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A Multi-Trial Analysis Evaluating the Effects of Pharmacological Levels of IntelliBond Copper on Growing-Finishing Pig Growth Performance and Carcass Characteristics[1]

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Summary

A multi-trial analysis was conducted to evaluate the effects of pharmacological levels of added IntelliBond Copper (IBC) on growing-finishing pig growth performance and carcass characteristics compared to pigs fed control diets containing typical additions of copper from a trace mineral premix. Data with 331 observations within 8 trials were included in the final database. Inclusion rates for IBC were either 150 (7 trials), or 200 (1 trial) ppm. Pigs fed IBC throughout the entire grow-finish period had greater ($P < 0.05$) overall ADG, ADFI, and final BW and tended ($P = 0.085$) to be more efficient than pigs fed control diets. There was no evidence for differences ($P > 0.10$) between dietary treatments for the percentage of pigs marketed. Pigs fed IBC also had ($P < 0.05$) heavier HCW and greater carcass ADG compared to pigs fed a control diet. There were no differences ($P > 0.10$) between pigs fed the control or IBC diets for carcass characteristics, carcass yield, and carcass feed efficiency. In conclusion, the addition of IBC at growth promotion levels throughout the entire growing-finishing period increased final BW, HCW, and ADG on a live and carcass basis.

Introduction

Copper is an essential trace mineral that plays an important role in hemoglobin synthesis and is needed for the activation of enzymes necessary for normal metabolism. According to the NRC (2012),[4] growing-finishing pigs require 5 to 6 ppm of copper. However, research has shown that feeding pharmacological levels of copper (75 to 200 ppm) during the growing-finishing period can improve growth performance. Multiple trials have been conducted to evaluate the effects of the copper source, IntelliBond C (IBC), when supplemented at pharmacological levels, on growth performance and carcass characteristics. However, an analysis summarizing results of all the studies

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[4] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.

has not been conducted. Therefore, the objective of this analysis was to summarize the results of 8 trials that evaluated the effects of pharmacological levels of IBC on growing-finishing pig growth performance and carcass characteristics.

Procedures

Database

All data were derived exclusively from experiments that were verified to be comparing a control diet containing copper levels derived only from the trace mineral premix versus diets containing IBC supplemented at pharmacological levels throughout the entire growing-finishing period. A total of 6,790 pigs from 8 trials with 331 observations (pens) were recorded in the final analysis (Table 1). Inclusion rates of growth promotional IBC consisted of 75 (1 trial), 150 (7 trials), or 200 (1 trial) ppm. Feeding duration of supplemental IBC in four trials was from 80 to 99 d and four trials fed IBC from 100 to 120 d in duration. For initial pig inventory, two trials had 9 pigs per pen, 1 trial had 20 pigs per pen, 2 trials had 26 pigs per pen, and 3 trials had 27 pigs per pen. Trials conducted included 2 with fewer than 500 pigs, 3 with 501–1,000 pigs, and 3 with greater than 1,000 pigs in a trial. To be included in the final growth performance database, observations needed to have a recorded final BW and the same basal diet composition needed to be used for both the control and IBC treatments throughout the entire study. To be included in the final carcass characteristics database, observations needed to have a recorded HCW. If an observation lacked any other measured carcass characteristics, that observation was omitted only from that specific measurement. Categorical variables such as barn, diet composition, gender, growing season, pen space, and ractopamine usage were also included in the final database. Some trials were conducted as factorials measuring the influence of IBC supplementation dependent on basal diet formulation and in these cases, the basal diet formulations were treated as separate observations. Therefore, treatment diet compositions consisted of corn-soybean meal (2 trials), corn-soybean meal-dried distillers grains with solubles (2 trials), and corn-soybean meal-DDGS-bakery meal (4 trials). Three trials used mixed sex pens of pigs while the remaining 5 trials sorted pens by gender. Season was determined by the month when the majority of the pigs were marketed for the trial, with 5 trials marketed in the fall, 2 trials in the winter, and 1 trial in the spring. Pen space across all trials ranged from 6.50 to 6.85 square feet per pig. Ractopamine was fed in 5 of the 8 trials.

Data from each trial were recorded in a spreadsheet that included growth performance and carcass characteristics. Growth performance data were categorized into grower (75.1 ± 3.92 lb to 150.2 ± 3.57 lb), finisher (150.2 ± 3.57 lb to 279.8 ± 2.05 lb), and overall (75.1 ± 3.92 lb to 279.8 ± 2.05 lb) periods. Measured growth performance data included initial, grower, and final BW along with ADG, ADFI, and F/G for each respective period. Percentage of pigs marketed was also measured by taking the number of pigs marketed divided by the number of pigs placed. Measured carcass data included HCW, carcass yield, carcass ADG, carcass F/G, backfat, percentage lean, and loin depth.

Statistical analysis

Data were analyzed using the lmer function from the lme4 package in R (version 3.5.1 (2018-07-02), R Foundation for Statistical Computing, Vienna, Austria). The Weights statement in R was used to account for heterogeneity in the variance of the residuals. Response variables were weighted based on the number of observations for each study using the inverse of the squared SEM. To determine the SEM for each treatment within each trial, the lm function from the lme4 package in R was used. Study, barn, season, experimental diet composition, and gender were included as a random effect. The statistical inclusion of terms as covariates in the model was determined at $P < 0.05$. Initial BW was used as a covariate for all growth performance characteristics and carcass characteristics except backfat, percentage lean, and loin depth, where HCW was used as a covariate. No categorical variable was used as a covariate because all the categorical variable by treatment interactions were nonsignificant ($P > 0.05$).

From the results, an economic comparison scenario was devised. Prices used were IBC ($3.85/lb), total feed cost without added IBC ($50.00/pig), and HCW ($0.65/lb). For this scenario, IBC was included at 0.56 lb/ton to achieve 150 ppm of additional Cu supplementation in the diet. Revenue was calculated as HCW multiplied by $0.65. Income over feed cost (IOFC) was calculated as revenue minus total feed cost.

Results and Discussion

There was no evidence ($P > 0.05$) for categorical variable by treatment interactions, which is likely a result of not having sufficient data for the categorical variables of diet composition, gender, growing season, pen space, or ractopamine usage, to truly assess if these variables influence the growth response to feeding pharmacological levels of IBC.

In the grower period, pigs fed pharmacological levels of IBC had greater ($P < 0.05$) ADG, ADFI, and heavier BW at the end of the grower period when compared with pigs fed control diets (Table 2). In the finisher period, pigs fed pharmacological levels of IBC had greater ($P < 0.05$) ADG and tended ($P = 0.075$) to have increased ADFI compared with pigs fed control diets. There were no differences ($P > 0.10$) in feed efficiency between dietary treatments in both the grower and finisher period.

Overall, pigs fed pharmacological levels of IBC had greater ($P < 0.05$) ADG, ADFI, and final BW, and tended to have improved ($P = 0.085$) feed efficiency compared with pigs fed control diets. There were no differences ($P > 0.10$) between dietary treatments for the percentage of pigs marketed. Pigs fed IBC throughout the growing-finishing period also had greater ($P < 0.05$) HCW and ADG on a carcass weight basis when compared to pigs fed the control diets. There was no evidence for differences ($P > 0.10$) between pigs fed the control or IBC diets for backfat, loin depth, percentage lean, carcass yield, or carcass feed efficiency. In conclusion, the addition of IBC at growth promotional levels throughout the entire growing-finishing period increased final BW, HCW, and ADG on a live and carcass basis.

To determine the potential economic implications of the multi-trial analysis results, the following example is provided: prior to the addition of pharmacological levels of IBC, growing-finishing pigs in this fixed time scenario of 100 d were assumed to have an ADFI of 5.91 lb/day. When 150 ppm of supplemental IBC is added to the diet, an increase in $1.32 per pig of additional feed cost will accrue from the inclusion of IBC and from the increase in ADFI, which is now $5.99 lb/day. The usage of pharmacological levels of IBC, however, will result in a 2.9 lb increase in HCW and would increase revenue per pig by $1.89, if HCW is valued at $0.65. Overall, the improvement in IOFC is $0.56 per pig for this economic scenario.

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Table 1. Summary of experiments used in the multi-trial analysis to determine growth performance and carcass characteristics from pharmacological levels of IBC[1]

Experiment[2]	Avg. length, d	Barns, n	Total pens, n	Total pigs, n	Avg. initial BW, lb	Avg. final BW, lb	IBC level, ppm	Diet composition	Season	Pen gender	Ractopamine	Initial pen space, ft^2
Trial 1	111	1	21	570	55.3	281.2	75, 150	CSDB	Winter	Mix	Yes	6.85
Trial 2	120	1	48	1,248	63.8	276.6	150	CSDB	Fall	Mix	Yes	6.85
Trial 3	120	1	24	632	58.3	289.0	150	CSDB	Spring	Mix	Yes	6.85
Trial 4	118	1	42	1,133	60.8	277.8	150	CS, CSDB	Winter	Mix	Yes	6.85
Trial 5	81	3	101	2,005	103.7	280.1	150	CSD	Fall	Same	Yes	6.50
Trial 6	103	2	19	518	83.6	284.8	200	CSD	Fall	Mix	No	6.85
Trial 7	87	2	38	342	62.2	276.5	150	CS	Fall	Same	No	N/A
Trial 8	82	2	38	342	70.2	268.5	150	CS	Fall	Same	No	N/A

[1]A total of 6,790 pigs were used in eight experiments to evaluate the effects of diets containing no added copper or diets with 75 to 200 ppm of additional copper from IntelliBond C (IBC, Micronutrients, Indianapolis, IN) on growth performance. A total of 6,737 pigs were used in eight experiments to evaluate the effects of diets containing no supplemental copper or diets with 75 to 200 ppm of additional copper from IBC on carcass characteristics.
[2]BW = body weight. CS = corn-soy. CSD = corn-soy-dried distillers grains with solubles. CSDB = corn-soy-dried distillers grains with solubles-bakery meal.

Table 2. Effects of added IntelliBond C on grow-finish pig growth performance and carcass characteristics[1]

Item	Control	IBC	SEM	Probability, $P =$
BW				
Grower, lb[2]	147.8	150.2	3.57	< 0.001
Final, lb	276.0	279.8	2.07	< 0.001
Grower				
ADG, lb	2.05	2.12	0.041	< 0.001
ADFI, lb	4.55	4.68	0.093	< 0.001
F/G	2.25	2.25	0.033	0.563
Finisher[3]				
ADG, lb	2.18	2.21	0.065	0.015
ADFI, lb	6.72	6.77	0.202	0.075
F/G	3.07	3.08	0.037	0.198
Overall				
ADG, lb	2.11	2.15	0.065	< 0.001
ADFI, lb	5.91	5.99	0.164	0.008
F/G	2.82	2.80	0.047	0.085
Percent marketed, %[4]	91.7	91.0	1.80	0.247
Carcass characteristics				
HCW, lb	205.3	208.2	1.56	< 0.001
Carcass yield, %	74.5	74.6	0.03	0.486
Carcass ADG, lb	1.57	1.60	0.047	< 0.001
Carcass F/G	3.79	3.76	0.078	0.105
Backfat, in.[5]	0.76	0.75	0.041	0.463
Lean, %[5]	55.4	55.2	1.42	0.914
Loin depth, in.[5]	2.61	2.61	0.078	0.984

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[2]Initial BW was used as a covariate. Initial BW were 73.8 and 75.1 lb for control and IBC, respectively. Grower period is from 70 to 150 lb.
[3]Finisher period is from 150 lb to marketing.
[4]Percent marketed = pigs marketed/pigs placed.
[5]HCW was used as a covariate.