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Effects of Added Potassium to Diets with High or and Low Crystalline Lysine on Finishing Pig Growth Performance

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Effects of Added Potassium to Diets with High or and Low Crystalline Lysine on Finishing Pig Growth Performance

Abstract

This experiment was conducted to evaluate the effect of balancing dietary cation-anion difference (DCAD) levels, via added potassium bicarbonate ($KHCO_3$), to diets containing low or high levels of L-Lys HCL on growth performance of growing-finishing pigs. A total of 1,944 pigs (PIC L337 × 1050; initially 77.6 ± 1.88 lb BW) were used in a 120-d study to determine the effect of added potassium bicarbonate to diets containing low or high levels of crystalline lysine on growth performance and carcass characteristics of finishing pigs. Pens of pigs were blocked by BW and randomly allotted to 1 of 4 dietary treatments in a randomized complete block design arranged in a 2 × 2 factorial with main effects of $KHCO_3$ (0 vs. 0.4%), and L-Lys HCl level (low vs. high). There were 27 pigs per pen and 18 replicates per treatment and a similar number of barrows and gilts placed in each pen. Treatment diets were corn-soybean meal-based and formulated in four dietary phases (approximately 80 to 130 lb, 130 to 185 lb, 185 to 230 lb, and 230 to 285 lb). Dietary treatments were formulated such that in each phase the diet containing a low level of L-Lys HCl without $KHCO_3$ and the diet containing a high level of L-Lys HCl with $KHCO_3$, had similar calculated DCAD values. Additionally, the diet with a low level of L-Lys HCl with $KHCO_3$ was formulated to have the highest DCAD in each phase, while the diet with a high level of L-Lys HCl without $KHCO_3$ was formulated to have the lowest DCAD. Overall, there was no evidence ($P > 0.10$) for a $KHCO_3$ × L-Lys HCl interaction or main effect for final BW or any observed growth response or carcass characteristics. The results of this study suggest that supplementing $KHCO_3$ to finishing pig diets with either high or low levels of L-Lys HCl and the corresponding changes in DCAD values did not impact growth performance or carcass characteristics.

Keywords

crystalline lysine, dietary cation-anion difference, finishing pig, potassium

Cover Page Footnote

Appreciation is expressed to New Horizon Farms, Pipestone, MN, for their technical support and expertise in conducting this experiment.

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Effects of Added Potassium to Diets with High or and Low Crystalline Lysine on Finishing Pig Growth Performance[1]

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Summary

This experiment was conducted to evaluate the effect of balancing dietary cation-anion difference (DCAD) levels, via added potassium bicarbonate ($KHCO_3$), to diets containing low or high levels of L-Lys HCL on growth performance of growing-finishing pigs. A total of 1,944 pigs (PIC L337 × 1050; initially 77.6 ± 1.88 lb BW) were used in a 120-d study to determine the effect of added potassium bicarbonate to diets containing low or high levels of crystalline lysine on growth performance and carcass characteristics of finishing pigs. Pens of pigs were blocked by BW and randomly allotted to 1 of 4 dietary treatments in a randomized complete block design arranged in a 2 × 2 factorial with main effects of $KHCO_3$ (0 vs. 0.4%), and L-Lys HCl level (low vs. high). There were 27 pigs per pen and 18 replicates per treatment and a similar number of barrows and gilts placed in each pen. Treatment diets were corn-soybean meal-based and formulated in four dietary phases (approximately 80 to 130 lb, 130 to 185 lb, 185 to 230 lb, and 230 to 285 lb). Dietary treatments were formulated such that in each phase the diet containing a low level of L-Lys HCl without $KHCO_3$ and the diet containing a high level of L-Lys HCl with $KHCO_3$, had similar calculated DCAD values. Additionally, the diet with a low level of L-Lys HCl with $KHCO_3$ was formulated to have the highest DCAD in each phase, while the diet with a high level of L-Lys HCl without $KHCO_3$ was formulated to have the lowest DCAD. Overall, there was no evidence ($P > 0.10$) for a $KHCO_3$ × L-Lys HCl interaction or main effect for final BW or any observed growth response or carcass characteristics. The results of this study suggest that supplementing $KHCO_3$ to finishing pig diets with either high or low levels of L-Lys HCl and the corresponding changes in DCAD values did not impact growth performance or carcass characteristics.

Introduction

The use of crystalline lysine (L-Lys HCl) to replace a portion of the lysine provided by feeding soybean meal to growing-finishing pigs is common in modern swine production. Several studies have indicated that adding more than 0.15% L-Lys HCl without the addition of other feed-grade amino acids can limit growth performance due to

[1] Appreciation is expressed to New Horizon Farms, Pipestone, MN, for their technical support and expertise in conducting this experiment.
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resulting deficiencies in other amino acids.[3] The development and inclusion of various crystalline amino acids in swine diets in recent years has helped to address this issue. However, it has also been shown that the resulting reduction in DCAD that is caused by adding high levels of Cl^-, via L-Lys HCl, may result in decreased performance.[4] It is possible that this could be rectified by the addition of monovalent cations, such as Na^+ or K^+, to balance intracellular anions, thus regaining lost performance. Therefore, the objective of this study was to evaluate the effect of balancing DCAD levels, via added potassium bicarbonate ($KHCO_3$), to diets containing low or high levels of L-Lys HCl on growth performance of growing-finishing pigs.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. This study was conducted at a commercial research-finishing site in southwest Minnesota (New Horizon Farms, Pipestone, MN). The barns were naturally ventilated and double-curtain-sided, with completely slatted concrete flooring over deep pits for manure storage. Each pen (10 × 18 ft) was equipped with a 5-hole stainless steel dry feeder (Thorp Equipment, Inc., Thorp, WI) and a pan waterer for *ad libitum* access to feed and water.

Animals and diets

A total of 1,944 pigs (PIC L337 × 1050; initially 77.6 ± 1.88 lb BW) were used in a 120-d study, split between 2 barns with 27 pigs per pen and 18 replicates per treatment. Pens of pigs were blocked by initial BW and randomly assigned to 1 of 4 dietary treatments in a randomized complete block design arranged in a 2 × 2 factorial with main effects of $KHCO_3$ (0 vs. 0.4%), and L-Lys HCl level (low vs. high). Daily feed additions to each pen were accomplished using a robotic feeding system (FeedPro, Feedlogic Corp., Wilmar, MN) able to record feed amounts for individual pens. All treatment diets were manufactured at the New Horizon Farms Feed Mill in Pipestone, MN, and formulated to meet or exceed NRC[5] requirement estimates for growing-finishing pigs for their respective weight ranges (Table 1). Diets were fed in meal form in four dietary phases from approximately 80 to 130 lb, 130 to 185 lb, 185 to 230 lb, and 230 to 285 lb.

Experimental diets were corn-soybean meal-based and formulated with either low or high levels of L-Lys HCl with the addition of other feed-grade amino acids. Dietary treatments were formulated such that in each phase the diet containing a low level of L-Lys HCl without $KHCO_3$ and the diet containing a high level of L-Lys HCl with $KHCO_3$ had similar calculated DCAD values. Additionally, the diet with a low level of L-Lys HCl with $KHCO_3$ was formulated to have the highest DCAD in each phase,

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[3] De la Llata, M., S. S. Dritz, M. D. Tokach, R. D. Goodband, and J. L. Nelssen. 2002. Effects of increasing L-lysine HCL in corn- or sorghum-soybean meal-based diets on growth performance and carcass characteristics of growing-finishing pigs. J. Anim. Sci., 80:2420-2432. doi:10.1093/ansci/80.9.2420.

[4] Dersjant-Li, Y., H. Schulze, J. W. Schrama, J. A. Verreth, and M. W. A. Verstegen. 2001. Feed intake, growth, digestibility of dry matter and nitrogen in young pigs as affected by dietary cation-anion difference and supplementation of xylanase. J. Anim. Physiol., 85:101-109. doi: 10.1046/j.1439-0396.2001.00307.x.

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

while the diet with a high level of L-Lys HCl without $KHCO_3$ was formulated to have the lowest DCAD (Table 2).

Pens of pigs were weighed, and feed disappearance was measured approximately every 14 d from d 0 to 120 of the trial to determine ADG, ADFI, and F/G. The 3 heaviest pigs from each pen were marketed on d 98 (group 1) and d 99 (group 2). These pigs were included in the growth performance data, but not in carcass data.

At completion of the study, final pen weights were taken, individual pigs were tattooed with a pen identification number, and pigs were transported to a commercial abattoir (JBS, Worthington, MN) for processing and carcass data collection. Carcass measurements included HCW, backfat depth, loin depth, and percentage lean. Carcass yields were then calculated by the pen average HCW from the plant divided by the pen average final BW on the farm.

Statistical analysis

Data were analyzed as a randomized complete block design for one-way ANOVA using the lmer function from the lme4 package in R (Version 3.5.2, R Core Team, Vienna, Austria), with pen considered as the experimental unit, initial BW as a blocking factor, and treatment as a fixed effect. Preplanned contrasts were used to evaluate the main effects and interactions of dietary $KHCO_3$ and L-Lys HCl. Results were considered significant at $P \leq 0.05$, and marginally significant at $P \leq 0.10$.

Results and Discussion

Analyzed crude protein (CP) levels in treatment diets for phases 1 and 2 were similar to formulated values and followed the trend of reducing CP with the addition of L-Lys HCl (Table 2). The treatment diets in phases 3 and 4 had lower analyzed CP than calculated; however, these diets still followed the trend of reducing CP with increasing L-Lys HCl. Most analyzed mineral and DCAD values are similar to our estimated values when accounting for variation in mineral concentrations of corn-soybean meal from NRC[5] estimates, as well as analytical variation.

Overall, there was no evidence ($P > 0.10$) for a $KHCO_3$ × L-Lys HCl interaction or main effect for final BW or any observed growth responses. For carcass characteristics, there was no evidence ($P > 0.10$) for a $KHCO_3$ × L-Lys HCl interaction or main effect for any observed response.

In summary, these results suggest that supplementing $KHCO_3$ to finishing pig diets with either high or low levels of L-Lys HCl and the associated changes in DCAD values did not significantly impact growth performance or carcass characteristics.

Table 1. Diet composition by phase (as-fed basis)[1]

	Phase 1		Phase 2		Phase 3		Phase 4	
Item **L-Lys HCl:**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
Ingredients, %								
Corn	64.64	71.09	71.33	77.60	74.76	81.47	78.08	84.86
Soybean meal	31.67	24.57	25.35	18.42	22.14	14.72	19.08	11.67
Choice white grease	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Calcium carbonate	1.00	0.98	0.90	0.90	0.85	0.85	0.80	0.80
Monocalcium phosphate	0.70	0.80	0.50	0.60	0.40	0.50	0.20	0.25
Sodium chloride	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
L-Lys HCl	0.21	0.43	0.19	0.41	0.15	0.38	0.13	0.36
DL-Met	0.06	0.12	0.02	0.09	0.01	0.08	---	0.07
L-Trp	---	0.04	---	0.04	---	0.04	---	0.04
L-Val	---	0.12	---	0.12	---	0.13	---	0.12
Thr biomass[2]	0.06	0.18	0.03	0.16	0.02	0.16	0.04	0.16
VTM	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Phytase[2]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Potassium bicarbonate[3]	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-
Total	100	100	100	100	100	100	100	100
Calculated analysis								
SID AA, %								
Lys	1.12	1.12	0.95	0.95	0.84	0.84	0.75	0.75
Ile:Lys	67	56	68	56	71	56	72	56
Leu:Lys	138	123	148	130	158	137	168	144
Met:Lys	30	33	29	33	30	34	31	35
Met and Cys:Lys	56	56	56	56	59	59	61	61
Thr:Lys	61	61	61	61	63	63	66	66
Trp:Lys	19.8	19.7	19.6	19.7	20.1	20.1	20.3	20.0
Val:Lys	73	73	75	75	79	79	82	81
NE, kcal/lb	1,203	1,204	1,206	1,207	1,207	1,209	1,210	1,211
SID Lys:NE, g/Mcal	4.22	4.22	3.57	3.57	3.15	3.15	2.81	2.80
CP, %	20.7	18.3	18.2	15.8	16.9	14.4	15.7	13.2
Ca, %	0.66	0.64	0.56	0.56	0.52	0.51	0.45	0.44
STTD P, %	0.41	0.41	0.36	0.36	0.33	0.33	0.28	0.28

[1]Phase 1 was fed from approximately 80 to 130 lb, phase 2 was fed from approximately 130 to 185 lb, phase 3 was fed from approximately 185 to 230 lb, and phase 4 was fed from approximately 230 to 285 lb.
[2] Thr Pro, CJ America Bio, Downers Grove, IL.
[2] Optiphos Plus (Huvepharma, Peachtree City, GA) provided 790 FTU/lb.
[3] Potassium bicarbonate was included at 0 or 0.40% of the diet in all phases.

Table 2. Analysis of diets (as-fed basis)

	Phase 1				Phase 2				Phase 3				Phase 4			
L-Lys HCl:	Low	Low	High	High	Low	Low	High	High	Low	Low	High	High	Low	Low	High	High
Item $KHCO_3$:	-[2]	+[2]	-	+	-	+	-	+	-	+	-	+	-	+	-	+
Calculated analysis																
Na, %	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Cl, %	0.38	0.38	0.42	0.42	0.38	0.38	0.42	0.42	0.37	0.37	0.42	0.42	0.37	0.37	0.41	0.41
K, %	0.92	1.11	0.78	0.98	0.80	0.99	0.66	0.86	0.74	0.93	0.59	0.79	0.68	0.87	0.53	0.73
DCAD[1]	230	281	182	232	199	249	151	201	184	234	133	183	169	220	118	169
Chemical analysis[3]																
DM, %	87.9	88.3	87.8	88.2	88.1	88.0	87.6	88.0	87.1	88.1	87.3	87.5	87.1	87.6	87.5	88.0
CP, %	19.7	19.4	16.7	16.6	18.4	18.2	16.3	15.9	16.1	15.7	13.1	13.4	14.0	14.8	11.5	12.2
Na, %	0.30	0.29	0.38	0.24	0.39	0.30	0.34	0.33	0.26	0.17	0.23	0.23	0.27	0.21	0.29	0.20
Cl, %	0.47	0.45	0.58	0.37	0.60	0.47	0.52	0.51	0.40	0.26	0.35	0.36	0.41	0.33	0.45	0.31
K, %	0.82	1.13	0.76	0.92	0.90	0.94	0.67	0.94	0.67	0.81	0.52	0.67	0.51	0.59	0.39	0.54
DCAD	210	289	194	235	231	240	171	240	171	207	133	171	130	151	100	138

[1] Dietary cation anion difference; calculated as Na + K – Cl, in mEq/kg diet.
[2] Potassium bicarbonate was included at 0% in diets without (-) $KHCO_3$ or 0.40% in diets with (+) $KHCO_3$ in all phases.
[3] Composite samples were submitted to Ward Laboratories, Inc. (Kearney, NE) for DM and CP analysis, as well as the K-State Research and Extension Soil Testing Laboratory, Manhattan, KS, for mineral analysis.

Table 3. Effects of potassium bicarbonate with high and low crystalline lysine levels on growing-finishing pig performance[1]

L-Lys HCl:	Low		High			$P =$
Item KHCO$_3$:	-[2]	+[2]	-	+	SEM	KHCO$_3$ × L-Lys HCl
Starting weight, lb	77.6	77.7	77.6	77.6	1.88	0.923
Ending weight, lb	285.8	284.8	284.2	286.6	2.36	0.281
Overall (d 0 to 120)						
ADG, lb	1.73	1.72	1.72	1.73	0.011	0.695
ADFI, lb	4.49	4.46	4.48	4.51	0.057	0.303
F/G	2.60	2.59	2.60	2.61	0.030	0.375
Carcass characteristics						
HCW, lb	213.4	213.1	212.8	213.0	1.70	0.847
Carcass yield, %	74.69	74.84	74.91	74.35	0.279	0.199
Backfat depth, in.[3]	0.64	0.64	0.65	0.66	0.012	0.339
Loin depth, in.	2.71	2.72	2.72	2.73	0.020	0.994
Lean, %	57.19	57.28	57.12	56.99	0.201	0.442

[1] A total of 1,944 pigs (PIC L337 × 1050; initially 77.6 ± 1.88 BW) were used in a 120-d study, split between 2 barns located at New Horizon Farms, Pipestone, MN, with 27 pigs per pen and 18 replicates per treatment.
[2] Potassium bicarbonate was included at 0% in diets without (-) KHCO$_3$ or 0.40% in diets with (+) KHCO$_3$ in all phases.
[3] Hot carcass weight served as a covariate for the analysis of backfat depth, in.; loin depth, in.; and lean, %.

Table 4. Main effects of potassium bicarbonate and high or low crystalline lysine levels on growing-finishing pig performance[1]

	L-Lys HCl				$KHCO_3$			
Item	**Low**	**High**	**SEM**	***P* =**	**-**	**+**	**SEM**	***P* =**
Starting weight, lb	77.7	77.6	1.88	0.831	77.6	77.7	1.88	0.831
Ending weight, lb	285.3	285.4	2.36	0.952	285.0	285.7	2.36	0.656
Overall (d 0 to 120)								
ADG, lb	1.73	1.73	0.011	0.902	1.72	1.73	0.011	0.844
ADFI, lb	4.48	4.49	0.057	0.574	4.48	4.49	0.057	0.947
F/G	2.59	2.60	0.030	0.581	2.60	2.60	0.030	0.977
Carcass characteristics								
HCW, lb	213.3	212.9	1.70	0.767	213.1	213.1	1.70	0.959
Carcass yield, %	74.76	74.63	0.279	0.636	74.80	74.59	0.279	0.461
Backfat depth, in.[3]	0.64	0.65	0.012	0.154	0.65	0.65	0.012	0.872
Loin depth, in.	2.71	2.73	0.020	0.426	2.72	2.72	0.020	0.766
Lean, %	57.24	57.05	0.201	0.204	57.16	57.13	0.201	0.878

[1] A total of 1,944 pigs (PIC L337 × 1050; initially 77.6 ± 1.88 BW) were used in a 120-d study, split between 2 barns located at New Horizon Farms, Pipestone, MN, with 27 pigs per pen and 18 replicates per treatment.
[2] Potassium bicarbonate was included at 0% in diets without (-) $KHCO_3$ or 0.40% in diets with (+) $KHCO_3$ in all phases.
[3] Hot carcass weight served as a covariate for the analysis of backfat depth, in.; loin depth, in.; and lean, %.