IL), and Minolta color data were determined as described by Matthews et al. (2001b). Fat-free lean and percent fat-free lean were also determined by NPPC (2000) equations. Hot carcass weight and belly weights were collected for determination of belly yield.

Pork Quality. Chop samples were collected for evaluation of drip, cook, and purge (thaw) loss and shear force (SF). Pork quality measurements were taken from the left side of the carcass after a 20-h chill at 2°C and determined as described by Matthews et al. (2001c). Carcasses were split between the 10^{th} and 11^{th} ribs to determine LM area.

Table 3.2. Ratio of ME and true digestible amino acids to Lys for four phases of growth in gilts[a]

Item	Grower	Finisher 1	Finisher 2	Finisher 3
Weight range, kg	20 to 43	43 to 66	66 to 89	89 to 113
ME:Lys, kcal %	3,511	4,031	4,598	5,629
True digestible Lys	100	100	100	100
True digestible TSAA	57	58	58	60
True digestible Trp	18	19	18	19
True digestible Thr	63	64	65	66

[a] Based on the requirement for gilts gaining 350 g/d lean as calculated using NRC (1998).

Table 3.3. Timeline for phase changes

Item	Trial 1	Trial 2
Phase 1 initial BW, kg [a]	29.76	27.98
End of phase 1 wt., kg [b]	39.43	40.16
Days on phase 1	14	14
End of phase 2 wt., kg [c]	73.45	66.14
Days on phase 2	36	28
End of phase 3 wt., kg [d]	91.80	92.10
Days on phase 3	24	28
End of phase 4 wt., kg	112.24	104.71
Days on phase 4	23	18
Total days	98	89

[a] Beginning of phase 1 (grower diet fed).
[b] Phase 2 feeding begins (finisher 1 diet fed).
[c] Phase 3 feeding begins (finisher 2 diet fed).
[d] Phase 4 feeding begins (finisher 3 diet fed).

A section of loin was removed and Commission internationale de I'Eclairage (CIE) L*, a*, and b* values were determined using the CIELAB space with a D65 illuminant. They were obtained from three orientations on the 10th rib loin interface using a Minolta spectrophotometer (Model CM-508d; Minolta Corporation, Ramsey, NJ). Pork quality scores (color and marbling) also were determined on the 10th-rib loin interface using the guidelines of the NPPC (2000). Two individuals independently scored the loins and the average was used. After collection of all carcass data, two 2.54-cm chops were collected from the 9th and 10th ribs. The 9th rib chop was used to determine fresh chop DL (24 h) using the suspension method described by Matthews et al. (2001b). For determination of DL, the loin sections were de-boned and fat was uniformly trimmed. The 10th rib chop was also uniformly trimmed, weighed, placed in vacuum bags, vacuum sealed, and frozen for later determination of frozen chop thaw, cook, and total losses. Fresh chop cooking and total loss were then determined as described by Matthews et al. (2001c).

Belly Bending. Belly bending, firmness measurements, and belly fat collection were conducted. Bellies were draped skin side down over a bar and the inside distance measured 15.2 cm below the bar. The distance was measured on both the teatline and scribe side of the belly. Belly thickness was measured in five locations: 1) mid-point of the belly on the teatline side of the belly; 2) mid-point of the belly on the scribe side of the belly; 3) on the shoulder end of the belly; 4) on the flank end of the belly; 5) in the center of the belly. Belly length and width measurements were also collected.

Fat Characteristics. Backfat tissue samples were taken from each carcass at a location approximately 10 cm below the last rib and 2 cm left of the midline cut. Core samples also were removed from the belly and evaluated for IV and fatty acid composition. The fat sample core was collected from the belly on the midline in the general location of the first teat.

Fat samples were stored frozen (-80°C) and shipped frozen to Premium Standard Farms for IV and fatty acid composition analyses (Averette Gatlin et al., 2002). Fatty acid analysis was conducted on the tallow and CWG before they were added to the diets (Appendix, Table 1).

Statistical Analysis. Data were analyzed by ANOVA (Steel and Torrie, 1980) using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC) as a randomized complete block design with a 2 X 3 factorial arrangement of treatments. The arrangement consisted of two levels of Cr (0 and 200 ppb) and three fat sources (no added fat, CWG, or tallow). Treatment comparisons were Cr vs. no Cr, fat vs. no fat, tallow vs. CWG, Cr x fat vs. no fat interaction, and Cr x tallow vs. CWG interaction (Appendix, Table 2). The pen of pigs served as the experimental unit for all data.

Results

Growth Performance. Chromium addition did not affect growth performance, and there were no Cr x fat source interactions (Table 3.4, $P > 0.10$). The addition of fat regardless of source decreased ($P < 0.03$) ADFI and increased ($P < 0.003$) G:F. The growth performance data for each diet and for each period are presented in Appendix, Table 3.

Carcass Traits. Chromium addition decreased 10th rib back fat (P < 0.04) and average back fat ($P < 0.07$) and increased percent muscling ($P < 0.02$), calculated by the NPPC equation. Average back fat was decreased ($P < 0.01$) by the addition of tallow *vs* CWG.

Table 3.4. The effect of chromium propionate on growth performance of gilts fed no fat or added tallow or choice white grease [a]

	Diets						
	0 ppb Cr			200 ppb Cr			
	No fat	4% Tallow	4% CWG	No fat	4% Tallow	4% CWG	SEM
ADG, kg	0.850	0.893	0.837	0.843	0.868	0.889	0.03
ADFI, kg [b]	2.583	2.410	2.398	2.519	2.465	2.502	0.05
G:F, kg [c]	0.329	0.371	0.350	0.334	0.352	0.355	0.01

[a] Data are means of six replicates of three pigs per replicate.
[b] Fat *vs* no added fat ($P < 0.03$).
[c] Fat *vs* no added fat ($P < 0.003$).

Hot carcass weight (*P* < 0.06) and dressing percentage (*P* < 0.02) were increased by the addition of a fat, regardless of source.

Pork Quality. Ninth rib shear force was decreased (P < 0.09) by Cr. Ninth rib CL, 9th rib total loss, and 10th rib DL and total loss were decreased (*P* = 0.02 to 0.04) by the addition of tallow.

Belly Bending. Belly width was decreased (P < 0.10) with the addition tallow compared with CWG (Table 3.7). Belly bending on both the teatline and scribe side were decreased (*P* = 0.01 to 0.02) by the addition of tallow (Table 3.7). Chromium supplementation had no effect on belly bending properties.

Fat Characteristics. Iodine values on belly and loin samples were increased (P < 0.001) with the addition of CWG, but were not affected by CrProp (Tables 3.8 and 3.9).

Discussion

The results of this study indicate that Cr as CrProp had no effect on overall growth performance. However, 10th rib BF and percent muscling were positively affected by CrProp. The addition of fat to the diet resulted in responses similar to those previously reported (Azain, 2001, 2004). Fat addition decreased ADFI and increased G:F. Fat source had no effect on growth performance. The addition of tallow decreased average backfat thickness, 9th rib CL, and total loss compared with the addition of CWG. Belly width and belly bending on both the teatline and scribe side were increased with the addition of CWG. Iodine values on belly and loin samples were increased with the addition of CWG, but were not affected by CrProp. Some reports have indicated that Cr does not affect growth performance (Matthews et al., 2003), while others report its effectiveness (Boleman et al., 1995, Lien et al., 1996; Page et al. 1993). Matthews et al. (2001a) reported that the addition of 200 ppb CrProp did not affect growth performance or carcass traits; however, Matthews et al. (2003, 2005) reported that CrProp had positive effects on some aspects of pork quality.

Table 3.5. The effect of chromium propionate on carcass traits of gilts fed no fat or added tallow or choice white grease [a]

	0 ppb Cr			200 ppb Cr			SEM	*P* > F Source		Contrast				
	No fat	4% Tallow	4% CWG	No fat	4% Tallow	4% CWG		TRT	TIME	Cr	Fat *vs* no fat	Fat	Cr x fat *vs* no fat	Cr x fat
Carcass traits [b]														
FKPW, kg	107.76	113.06	108.11	107.43	108.04	112.10	2.19	0.30	0.001	0.80	0.16	0.84	0.96	0.05
HCW, kg [c]	79.47	84.61	80.21	79.59	80.95	84.08	1.72	0.16	0.02	0.94	0.06	0.72	0.10	0.04
LM area, cm^2 [d]	44.25	47.01	45.77	46.94	48.46	47.24	1.59	0.54	0.79	0.16	0.28	0.45	0.66	0.10
10^{th} rib fat, cm [e]	1.78	1.81	1.62	1.40	1.48	1.63	0.13	0.22	0.01	0.04	0.70	0.91	0.33	0.21
ABF, cm [f]	2.40	2.43	2.49	2.25	2.21	2.53	0.07	0.02	0.001	0.07	0.15	0.01	0.63	0.07
Ham face fat, cm	1.15	1.28	1.03	0.99	1.14	1.17	0.11	0.54	0.07	0.60	0.40	0.35	0.45	0.21
CL, cm [g]	80.59	81.97	79.11	81.02	79.75	80.96	0.67	0.08	0.001	0.98	0.54	0.23	0.61	0.01
DP	73.74	74.81	74.20	74.11	74.97	75.01	0.37	0.11	0.001	0.15	0.02	0.45	0.86	0.38
TOBEC [h]														
FFL, kg [i]	41.41	44.71	42.64	42.45	41.64	43.98	1.26	0.40	0.48	0.83	0.24	0.92	0.40	0.10
FATC, cm	20.72	21.69	19.61	18.89	20.26	21.53	1.09	0.44	0.002	0.62	0.31	0.72	0.28	0.14
Lean:Fat, kg	2.123	2.114	2.258	2.345	2.101	2.092	0.15	0.78	0.02	0.91	0.48	0.65	0.24	0.61
% Lean	52.12	52.72	53.13	53.45	51.47	52.32	1.11	0.83	0.10	0.79	0.70	0.58	0.23	0.85
% Fat	26.04	25.72	24.43	23.59	24.99	25.55	1.22	0.73	0.01	0.50	0.74	0.77	0.22	0.45
NPPC [j]														
% Muscle [k]	55.49	55.51	56.59	58.09	57.94	56.44	0.81	0.12	0.01	0.02	0.81	0.80	0.30	0.12
Kg lean	44.10	47.02	45.38	46.18	46.92	47.43	1.25	0.44	0.55	0.20	0.17	0.66	0.61	0.40

[a] Data are means of six replicates of two pigs per replicate.
[b] FKPW = final killed pig weight; HCW = hot carcass weight; ABF = average back fat; DP = dressing percent; CL = carcass length.
[c] Fat *vs* no fat ($P < 0.06$); Cr x fat *vs* no fat ($P < 0.10$); Cr x fat ($P < 0.04$).
[d] Cr x fat ($P < 0.10$).
[e] Cr ($P < 0.04$).
[f] Cr ($P < 0.07$); tallow *vs* CWG ($P < 0.01$); Cr x fat ($P < 0.07$).
[g] Cr x fat ($P < 0.01$).
[h] FFL = fat-free lean; FATC = total fat of carcass. Data analyzed using TOBEC equations (Higbie et al., 2002).

[i] Cr x fat ($P <$ 0.10).
[j] Calculated using the equation described by the NPPC (2000), which uses 5% estimation for intramuscular fat and compensates for unequal body weights.
[k] Cr ($P < 0.02$).

Table 3.6. The effect chromium propionate on pork quality traits of gilts fed no fat or added tallow or choice white grease [a]

	0 ppb Cr			200 ppb Cr			SEM	*P* > F Source		Contrast			
	No fat	4% Tallow	4% CWG	No fat	4% Tallow	4% CWG		TRT	TIME	Cr	Fat *vs* no fat	Fat	Cr x fat *vs* no fat	Cr x fat
Temperature,°C														
Ham	4.93	5.43	4.74	5.11	5.37	5.35	0.24	0.30	0.09	0.24	0.35	0.16	0.82	0.18
Rectal	39.35	39.22	39.39	39.24	39.50	39.45	0.18	0.86	0.001	0.61	0.56	0.74	0.39	0.55
45 min	41.26	41.61	42.16	41.58	42.01	41.91	0.36	0.54	0.02	0.61	0.12	0.54	0.71	0.38
24 H	4.93	5.43	4.74	5.11	5.37	5.35	0.24	0.30	0.09	0.24	0.35	0.16	0.82	0.18
Pork quality [b]														
Color score	2.63	2.38	2.54	2.54	2.75	2.5	0.13	0.46	0.001	0.43	0.71	0.75	0.27	0.12
Marbling	1.21	1.25	1.21	1.21	1.46	1.08	0.13	0.52	0.05	0.80	0.72	0.13	0.86	0.22
CIE L*	49.29	51.81	49.69	51.53	48.88	53.18	1.45	0.27	0.60	0.44	0.70	0.46	0.44	0.04
CIE a*	1.52	1.29	0.81	1.41	0.80	2.24	0.46	0.29	0.31	0.47	0.65	0.31	0.48	0.05
CIE b*	10.41	11.30	10.39	11.28	10.03	12.36	0.73	0.27	0.76	0.39	0.78	0.34	0.68	0.04
Fresh chop [c]														
9^{th} drip loss [d]	4.67	5.91	4.96	5.74	3.74	6.56	0.71	0.12	0.22	0.78	0.89	0.21	0.29	0.01
9^{th} cook loss [e]	24.62	20.00	23.56	21.73	20.23	23.13	1.49	0.20	0.03	0.41	0.27	0.04	0.29	0.83
9^{th} total loss [f]	29.29	25.91	28.51	27.47	23.97	29.68	1.70	0.18	0.16	0.54	0.36	0.02	0.63	0.37
Shear force, kg [g]	4.06	3.68	4.11	3.73	3.55	3.59	0.23	0.39	0.64	0.09	0.42	0.32	0.98	0.40
Frozen chop [h]														
10^{th} drip loss [i]	15.92	15.29	15.81	15.64	13.72	16.68	0.75	0.16	0.03	0.60	0.53	0.03	0.95	0.11
10^{th} cook loss	22.67	22.75	27.07	23.99	24.84	25.65	1.58	0.35	0.52	0.61	0.21	0.12	0.72	0.28
10^{th} total loss [i]	38.58	38.04	42.88	39.63	38.56	42.33	1.80	0.28	0.70	0.82	0.40	0.03	0.74	0.77
Shear force, kg	3.33	3.16	3.63	3.41	3.59	3.78	0.24	0.53	0.32	0.28	0.43	0.19	0.61	0.57

[a] Data are means of six replicates of two pigs per replicate.

[b] The CIE L*, a*, and b* values (determined using the CIELAB space with a D65 illuminant) were obtained from three orientations on the 10th rib chop using a Minolta spectrophotometer (model CM-508d; Minolta Corporation, Ramsey, NJ).
[c] Deboned 9th rib chop suspended in sealed Whirl-pak bag for 24 h at 2°C then weighed to determine drip loss and immediately cooked for cook loss.
[d] Cr x fat ($P < 0.01$).
[e] Tallow *vs* CWG ($P < 0.04$).
[f] Cr x fat ($P < 0.02$).
[g] Cr ($P < 0.09$). Shear force was determined on four (2.54 cm) core samples.
[h] Deboned 10th rib chop vacuum sealed and frozen for 35 d (trial No. 1) and 40 d (No. 2) at -20°C, allowed to thaw at room temperature for 18 h, and then weighed to determine drip loss and immediately cooked for cook loss.
[i] Tallow *vs* CWG ($P < 0.03$).

Table 3.7. The effect of chromium propionate on belly bending properties of gilts fed no fat or added tallow or choice white grease [a, b]

	0 ppb Cr			200 ppb Cr			SEM	*P* > F Source		Contrast				
Item	No fat	4% Tallow	4% CWG	No fat	4% Tallow	4% CWG		TRT	TIME	Cr	Fat *vs* no fat	Fat	Cr x fat *vs* no fat	Cr x fat
Weight, kg	4.66	5.00	4.53	4.67	4.69	4.95	0.20	0.51	0.10	0.81	0.46	0.59	0.89	0.75
Length, cm	53.71	54.61	51.50	55.52	52.87	53.95	1.00	0.12	0.11	0.31	0.12	0.32	0.41	0.05
Width, cm [c]	24.97	24.84	25.81	24.86	24.65	25.80	0.61	0.62	0.32	0.84	0.50	0.10	0.99	0.88
Belly yield, % [d]	11.94	12.08	11.47	12.00	11.86	11.96	0.37	0.89	0.36	0.72	0.69	0.51	0.91	0.35
Belly area, cm^2	1341.80	1356.61	1329.95	1379.33	1304.09	1393.80	42.62	0.71	0.88	0.64	0.70	0.47	0.67	0.18
Thickness, cm	3.64	3.87	3.54	3.56	3.82	3.76	0.13	0.35	0.71	0.77	0.19	0.14	0.48	0.30
Teatline flop, cm [e]	15.67	19.59	15.66	16.95	18.40	15.93	1.24	0.16	0.01	0.90	0.32	0.02	0.43	0.56
Scribe flop, cm [f]	11.00	15.43	10.97	12.03	13.28	11.52	1.01	0.03	0.51	0.82	0.15	0.01	0.30	0.19

[a] Data are means of six replicates of two pigs per replicate.
[b] Belly bending was determined by draping the belly, skin side down, across a metal bar and measuring a distance 15.2 cm below the bar on both the teatline and scribe side of the belly.
[c] Tallow *vs* CWG ($P < 0.10$).
[d] The following equation was used to calculate percent belly yield: (belly wt/cold carcass wt) * 100.
[e] Tallow *vs* CWG ($P < 0.02$).
[f] Tallow *vs* CWG ($P < 0.01$).

Table 3.8. The effect of chromium propionate on fatty acid analysis for belly fat of gilts fed no fat or added tallow or choice white grease [a]

	0 ppb Cr			200 ppb Cr			SEM	*P* > F Source			Contrast			
	No fat	4% Tallow	4% CWG	No fat	4% Tallow	4% CWG		TRT	TIME	Cr	Fat *vs* no fat	Fat	Cr x fat *vs* no fat	Cr x fat
Fatty acid, weight														
C14:0	2.45	2.87	2.47	2.64	2.74	2.44	0.09	0.01	0.001	0.87	0.27	0.001	0.09	0.57
C16:0	27.05	25.50	24.78	27.28	25.47	25.68	0.49	0.01	0.12	0.37	0.001	0.60	0.81	0.35
C16:1	4.29	4.21	3.66	4.35	4.15	3.85	0.22	0.21	0.001	0.73	0.08	0.06	0.99	0.57
C18:0	8.22	8.22	7.62	8.54	8.55	8.01	0.24	0.11	0.002	0.09	0.20	0.03	0.93	0.89
C18:1	43.83	42.62	42.11	41.57	43.06	43.35	0.84	0.48	0.81	0.78	0.91	0.90	0.04	0.64
C18:2	11.33	11.83	15.70	12.54	11.23	13.40	1.07	0.06	0.25	0.52	0.24	0.01	0.16	0.43
C18:3	0.58	0.74	0.88	0.66	0.72	0.71	0.07	0.11	0.40	0.49	0.02	0.37	0.16	0.33
C20:1	0.58	0.50	0.56	0.48	0.54	0.64	0.03	0.02	0.86	0.82	0.24	0.02	0.01	0.59
IV [b]	63.36	63.49	69.61	63.69	62.73	66.50	1.34	0.01	0.22	0.29	0.09	0.001	0.34	0.39

[a] Data are means of six replicates of two pigs per replicate with the core sample extracted from the belly.
[b] Fat *vs* no fat ($P < 0.09$); tallow *vs* CWG ($P < 0.001$).

Table 3.9. The effect of chromium propionate on fatty acid analysis for loin fat of gilts fed no fat or added tallow or choice white grease [a]

	0 ppb Cr			200 ppb Cr			SEM	*P* > F Source		Contrast			
	No fat	4% Tallow	4% CWG	No fat	4% Tallow	4% CWG		TRT	TIME	Cr	Fat *vs* no Fat	Fat	Cr x fat *vs* no fat	Cr x fat
Fatty acid, weight														
C14:0	2.12	2.52	1.98	2.20	2.39	2.06	0.06	0.001	0.001	0.85	0.16	0.001	0.38	0.11
C16:0	25.06	23.42	22.77	25.18	23.07	23.03	0.34	0.001	0.33	0.98	0.001	0.33	0.80	0.38
C16:1	3.03	3.44	2.90	3.25	3.31	3.16	0.17	0.28	0.001	0.41	0.68	0.05	0.61	0.26
C18:0	9.20	8.70	8.28	9.34	8.64	7.67	0.39	0.06	0.45	0.58	0.01	0.09	0.49	0.50
C18:1	41.47	41.16	42.74	41.26	41.70	43.16	0.39	0.01	0.02	0.65	0.01	0.002	0.44	0.81
C18:2	15.34	13.82	17.24	15.05	14.13	16.75	0.44	0.001	0.95	0.67	0.46	0.001	0.80	0.38
C18:3	0.75	0.83	0.86	0.71	0.84	0.84	0.03	0.03	0.007	0.50	0.001	0.68	0.46	0.70
C20:1	0.63	0.61	0.72	0.61	0.61	0.75	0.02	0.001	0.12	0.97	0.01	0.001	0.46	0.52
IV [b]	67.58	65.51	72.17	66.97	66.14	71.92	0.87	0.001	0.96	0.91	0.04	0.001	0.60	0.62

[a] Data are means of six replicates of two pigs per replicate with the core sample extracted from the loin.
[b] Fat *vs* no fat ($P < 0.04$); tallow *vs* CWG ($P < 0.001$).

Table 3.10. The effect of chromium propionate on fatty acid analysis of the mean values of the belly and loin fat of gilts fed no fat or added tallow or choice white grease [a]

	0 ppb Cr			200 ppb Cr			SEM	*P* > F Source			Contrast		
	No fat	4% Tallow	4% CWG	No fat	4% Tallow	4% CWG		TRT	TIME	Cr	Fat *vs* no fat	Fat	Cr x fat *vs* no fat	Cr x fat
Fatty acid, weight														
C14:0	2.28	2.70	2.23	2.42	2.57	2.25	0.06	0.001	0.001	0.84	0.14	0.001	0.10	0.23
C16:0	26.06	24.46	23.77	26.23	24.27	24.36	0.37	0.001	0.56	0.54	0.001	0.42	0.97	0.30
C16:1	3.66	3.83	3.28	3.80	3.73	3.50	0.17	0.20	0.001	0.52	0.32	0.03	0.81	0.34
C18:0	8.71	8.46	7.95	8.94	8.59	7.84	0.28	0.07	0.05	0.72	0.02	0.04	0.65	0.68
C18:1	42.65	42.04	42.42	41.42	42.38	43.26	0.54	0.30	0.28	0.96	0.30	0.26	0.06	0.65
C18:2	13.33	12.83	16.47	13.80	12.68	15.08	0.67	0.003	0.37	0.52	0.24	0.001	0.30	0.36
C18:3	0.67	0.79	0.87	0.68	0.78	0.77	0.05	0.04	0.67	0.43	0.003	0.39	0.41	0.37
C20:1	0.60	0.56	0.64	0.55	0.58	0.69	0.02	0.001	0.38	0.87	0.04	0.001	0.03	0.51
IV [b]	65.47	64.50	70.89	65.33	64.43	69.21	0.97	0.001	0.41	0.43	0.04	0.001	0.67	0.41

[a] Data are means of six replicates of two pigs per replicate with two samples extracted (belly and loin).
[b] Fat *vs* no fat ($P < 0.04$); tallow *vs* CWG ($P < 0.001$).

Shelton et al. (2003) reported that 200 ppb CrProp increased LM area, ham wt, ham fat-free lean, and total carcass lean, but the responses were dependent on the energy content of the diet.

Further research is needed to distinguish if Cr supplementation can be advantageous in lowering IV, while aiding fat supplementation in producing leaner carcasses with higher quality.

CHAPTER 4

SUMMARY AND CONCLUSIONS

Experiments 1 and 2 were conducted to evaluate the effect of CrProp on growth performance and carcass traits (Exp 1 only) in 0 to 42 d-old and 0 to 49 d-old commercial broilers, respectively. Chromium propionate was included in the diet to provide 0, 200, 400, or 800 ppb Cr. In the grower phase, the 400 ppb Cr treatment decreased ADG and G:F, and mortality was reduced in broilers fed 200 or 800 ppb Cr. In the finisher phase, G:F was increased in broilers fed all dietary levels of Cr, and mortality was reduced in broilers fed 200 and 400 ppb Cr. Chromium supplementation did not affect overall growth performance or carcass traits. Chromium supplementation did not affect overall growth performance in Exp. 2.

Experiment 3 was conducted with crossbred gilts. Chromium (0 or 200 ppb) in the form of CrProp was added to diets with no added fat or added tallow or CWG. Chromium supplementation had no effect on growth performance but decreased 10^{th} rib back fat and average back fat and increased percent muscling. Addition of fat to the diet increased G:F and decreased ADFI. Average back fat was decreased by the addition of tallow *vs* CWG. Hot carcass weight and dressing percentage were increased by the addition of fat to the diet, regardless of source. Ninth rib shear force was decreased with the addition of Cr. Ninth rib CL, 9^{th} rib total loss, 10^{th} rib DL, and 10^{th} rib total loss were all decreased by the addition of tallow. Belly width and belly bending on both the teatline and scribe side was decreased by the addition of tallow *vs* CWG. Iodine values on belly and loin samples were increased with CWG but were not affected by CrProp. Overall, Cr had effects on carcass traits (10^{th} rib back fat, average back fat, and percent muscling). The inclusion of tallow to a diet decreased 9^{th} rib CL, 9^{th} rib total loss, 10^{th} rib DL, 10^{th} rib total loss, belly bending, and loin IV further than CWG or no added fat, which is a favorable carcass trait. However, these results were not affected by CrProp.

REFERENCES

Amoikon, E. K., J. M. Fernandez, L. L. Southern, D. L. Thompson, Jr., T. L. Ward, and B. M. Olcott. 1995. Effect of chromium tripicolinate on growth, glucose tolerance, insulin sensitivity, plasma metabolites, and growth hormone in pigs. J. Anim. Sci. 73:1123–1130.

AOAC. 1996. Official Methods of Analysis. 16th ed. Assoc. Off. Anal. Chem., Washington, DC.

AOCS. 1998. Official Methods and Recommended Practices of the AOCS. 5th ed. Recommended practice Cd 1c-85. Am. Oil. Chem. Soc., Champaign, IL.

Averette Gatlin, L., M. T. See, J. A. Hansen, and J. Odle. 2003. Hydrogenated dietary fat improves pork quality of pigs from two lean genotypes. J. Anim. Sci. 81:1989–1997.

Averette Gatlin, L., M. T. See, J. A. Hansen, D. Sutton, and J. Odle. 2002. The effects of dietary fat sources, levels, and feeding intervals on pork fatty acid composition. J. Anim. Sci. 80:1606–1615.

Azain, M. J. 2001. Fat in swine nutrition. Page 95 in Swine Nutrition. A. J. Lewis and L. L. Southern, ed. CRC Press, New York, NY.

Azain, M. J. 2004. Role of fatty acids in adipocyte growth and development. J. Anim. Sci. 82:916–924.

Boleman, S. L., S. J. Boleman, T. D. Bidner, L. L. Southern, T. L. Ward, J. E. Pontif, and M. M. Pike. 1995. Effect of chromium picolinate on growth, body composition, and tissue accretion in pigs. J. Anim. Sci. 73:2033–2042.

Debski, B., W. Zalewski, M. A. Gralak, and T. Kolsa. 2004. Chromium-yeast supplementation of chicken broilers in an industrial farming system. J. Trace Elem. Med. Biol. 18(1):47-51. (Abstr.)

Higbie, A. D., T. D. Bidner, J. O. Matthews, L. L. Southern, T. G. Page, M. A. Persica, M. B. Sanders, and C. J. Monlezun. 2002. Prediction of swine body composition by total body electrical conductivity (TOBEC). J. Anim. Sci. 80:113–122.

Kim, S. W., I. K. Han, Y. J. Choi, Y. H. Kim, I. S. Shin, and B. J. Chae. 1995a. Effect of chromium picolinate on growth performance, carcass composition, and serum traits of broilers fed dietary different levels of crude protein. Asian-Aust. J. Anim. Sci. 8:463-470.

Kim, S. W., I. K. Han, I. S. Shin, and B. J. Chae. 1995b. Effects of supplemental chromium picolinate on growth performance, carcass composition, and serum traits of broilers fed diets varying in protein and lysine. Asian-Aust. J. Anim. Sci. 8:455-462.

Kim, Y. H., I. K. Han, Y. J. Choi, I. S. Shin, B. J. Chae, and T. H. Kang. 1996a. Effect of dietary levels of chromium picolinate on growth performance, carcass quality, and serum traits in broiler chicks. Asian-Aust. J. Anim. Sci. 9:341-347.

Kim, Y. H., I. K. Han, I. S. Shin, B. J. Chae, and T. H. Kang. 1996b. Effect of dietary excessive chromium picolinate on growth performance, nutrient utilizability and serum traits in broiler chicks. Asian-Aust. J. Anim. Sci. 9:349-354.

Laborde, C. J., A. M. Chapa, D. W. Burleigh, D. J. Salgado, and J. M. Fernandez. 1995. Effects of processing and storage on the measurement of nitrogenous compounds in ovine blood. Small Ruminant Res. 17:159–166.

Lee, D. N., F. Y. Wu, Y. H. Cheng, R. S. Lin, and P. C. Wu. 2003. Effects of dietary chromium picolinate supplementation on growth performance and immune responses of broilers. Asian-Aust. J. Anim. Sci. 16:227–233.

Lien, T. F., Y. M. Horng, and K. H.Yang. 1999. Performance, serum characteristics, carcass traits and lipid metabolism of broilers as affected by supplementation of chromium picolinate. Br. Poult. Sci. 40:357-363.

Lien, T. F., S. Y. Chen, C. P. Wu, C. L. Chen, and C. Y. Hu. 1996. Effects of chromium picolinate and chromium chloride on growth performance and serum traits of growing-finishing swine. J. Anim. Sci. 74 (Suppl. 1):185. (Abstr.)

Lindemann, M. D., S. D. Carter, L. I. Chiba, C. R. Dove, F. M. LeMieux, and L. L. Southern. 2004. A regional evaluation of chromium tripicolinate supplementation of diets fed to reproducing sows. J. Anim Sci. 82: 2972-2977.

Lindemann, M. D., C. M. Wood, A. F. Harper, E. T. Kornegay, and R. A. Anderson. 1995. Dietary chromium picolinate additions improve gain:feed and carcass characteristics in growing-finishing pigs and increase litter size in reproducing sows. J. Anim. Sci. 73:457–465.

Matthews, J. O., A. C. Guzik, F. M. LeMieux, L. L. Southern, and T. D. Bidner. 2005. Effect of chromium propionate on growth, carcass traits, and pork quality of growing-finishing pigs. J. Anim. Sci. 83:858-862.

Matthews, J. O., A. D. Higbie, L. L. Southern, D. F. Coombs, T. D. Bidner, and R. L. Odgaard. 2003. Effect of chromium propionate and metabolizable energy on growth, carcass traits, and pork quality of growing-finishing pigs. J. Anim. Sci. 81:191–196.

Matthews, J. O., F. M. LeMieux, A. C. Guzik, L. L. Southern, T. D. Bidner, and M. A. Persica. 2001a. Effect of chromium propionate on growth, carcass traits, and pork quality of finishing gilts. J. Anim. Sci. 79 (Suppl. 2):188. (Abstr.)

Matthews, J. O., L. L. Southern, T. D. Bidner, and M. A. Persica. 2001b. Effects of betaine, pen space, and slaughter handling method on growth performance, carcass traits, and pork quality of finishing barrows. J. Anim. Sci. 79:967–974.

Matthews, J. O., L. L. Southern, A. D. Higbie, M. A. Persica, and T. D. Bidner. 2001c. Effects of betaine on growth, carcass characteristics, pork quality, and plasma metabolites of finishing pigs. J. Anim. Sci. 79:722–728.

Matthews, J. O., L. L. Southern, J. M. Fernandez, J. E. Pontif, T. D. Bidner, and R. L. Odgaard. 2001d. Effect of chromium picolinate and chromium propionate on glucose and insulin kinetics of growing barrows and on growth and carcass traits of growing-finishing barrows. J. Anim. Sci. 79:2172–2178.

Schwarz, K. and W. Mertz. 1959. Chromium (III) and the glucose tolerance factor. Arch. Biochem. Biophys. 85:292-295.

Min, J. K., W. Y. Kim, B. J. Chae, I. B. Chung, I. S. Shin, Y. J. Choi, and I. K. Han. 1997. Effects of chromium picolinate (CrP) on growth performance, carcass characteristics and serum traits in growing-finishing pigs. Asian-Aust. J. Anim. Sci. 10:8–14.

NPPC. 2000. Pork Composition and Quality Assessment Procedures. Natl. Pork Prod. Counc., Des Moines, IA.

NRC. 1997. The Role of Chromium in Animal Nutrition. Natl. Acad. Press, Washington, DC.

NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

NRC. 1994. Nutrient Requirements of Poultry. 9th rev. ed. Natl. Acad. Press, Washington, DC.

Page, T. G., L. L. Southern, T. L. Ward, and D. L. Thompson, Jr. 1993. Effect of chromium picolinate on growth and serum and carcass traits of growing-finishing pigs. J. Anim. Sci. 71:656–662.

Rosebrough, R. W., and N. C. Steele. 1981. Effect of supplemental dietary chromium or nicotinic acid on carbohydrate metabolism during basal, starvation, and refeeding periods in poults. Poultry Sci. 60:407–417.

Sahin, K., N. Sahin, and O. Kucuk. 2002a. Effects of chromium and ascorbic acid supplementation on growth, carcass traits, serum metabolites, and antioxidant status of broiler chickens reared at a high ambient temperature (32 deg C). Nutr. Res. 23:225-238.

Sahin, K., N. Sahin, M. Onderci, F. Gursu, and G. Cikim. 2002b. Optimal dietary concentration of chromium for alleviating the effect of heat stress on growth, carcass qualities, and some serum metabolites of broiler chickens. J. Biol. Trace Elem. Res. 89(1):53-64.

Shelton, J. L., R. L. Payne, S. L. Johnston, T. D. Bidner, L. L. Southern, and R. L. Odgaard. 2003. Effect of chromium propionate on growth, carcass traits, pork quality, and plasma metabolites in growing-finishing pigs. J. Anim. Sci. 81:2515–2524.

Stahly, T. 1984. Use of fats in diets for growing pigs. Page 313 in Fats in Animal Nutrition. J. Wiseman, ed. Butterworths, Boston, MA.

Ward, T. L. 1995. Dietary chromium supplementation for pigs and chickens. Ph.D. dissertation. Louisiana State University, Baton Rouge.

Ward, T. L., L. L. Southern, and T. D. Bidner. 1997. Interactive effects of dietary chromium tripicolinate and crude protein level in growing-finishing pigs provided inadequate and adequate pen space. J. Anim. Sci. 75:1001–1008.

Ward, T. L., L. L. Southern, and S. L. Boleman. 1993. Effect of dietary chromium picolinate on growth, nitrogen balance and body composition of growing broiler chicks. J. Anim. Sci. 73 (Suppl.1):37. (Abstr.)

APPENDIX

Table 1. Choice white grease and tallow fatty acid analysis [a]

	Choice white grease [b]		Tallow [b]	
	Barrel No. 1	Barrel No. 2	Barrel No. 1	Barrel No. 2
Fatty Acid				
C10:0	0.00	0.00	0.00	0.00
C12:0	0.10	0.17	0.20	0.24
C14:0	2.40	2.50	6.67	6.79
C15:0	0.10	0.10	0.85	0.85
C15:1	0.00	0.21	0.24	0.26
C16:0	23.42	22.32	25.77	25.30
C16:1	5.15	5.23	4.18	4.72
C17:0	0.30	0.32	1.42	1.40
C17:1	0.38	0.40	0.07	0.07
C18:0	5.67	5.09	13.06	13.09
C18:1	41.41	40.44	38.07	37.96
C18:2	16.39	16.54	2.82	2.82
C18:3	0.83	1.00	0.47	0.47
C20:0	0.13	0.18	0.06	0.17
C20:1	0.14	0.17	0.09	0.09
C20:2	0.42	0.43	0.06	0.05
C20:3	0.44	0.42	0.00	0.06
C20:4	0.00	0.00	0.00	0.00
C20:5	0.17	0.17	0.00	0.05
IV [c]	71.17	71.13	42.91	43.30

[a] Fat samples were prepared for analysis using the methods of Averette-Gatlin et al., 2002.

[b] Barrel one and two represents the individual 55 gallon drums needed to mix all feed.

[c] The following equation (AOCS, 1998) was used to determine iodine value (IV): (C16:1 * 0.95) + (C18:1 * 0.86) + (C18:2 * 1.732) + (C18:3 * 2.616) + (C20:1 * 0.785) + (C22:1 * 0.723).

Table 2. Contrast statements for a 2 X 3 factorial arrangement of treatments

	0 ppb Cr			200 ppb Cr		
	No fat	4% Tallow	4% CWG	No fat	4% Tallow	4% CWG
Cr effect	-1	-1	-1	1	1	1
Fat vs no fat	-2	1	1	-2	1	1
Fat source effect	0	-1	1	0	-1	1
Cr by fat vs no fat effect	2	-1	-1	-2	1	1
Cr by fat source effect	0	1	-1	0	-1	1

Table 3. The effect of chromium propionate on growth performance of gilts fed no fat or added tallow or choice white grease by phase [a]

Item	0 ppb Cr			200 ppb Cr			SEM	*P* > F Source		Contrast				
	No fat	4% Tallow	4% CWG	No fat	4% Tallow	4% CWG		TRT	TIME	Cr	Fat *vs* no fat	Fat	Cr x fat vs no fat	Cr x fat
ADG- Phase 1	0.798	0.845	0.753	0.718	0.823	0.744	0.05	0.41	0.0001	0.34	0.43	0.09	0.45	0.89
ADG- Phase 2	0.918	0.930	0.906	0.958	0.947	0.947	0.02	0.54	0.50	0.08	0.76	0.61	0.77	0.59
ADG- Phase 3	0.833	0.879	0.835	0.809	0.838	0.907	0.04	0.56	0.0001	0.95	0.22	0.76	0.58	0.17
ADG- Phase 4	0.784	0.846	0.765	0.762	0.791	0.839	0.05	0.80	0.0002	0.99	0.42	0.75	0.73	0.24
ADG- Overall	0.850	0.893	0.837	0.843	0.868	0.889	0.03	0.52	0.27	0.76	0.27	0.50	0.65	0.15
ADFI- Phase 1	1.854	1.692	1.586	1.573	1.625	1.542	0.06	0.01	0.0001	0.01	0.06	0.12	0.04	0.85
ADFI- Phase 2	2.571	2.335	2.469	2.719	2.593	2.414	0.07	0.01	0.0001	0.06	0.01	0.75	0.71	0.04
ADFI- Phase 3	2.593	2.353	2.329	2.433	2.355	2.577	0.10	0.24	0.0001	0.71	0.21	0.32	0.10	0.22
ADFI- Phase 4	3.042	3.131	2.895	3.118	2.965	3.142	0.11	0.57	0.05	0.58	0.64	0.80	0.86	0.08
ADFI- Overall	2.583	2.410	2.398	2.519	2.465	2.502	0.05	0.18	0.33	0.48	0.03	0.82	0.14	0.65
G:F- Phase 1	0.433	0.496	0.475	0.451	0.506	0.481	0.02	0.25	0.05	0.56	0.03	0.32	0.80	0.93
G:F- Phase 2	0.358	0.403	0.368	0.355	0.369	0.396	0.01	0.07	0.0004	0.78	0.02	0.77	0.99	0.03
G:F- Phase 3	0.321	0.373	0.361	0.332	0.355	0.352	0.01	0.09	0.25	0.61	0.01	0.56	0.30	0.75
G:F- Phase 4	0.258	0.273	0.266	0.243	0.265	0.270	0.01	0.72	0.0001	0.60	0.15	0.94	0.61	0.71
G:F- Overall	0.329	0.371	0.350	0.334	0.352	0.355	0.01	0.04	0.77	0.69	0.003	0.34	0.43	0.19

[a] Data are means of six replicates of three pigs per replicate.

Table 4. Main effects of chromium propionate on growth performance of gilts fed no fat or added tallow or choice white grease

	Cr [a, b]			Fat [c]				*P* > F source	
	0 ppb Cr	200 ppb Cr	SEM	No fat	4% Tallow	4% CWG	SEM	Fat *vs* no fat	Fat
ADG, kg	0.860	0.867	0.015	0.847	0.881	0.863	0.018	0.269	0.489
ADFI, kg [d]	2.464	2.496	0.033	2.551	2.437	2.450	0.039	0.030	0.820
G:F, kg	0.350	0.347	0.006	0.332	0.361	0.353	0.006	0.003	0.332
FW, kg [e]	108.30	108.99	1.33	107.08	110.31	108.54	1.61	0.245	0.442

[a] Chromium data are means of 18 pens of three pigs each.
[b] No significant effects.
[c] Fat data are means of 12 pens of three pigs each.
[d] Fat *vs* no added fat ($P < 0.03$).
[e] FW = final weight.

Table 5. Main effects of chromium propionate on carcass traits of gilts fed no fat or added tallow or choice white grease

	Cr [a]			Fat [b]				*P* > F source	
	0 ppb Cr	200 ppb Cr	SEM	No fat	4% Tallow	4% CWG	SEM	Fat *vs* no fat	Fat
Carcass traits [c]									
FKPW, kg	109.64	109.19	1.31	107.59	110.55	110.10	1.58	0.17	0.84
HCW, kg	81.43	81.54	1.07	79.53	82.78	82.15	1.26	0.07	0.72
LM area, cm^2	45.68	47.55	0.88	45.60	47.74	46.51	1.11	0.27	0.44
10^{th} rib fat,cm [d]	1.74	1.50	0.08	1.59	1.64	1.63	0.10	0.72	0.92
BF, cm	2.44	2.33	0.05	2.33	2.32	2.51	0.05	0.18	0.02
Ham face fat, cm	1.15	1.10	0.07	1.07	1.21	1.10	0.08	0.40	0.34
CL, cm	80.56	80.57	0.43	80.80	80.86	80.04	0.53	0.58	0.28
DP, %	74.25	74.70	0.23	73.92	74.89	74.60	0.26	0.02	0.44
TOBEC [e]									
FFL, kg	42.92	42.69	0.74	41.93	43.18	43.31	0.91	0.25	0.92
FATC, kg	20.67	20.23	0.64	19.80	20.97	20.57	0.78	0.32	0.72
Lean:Fat, kg	2.16	2.18	0.08	2.23	2.11	2.18	0.10	0.47	0.65
% Lean	52.66	52.41	0.62	52.78	52.09	52.72	0.76	0.69	0.57
% Fat	25.39	24.71	0.69	24.81	25.35	24.99	0.86	0.73	0.77
NPPC [f]									
% Muscling [g]	55.86	57.49	0.46	56.79	56.73	56.52	0.64	0.83	0.82
Kg lean	45.50	46.85	0.71	45.14	46.97	46.41	0.88	0.16	0.65

[a] Chromium data are means of 18 pens of two pigs each.
[b] Fat data are means of 12 pens of two pigs each.
[c] FKPW = final killed pig weight; HCW = hot carcass weight; ABF = average back fat; DP = dressing percent; CL= carcass length.
[d] Cr ($P < 0.04$).
[e] FFL=fat-free lean; FATC=total fat of carcass. Data analyzed using TOBEC equations (Higbie et al., 2002).
[f] Calculated using the equation described by the NPPC (2000), which uses 5% estimation for intramuscular fat and compensates for unequal body weights.
[g] Cr ($P < 0.02$).

Table 6. Main effects of chromium propionate on pork quality of gilts fed no fat or added tallow or choice white grease

	Cr [a]			Fat [b]				*P* > F source	
	0 ppb Cr	200 ppb Cr	SEM	No fat	4% Tallow	4% CWG	SEM	Fat *vs* no fat	Fat
Temperature, °C									
Ham	5.04	5.28	0.14	5.02	5.40	5.05	0.17	0.35	0.16
Rectal	39.32	39.40	0.10	39.30	39.36	39.42	0.13	0.55	0.73
45 min	41.68	41.83	0.21	41.42	41.81	42.03	0.25	0.11	0.53
24 H	5.04	5.28	0.14	5.02	5.40	5.05	0.17	0.35	0.16
Pork quality [c]									
Color scores	2.51	2.60	0.07	2.58	2.56	2.52	0.09	0.72	0.75
Marbling	1.22	1.25	0.08	1.21	1.35	1.15	0.09	0.71	0.12
CIE L*	50.26	51.20	0.87	50.41	50.35	51.43	1.08	0.72	0.48
CIE a*	1.21	1.48	0.28	1.47	1.04	1.52	0.34	0.66	0.33
CIE b*	10.70	11.23	0.44	10.84	10.67	11.38	0.54	0.79	0.36
Fresh chop [d]									
Drip loss, %	5.18	5.35	0.45	5.21	4.83	5.76	0.55	0.90	0.24
Cook loss, %	22.72	21.70	0.91	23.17	20.11	23.34	1.03	0.26	0.04
Total loss, %	27.90	27.04	1.04	28.38	24.94	29.10	1.17	0.35	0.02
Shear force, kg	3.95	3.62	0.13	3.89	3.62	3.85	0.16	0.42	0.32
Frozen chop [e]									
Drip loss, %	15.67	15.35	0.46	15.78	14.50	16.24	0.53	0.53	0.03
Cook loss, %	24.16	24.83	0.94	23.33	23.80	26.36	1.08	0.20	0.11
Total loss, %	39.84	40.17	1.09	39.11	38.30	42.61	1.21	0.37	0.02
Shear force, kg [f]	3.37	3.59	0.14	3.37	3.38	3.70	0.17	0.42	0.18

[a] Chromium data are means of 18 pens of two pigs each.
[b] Fat data are means of 12 pens of two pigs each.
[c] The CIE L*, a* and b* values (determined using the CIELAB space with a D65 illuminant) were obtained from three orientations on the 10th rib chop using a Minolta spectrophotometer (Model CM-508d; Minolta Corporation, Ramsey, NJ).
[d] Deboned 9th rib chop suspended in sealed Whirl-pak bag for 24 h at 2°C then weighed to determine drip loss and immediately cooked for cook loss.
[e] Deboned 10th rib chop vacuum sealed and frozen for 35 d (trial No. 1) and 40 d (trial No. 2) at -20°C, allowed to thaw at room temperature for 18 h and then weighed to determine drip loss and immediately cooked for cook loss.
[f] Shear force determined on four (2.54 cm) core samples.

Table 7. Main effects of chromium propionate on belly bending properties of gilts fed no fat or added tallow or choice white grease

Item	Chromium [c,d]			Fat [e]				*P* > F Source	
	0 ppb Cr	200 ppb Cr	SEM	No fat	4% Tallow	4% CWG	SEM	Fat *vs* no fat	Fat
Weight, kg	4.73	4.77	0.12	4.66	4.85	4.74	0.14	0.46	0.59
Length, cm	53.27	54.12	0.62	54.62	53.74	52.73	0.74	0.14	0.34
Width, cm [f]	25.21	25.10	0.35	24.92	24.75	25.81	0.41	0.48	0.08
Belly yield, % [g]	11.83	11.94	0.21	11.97	11.97	11.72	0.25	0.69	0.46
Belly area, cm^2	1342.79	1359.07	24.07	1360.56	1330.35	1361.87	29.74	0.68	0.50
Thickness, cm	3.68	3.71	0.08	3.60	3.84	3.65	0.09	0.18	0.13
Teatline flop, cm [h]	16.97	17.09	0.77	16.31	18.99	15.80	0.85	0.30	0.01
Scribe flop, cm [i]	12.47	12.28	0.68	11.52	14.36	11.24	0.71	0.15	0.004

[a] Data are means of six replicates of two pigs per replicate.
[b] Belly bending was determined by draping the belly, skin side down, across a metal bar and measuring a distance 15.2 cm. below the bar on both the teatline and scribe side of the belly.
[c] Chromium data are means of 18 pens of two pigs each.
[d] No significant effects.
[e] Fat data are means of 12 pens of two pigs each.
[f] Tallow *vs* CWG ($P < 0.08$).
[g] The following equation was used to calculate percent belly yield: (belly wt./cold carcass wt.) * 100.
[h] Tallow *vs* CWG ($P < 0.01$).
[i] Tallow *vs* CWG ($P < 0.004$).

Table 8. Main effects of chromium propionate on fatty acid profile of the mean belly and loin fat of gilts fed no fat or added tallow or choice white grease

	Cr [a, b]			Fat [c]				P > F Source	
	0 ppb Cr	200 ppb Cr	SEM	No fat	4% Tallow	4% CWG	SEM	Fat *vs* no fat	Fat
Fatty acid, weight									
C14:0	2.40	2.41	0.06	2.35	2.63	2.24	0.05	0.15	<0.001
C16:0	24.76	24.95	0.31	26.14	24.37	24.06	0.25	<0.001	0.41
C16:1	3.59	3.68	0.10	3.73	3.78	3.39	0.11	0.30	0.02
C18:0	8.37	8.46	0.18	8.82	8.53	7.90	0.19	0.01	0.03
C18:1	42.37	42.35	0.33	42.03	42.21	42.84	0.39	0.31	0.26
C18:2	14.21	13.85	0.50	13.57	12.75	15.77	0.47	0.24	<0.001
C18:3	0.77	0.74	0.03	0.67	0.78	0.82	0.03	0.003	0.39
C20:1	0.60	0.60	0.02	0.57	0.57	0.67	0.02	0.04	0.001
IV [d]	66.96	66.32	0.83	65.40	64.47	70.05	0.67	0.03	<0.001

[a] Chromium data are means of 18 pens of two pigs each.
[b] No significant effects.
[c] Fat data are means of 12 pens of two pigs each.
[d] Fat *vs* no fat ($P < 0.03$); tallow *vs* CWG ($P < 0.001$).

Table 9. Main effects of chromium propionate on iodine value of the mean belly and loin fat of gilts fed no fat or added tallow or choice white grease

	Chromium [a, b]			Fat [c]				P > F Source	
IV	0 ppb Cr	200 ppb Cr	SEM	No fat	4% Tallow	4% CWG	SEM	Fat *vs* no fat	Fat
Belly IV [d]	65.49	64.31	0.95	63.53	63.11	68.05	0.94	0.09	0.0009
Loin IV [e]	68.42	68.34	0.84	67.27	65.83	72.05	0.59	0.03	<0.0001

[a] Chromium data are means of 18 pens of two pigs each.
[b] No significant effects.
[c] Fat data are means of 12 pens of two pigs each.
[d] Fat *vs* no fat ($P < 0.09$); tallow *vs* CWG, ($P < 0.001$). Core sample extracted from the belly.
[e] Fat *vs* no fat ($P < 0.03$); tallow *vs* CWG, ($P < 0.001$). Core sample extracted from the loin.

VITA

Ashunti Ria Jackson was born on August 8, 1980 to Allen Ray and Emily Jackson in Monroe, Louisiana. Ria, as called by her family, was reared to have love and respect for all of Gods creations. This led to her fascination with animals. She excelled in science throughout her secondary educational academia, in which the majority of it was spent in the Gifted and Talented program. She graduated from Ouachita Parish High School in May of 1998 with honors. She entered Louisiana State University in the Fall of 1998 in the Animal, Dairy, and Poultry Sciences program, in hopes of one day becoming a veterinarian. It wasn't until her senior year, when she was enrolled in a swine production course, that she realized how interested she was in farm animals. She received her Bachelor of Science on August 8, 2002, in Animal, Dairy, and Poultry Sciences. After eight months of being employed by J. P. Morgan Chase, she made the decision to pursue a career in non-ruminant nutrition. Ria accepted an assistantship to study non-ruminant nutrition under the supervision of Dr. L. Lee Southern, in the Fall of 2003. Ria completed her Masters of Science requirements in the Fall of 2005.