Increasing Profit by Optimizing Nutrition – Chromium

L. Lee Southern

Department of Animal Science, LSU Agricultural Center, Baton Rouge, LA, 70803
Email: lsouthern@agctr.lsu.edu

▪ Introduction

Chromium is a micromineral that is part of the glucose tolerance factor. It enhances insulin sensitivity and facilitates glucose uptake by cells. Several researchers have shown that organic chromium is bioactive and that it increases insulin sensitivity in pigs. In humans, chromium deficiency causes diabetes. We have worked with organic chromium since 1989, and along with other laboratories, have shown that organic chromium increases muscling and decreases fatness in pigs, in some instances. Research also has shown that organic chromium increases the number of pigs born alive and conception rate. Until recently in the U.S., the only source of organic chromium available for use in pigs was chromium picolinate. We have evaluated chromium picolinate, as well as many other sources of chromium. Most recently, we evaluated chromium propionate, and chromium propionate was recently allowed to be added to swine feeds by the Food and Drug Administration.

Several experiments were conducted to evaluate the effect of chromium propionate on growth, plasma metabolites, carcass traits, and meat quality of growing-finishing pigs. These are reported below.

▪ Bioavailability of Chromium

The first two experiments were conducted to determine the effect of chromium propionate and chromium picolinate on glucose tolerance, insulin sensitivity, and plasma nonesterified fatty acids (NEFA) in growing pigs. These two experiments were conducted to demonstrate bioactivity of chromium propionate to meet the criteria set forth by the Food and Drug Administration. In Exp. 1, growing barrows were allotted to the following treatments: 1) corn-soybean

(SBM) meal basal (B, control), 2) B + 200 ppb chromium as chromium picolinate, or 3) B + 200 ppb chromium as chromium propionate. Growth performance data were collected for 28 d and then pigs (7 or 8 per treatment) were fitted with jugular catheters and glucose tolerance (IVGTT) and insulin challenge tests (IVICT) were conducted. Fasting plasma total cholesterol, urea nitrogen, insulin, and HDL:total cholesterol concentrations were not affected ($P > 0.10$) by either chromium source. Pigs fed chromium picolinate had decreased ($P < 0.02$) fasting plasma NEFA concentrations, and pigs fed chromium propionate tended ($P = 0.12$) to have lower NEFA concentrations than control pigs. During the IVGTT, glucose and insulin kinetics were not affected by treatment ($P > 0.10$). During the IVICT, glucose clearance was increased ($P < 0.01$) in pigs fed chromium propionate and tended ($P = 0.12$) to be increased in pigs fed chromium picolinate. Glucose half-life was decreased ($P < 0.05$) in pigs fed both sources of chromium, but insulin kinetics were not affected ($P > 0.10$). In Exp. 2, treatments were a corn-SBM diet with 0, 100, 200, or 300 ppb chromium as chromium propionate. Each treatment was replicated six times with six barrows each. Plasma urea nitrogen (linear, $P < 0.02$) and NEFA (quadratic, $P < 0.06$) concentrations were decreased in pigs fed chromium. Changes in plasma NEFA and glucose kinetics from the IVICT indicate that both chromium propionate and chromium picolinate are bioavailable sources of chromium.

▪ Chromium Propionate and Chromium Picolinate – Growth and Carcass Traits

The remaining experiments were conducted to evaluate the chromium sources on growth performance, carcass traits, and meat quality of growing finishing pigs. In Exp. 3, barrows (four replicates of four pigs per replicate) were fed: 1) corn-SBM basal (B, control), 2) B + 200 ppb chromium as chromium picolinate, or 3) B + 200 ppb chromium as chromium propionate. Average daily feed intake tended to be decreased ($P = 0.13$) in pigs fed chromium propionate compared to pigs fed chromium picolinate, but gain and gain:feed were not affected ($P > 0.10$) by diet. Percentage muscling tended to be increased ($P = 0.11$) in pigs fed chromium propionate compared to control pigs. Other carcass measurements were not affected ($P > 0.10$) by diet.

▪ Chromium Propionate - Growth, Carcass Traits and Meat Quality

The pigs in Exp. 2 (corn-SBM diet with 0, 100, 200, or 300 ppb chromium as chromium propionate) were continued on the diets until market weight, and three pigs per pen were killed. In the late-finishing period, feed intake was decreased (linear, $P < 0.01$) as chromium propionate concentration increased. Carcass traits were not affected ($P > 0.10$) by chromium propionate. A subsequent similar experiment (Exp. 4) was conducted. The treatments were a corn-SBM diet with 0, 50, 100, or 200 ppb chromium as chromium propionate. Each treatment was replicated six times with four gilts each. The data from the 0 and 200 ppb chromium diets are the same as in Exp. 5. Gain:feed was increased as chromium concentrations increased (linear, $P < 0.02$) in the late-growing period. In the early-finishing period, feed intake was decreased (quadratic, $P < 0.06$) in pigs fed 50 or 100 ppb chromium. Loin muscle area tended to be increased as chromium concentration increased. Ham weight, fat-free lean in the ham and carcass, and kilograms of lean were increased (linear, $P < 0.09$) as chromium concentration increased. Lean:fat was increased (quadratic, $P < 0.07$) as chromium concentration increased. Percentage lean was decreased (quadratic, $P < 0.04$) in pigs fed 50 or 100 ppb chromium but not in pigs fed 200 ppb chromium. Cooking loss and total loss in a frozen chop were decreased (linear, $P < 0.05$) as chromium concentrations increased.

▪ Chromium Propionate and Dietary Energy Level - Growth, Carcass Traits and Meat Quality

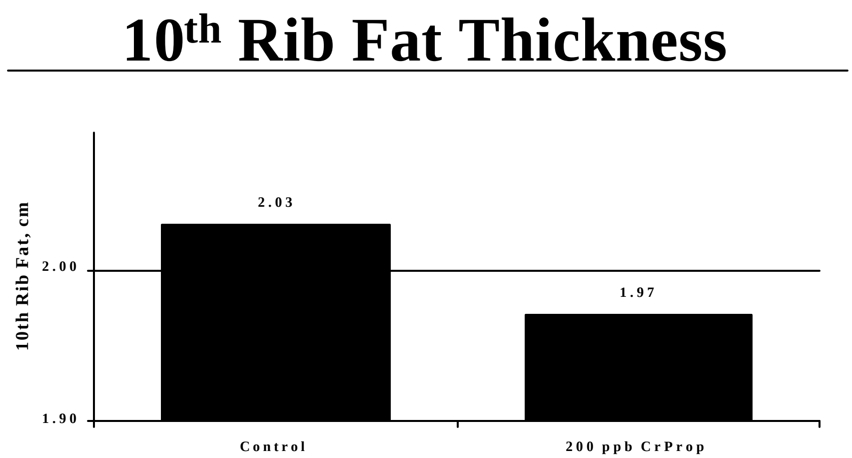
Experiment 5 was conducted to determine the effect of chromium propionate in low energy diets on growth, carcass traits, pork quality, and plasma NEFA in pigs. Crossbred gilts were allotted to four treatments: 1) corn-SBM, 2) C-SBM + 200 ppb chromium as chromium propionate, 3) C-SBM + 20% wheat midds (C-SBM-WM), 4) C-SBM-WM + 200 ppb chromium. Each treatment was replicated six times with four gilts each. The data from the 0 and 200 ppb chromium in C-SBM diets are the same as in Exp. 4. Diets for Exp. 5 were formulated to provide 105% of the true digestible Lys requirement, and the ratio of Lys to NE was held constant. Pigs fed C-SBM tended to have an increased ($P=0.12$) gain and gain:feed ($P < 0.07$) relative to pigs fed C-SBM-WM. Loin muscle area, dressing percentage, and kilograms of lean (NPPC) were increased in pigs fed chromium propionate in C-SBM diets but decreased in pigs fed C-SBM-WM (Cr x NE, $P < 0.05$). Lean gain per day tended to be decreased in pigs fed chromium propionate ($P=0.11$). Percentage fat and intramuscular fat were decreased in pigs fed C-SBM-WM relative to pigs fed C-SBM ($P < 0.10$). Total loss (drip + cook) of a fresh chop was decreased in pigs fed chromium propionate in C-SBM-WM but not affected in pigs fed C-SBM chromium propionate (Cr x NE, $P < 0.08$). Total loss of a frozen chop was decreased in pigs fed chromium propionate in C-SBM but not affected in pigs fed C-SBM-WM (Cr x NE, $P < 0.05$). Cook loss of a previously frozen chop was decreased in pigs fed chromium propionate ($P < 0.03$). Rectal temperature was decreased (an indication of reduced stress) in pigs fed chromium propionate in C-SBM but not affected in pigs fed C-SBM-WM (Cr x NE, $P < 0.08$). In the early-finisher phase, fasting plasma NEFA levels were decreased in pigs fed chromium propionate (P < 0.05).

Experiment 6 also was conducted to evaluate the effect of chromium propionate and metabolizable energy in the diet. Cambrough 22 barrows were allotted to four dietary treatments (six replicates of six pigs per replicate): 1) corn-SBM basal (B), 2) B + 200 ppb chromium (as chromium propionate), 3) B + 200 kcal ME/kg (4.5% added fat), or 4) B + 200 kcal ME/kg + 200 ppb chromium. Overall gain, feed intake, and gain:feed were not affected (P > 0.10) by diet. During the early growing period, gain was increased in pigs fed chromium without added fat, but decreased in pigs fed chromium in diets with added fat. Lean gain per day tended to be decreased in pigs fed chromium (P = 0.13). Loin muscle area (Cr × ME, P = 0.12) and kilograms of lean (Cr × ME, P = 0.11) tended to be decreased in pigs fed chromium propionate in diets with no added fat, but increased in pigs fed chromium in diets with added fat. Subjective color and firmness-wetness scores, and 45 min and 24 h pH were not affected (P > 0.10) by diet. Subjective marbling was increased (P < 0.03) and longissimus muscle percentage moisture and thaw loss were decreased (P < 0.04) by chromium.

▪ Chromium Propionate – Meat Quality and Shrink Loss

Experiment 7 was conducted to determine the effect of dietary chromium propionate on growth, carcass traits, and pork quality of crossbred finishing gilts. Dietary treatments were 0 or 200 ppb chromium as chromium propionate and each treatment was replicated four times with five gilts. Diets were fed from 80 to 115 kg BW. At trial termination, carcass and pork quality data were collected from four gilts per pen. Gain, feed intake, and gain:feed were not affected (P > 0.10) by chromium propionate. Prior to delivery at the abattoir, shrink loss was determined after an 18 h fast (fasting shrink) and after hauling (shipping shrink) pigs for 2.66 h (206 km). Fasting shrink and overall shrink were not affected (P > 0.15) by chromium propionate; however, shipping shrink tended (P = 0.14) to be decreased in pigs fed chromium propionate. Loin muscle area, tenth rib backfat thickness, average backfat thickness, dressing percentage, muscle score, fat-free lean, and percentage lean were not affected (P > 0.10) by chromium propionate. Ultimate loin pH was increased (P = 0.10) in pigs fed chromium propionate, but initial loin and ham pH and ultimate ham pH were not affected (P > 0.10) by chromium propionate. Subjective (color, marbling, firmness, and wetness) and objective (CIE L* a* b*) assessments of the loin muscle were not affected (P > 0.10) by chromium propionate. Forty-eight hour drip loss and 21-day purge loss were decreased (P = 0.10) in pigs fed chromium propionate, but cook loss, total loss (drip + cook loss), and shear force were not affected (P > 0.10) by chromium propionate.

Figure 1. Effect of chromium propionate on tenth rib fat thickness in pigs fed chromium propionate.



▪ Conclusion

In summary, the data on plasma metabolites and glucose clearance during an insulin challenge test suggest that chromium propionate and chromium picolinate are bioactive sources of chromium. Chromium propionate improved carcass traits by increasing percentage muscling or loin muscle area in some experiments but not in all experiments. Tenth rib fat was the most consistent carcass response variable changed by chromium propionate, but the change was not significant. The data in Figure 1 are means of seven comparisons between control diets or diets with 200 ppb added chromium propionate. In five of these seven comparisons, 200 ppb of chromium from chromium propionate decreased tenth rib fat thickness, resulting in a 3.2% overall decrease compared with pigs not fed chromium. Chromium propionate also consistently affected meat quality, usually by decreasing losses associated with short-term storage (drip loss), cooking, or thawing. The improvements in meat quality may be associated with a reduced stress as evidenced by a reduced rectal temperature in one experiment.