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Evaluation of Added Sodium and Chloride for 15 to 24 lb Nursery Pigs

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Abstract

A total of 360 pigs (Line 241 × 600; DNA, Columbus, NE) were used in a 14-d growth trial to determine if the response to added dietary salt in nursery pigs (15 to 24 lb) was due to either the Na or Cl concentration in the diet. Upon entry to the nursery, pigs were allotted by BW and fed a common starter diet (0.33% Na and 0.76% Cl) for 7 d after weaning. On d 7 after weaning, considered d 0 in the trial, pens were assigned to 1 of 4 dietary treatments that were fed from d 0 to 14. The 4 experimental treatments included a 10% dried whey diet with 12 lb/ton added salt (0.37% Na and 0.75% Cl); or 3 diets with dried whey replaced by 7.2% lactose containing either: 7 lb/ton added salt (0.18% Na and 0.47% Cl); 15.5 lb/ton added salt (0.35% Na and 0.72% Cl); or 23 lb/ ton sodium bicarbonate and 8 lb/ton potassium chloride (0.35% Na and 0.45% Cl), respectively. From d 0 to 14, pigs fed the 10% dried whey diet with 12 lb/ton added salt or the diet with lactose and 15.5 lb/ton added salt had improved ($P < 0.05$) ADG compared to pigs fed the lactose diet with 7 lb/ton added salt, with pigs fed the lactose diet with 23 lb/ton sodium bicarbonate and 8 lb/ton potassium chloride intermediate. Pigs fed the 10% dried whey diet with 12 lb/ton added salt had greater ($P < 0.05$) ADFI than those fed the lactose diet with 7 lb/ton added salt, with pigs fed the lactose diet with 15.5 lb/ton added salt and the lactose diet with 23 lb/ton sodium bicarbonate and 8 lb/ton potassium chloride intermediate. However, F/G tended to be poorest for pigs fed 10% dried whey compared with pigs fed 7.2% lactose and 15.5 lb/ton added salt, with others intermediate. In conclusion, diets should be formulated with enough added salt in order to meet NRC (2012) recommendation of dietary Na concentration of 0.35%, which is higher in Na than many nursery diets for 15 to 25 lb pigs.

Keywords

chlorine (Cl), sodium (Na), nursery pig, salt

Authors

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K-STATE Research and Extension

SWINE DAY 2016

KANSAS STATE UNIVERSITY SWINE INDUSTRY DAY 2016

Evaluation of Added Sodium and Chloride for 15 to 24 lb Nursery Pigs

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Summary

A total of 360 pigs (Line 241 × 600; DNA, Columbus, NE) were used in a 14-d growth trial to determine if the response to added dietary salt in nursery pigs (15 to 24 lb) was due to either the Na or Cl concentration in the diet. Upon entry to the nursery, pigs were allotted by BW and fed a common starter diet (0.33% Na and 0.76% Cl) for 7 d after weaning. On d 7 after weaning, considered d 0 in the trial, pens were assigned to 1 of 4 dietary treatments that were fed from d 0 to 14. The 4 experimental treatments included a 10% dried whey diet with 12 lb/ton added salt (0.37% Na and 0.75% Cl); or 3 diets with dried whey replaced by 7.2% lactose containing either: 7 lb/ton added salt (0.18% Na and 0.47% Cl); 15.5 lb/ton added salt (0.35% Na and 0.72% Cl); or 23 lb/ton sodium bicarbonate and 8 lb/ton potassium chloride (0.35% Na and 0.45% Cl), respectively. From d 0 to 14, pigs fed the 10% dried whey diet with 12 lb/ton added salt or the diet with lactose and 15.5 lb/ton added salt had improved ($P < 0.05$) ADG compared to pigs fed the lactose diet with 7 lb/ton added salt, with pigs fed the lactose diet with 23 lb/ton sodium bicarbonate and 8 lb/ton potassium chloride intermediate. Pigs fed the 10% dried whey diet with 12 lb/ton added salt had greater ($P < 0.05$) ADFI than those fed the lactose diet with 7 lb/ton added salt, with pigs fed the lactose diet with 15.5 lb/ton added salt and the lactose diet with 23 lb/ton sodium bicarbonate and 8 lb/ton potassium chloride intermediate. However, F/G tended to be poorest for pigs fed 10% dried whey compared with pigs fed 7.2% lactose and 15.5 lb/ton added salt, with others intermediate. In conclusion, diets should be formulated with enough added salt in order to meet NRC (2012)[2] recommendation of dietary Na concentration of 0.35%, which is higher in Na than many nursery diets for 15 to 25 lb pigs.

Key words: chlorine (Cl), sodium (Na), nursery pig, salt

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[2] NRC. 2012. Nutrient requirements of swine. 11th rev. ed. Natl. Acad. Press, Washington, DC.

Introduction

Dietary salt concentrations have been positively correlated to growth, feed efficiency, and feed intake (Mahan et al., 1996;[3] 1999[4]). The NRC (2012)[2] requirement for Na and Cl are 0.35 and 0.45%, respectively, for 15 to 25 lb pigs. With diets containing spray-dried blood plasma, lactose, and added salt, Mahan et al. (1999)[4] noted improvement in F/G up to a dietary salt concentration of 0.40%. When Na and Cl were independently analyzed, Mahan et al. (1999)[4] reported that F/G and growth was positively affected up to a 0.45% Cl, but there were no advantages to increasing dietary Na concentration beyond 0.20%. Because 10% dried whey typically contains 2 to 3% salt, most Phase 2 nursery diets typically contain 5 to 7 lb/ton added salt, but the dietary Na concentrations of the diets may still be deficient according to NRC (2012)[2] recommendations. In a previous study, Shawk et al. (2016)[5] observed improvement in ADG, ADFI, and F/G up to 12 lb/ton added salt in Phase 2 diets containing 10% dried whey. The calculated analysis of this 12 lb/ton added salt diet had a Na concentration of 0.37% and a Cl concentration of 0.72%. This increase in performance observed by Shawk et el. (2016)[5] could have been a result of either the dietary Na concentration matching NRC (2012)[2] recommendations, the Cl concentration exceeding NRC (2012)[2] recommendations, or both. Thus, the purpose of this study was to determine if Na and Cl, concentration or their source had an effect on the growth of nursery pigs weighing 15 to 24 lb.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. Each pen was equipped with a 4-hole, dry self-feeder and a nipple waterer to provide ad libitum access to feed and water. A total of 360 pigs (Line 241 × 600; DNA, Columbus, NE) were used in a 14-d growth trial. Pigs were weaned at approximately 21 d of age and placed into the nursery. Initially, pigs were randomly allotted to pens of 6 based on their initial BW. Pigs were fed a common diet (0.33 and 0.76% Na and Cl, respectively) for 7 d after weaning. On d 7 after weaning, considered d 0 in the trial, pens were randomly assigned to 1 of 4 dietary treatments with 15 replications per treatment. The 4 experimental treatments included a 10% dried whey diet with 12 lb/ton added salt (0.37% Na and 0.75% Cl); or 3 diets with dried whey replaced by 7.2% crystalline lactose with either: 7 lb/ton added salt (0.18% Na and 0.47% Cl); 15.5 lb/ton added salt (0.35% Na and 0.72% Cl%); or 23 lb/ton sodium bicarbonate and 8 lb/ton potassium chloride (0.35% Na and 0.45% Cl; Table 1). Pens of pigs were weighed and feed disappearance was recorded on d 0, 7, and 14 to determine ADG, ADFI, and F/G.

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[3] Mahan, D. C., E. A. Newton, and K. R. Cera. 1996. Effect of supplemental sodium chloride, sodium phosphate, or hydrochloric acid in starter pig diets containing dried whey. J. Anim. Sci. 74:1217-1222.

[4] Mahan, D. C., T. D. Wiseman, E. Weaver, and L. Russell. 1999. Effect of supplemental sodium chloride and hydrochloric acid added to initial starter diets containing spray-dried blood plasma and lactose on resulting performance and nitrogen digestibility of 3-week-old weaned pigs. J. Anim. Sci. 77:3016-3021.

[5] D.J. Shawk, J.M. DeRouchey, M.D. Tokach, R.D. Goodband, S.S. Dritz , J.C. Woodworth, H. E. Williams, and A. B. Clark. 2016. Effects of increasing salt concentration for 15 to 22 lb nursery pigs. Kansas Swine Industry Day, 2016, 17-118-J. Kansas Agricultural Experiment Station Research Reports, Volume 2, Issue 8.

All experimental diets were manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center, Manhattan, KS. Dietary treatments were corn-soybean meal-based and were fed in meal form. Corn was removed and replaced with an equal amount of either salt, potassium chloride, and/or sodium bicarbonate to create the treatment diets. Dried whey was replaced with crystalline lactose to create diets with the same lactose content, and all diets were formulated to the same NE concentration.

Diet samples were collected at the mill and subsampled. Subsamples were analyzed for DM, CP, Na, and Cl (Ward Laboratories, Inc., Kearney, NE, Table 2).

Data were analyzed as a randomized complete block design using PROC GLIMMIX in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit and dietary treatment as the fixed effect. The main effects that were tested were the dietary Na and Cl concentration. Results were considered significant at $P \leq 0.05$ and marginally significant between $P > 0.05$ and $P \leq 0.10$.

Results and Discussion

Chemical analysis indicated that the dietary Na concentration of the treatment diets was similar to formulated values, but the analyzed dietary Cl concentrations were slightly lower than formulated (Table 2). Sodium ranged from 0.18% to 0.37% and Cl ranged from 0.35% to 0.67%. The dried whey contained 0.79% Na and 1.45% Cl.

From d 0 to 14, pigs fed the 10% dried whey diet with 12 lb/ton added salt and those fed 7.2% lactose and 15.5 lb/ton added salt had greater ADG ($P < 0.05$) than pigs fed the 7.2% lactose diet with 7 lb/ton added salt, with intermediate performance observed for pigs fed the lactose diet with 23 lb/ton sodium bicarbonate and 8 lb/ton potassium chloride. Pigs fed the whey diet with 12 lb/ton added salt had the highest ($P < 0.05$) ADFI and pigs fed the lactose diet containing 7 lb/ton salt had the lowest, with the other treatments intermediate. There was a trend ($P < 0.10$) for improved F/G of pigs fed 7.2% lactose and 15.5 lb/ton added salt compared with those fed 10% dried whey and 12 lb/ton added salt, with the others intermediate.

All treatment diets (0.37% Na), except the lactose diet with the 7 lb/ton added salt (0.18% Na), had a similar dietary Na concentration to NRC (2012)[2] recommendations and greater ADG and ADFI than the diet that was deficient in Na. Due to no significant difference in ADG, ADFI, and F/G between the 10% dried whey diet with 12 lb/ton added salt and the lactose diet with 15.5 lb/ton added salt, results would suggest that the source of the salt in the diet (dried whey plus salt vs only salt) had no effect on overall performance. Results of this study would indicate the additional performance observed by Shawk et al. (2016)[5] was a result of dietary Na concentration meeting NRC (2012)[2] recommendations.

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

Item	12 lb/ton added salt, dried whey	7 lb/ton added salt, lactose	15.5 lb/ton added salt, lactose	KCl and $NaHCO_3$, lactose
Ingredient %				
Corn	50.36	50.47	49.76	48.59
Soybean meal (48% CP)	29.65	29.67	29.66	29.65
Lactose	---	7.20	7.20	7.20
Dried whey	10.00	---	---	---
HP 300[2]	5.00	7.75	7.80	7.88
Choice white grease	1.00	0.90	1.15	1.55
Monocalcium P (21% P)	1.05	1.33	1.33	1.15
Limestone	1.05	1.05	1.05	1.15
Potassium chloride	---	---	---	0.40
Sodium bicarbonate	---	---	---	1.15
Salt	0.60	0.35	0.78	---
Zinc oxide	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25	0.25
Phytase[3]	0.02	0.02	0.02	0.02
L-Lys-HCl	0.30	0.30	0.30	0.30
DL-Met	0.18	0.17	0.17	0.17
L-Thr	0.15	0.16	0.16	0.16
Total	100	100	100	100

continued

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

Item	12 lb/ton added salt, dried whey	7 lb/ton added salt, lactose	15.5 lb/ton added salt, lactose	KCl and $NaHCO_3$, lactose
Calculated analysis				
Standardized ileal digestible (SID) AA, %				
Lys	1.35	1.35	1.35	1.35
Ile:Lys	63	63	63	63
Leu:Lys	123	123	123	122
Met:Lys	35	35	35	34
Met and Cys:Lys	58	58	58	57
Thr:Lys	66	65	65	65
Tryp:Lys	19	19	19	19
Val:Lys	67	68	68	68
Total Lys, %	1.49	1.49	1.49	1.49
NE kcal/lb	1,110	1,110	1,110	1,110
SID Lys:ME, g/Mcal	4.06	4.05	4.05	4.06
CP, %	22.8	23.2	23.1	23.1
Ca, %	0.78	0.78	0.78	0.78
P, %	0.68	0.69	0.69	0.65
Available P, %	0.48	0.48	0.48	0.48
Na, %	0.37	0.18	0.35	0.35
Cl, %	0.75	0.47	0.72	0.45
K, %	1.14	1.02	1.01	1.22
Dietary electrolyte balance	240	205	207	337

[1] Experimental diets were fed from d 7 to 21 after weaning.
[2]Hamlet Protein, Findlay, OH.
[3] HiPhos 2700 (DSM Nutritional Products, Inc., Parsippany, NJ), providing 184.3 phytase units (FTU)/lb and an estimated release of 0.10% available P.

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

Item, %	12 lb/ton added salt, dried whey	7 lb/ton added salt, lactose	15.5 lb/ton added salt, lactose	KCl and $NaHCO_3$, lactose
DM	89.68	88.82	89.79	90.2
CP	22.5	22.3	22.4	22.1
Na	0.37	0.18	0.37	0.37
Cl	0.67	0.36	0.60	0.35

[1]Multiple samples were collected from each diet throughout the study, homogenized, and then subsampled for analysis (Ward Laboratories, Inc., Kearney, NE).

Table 3. Effects of increasing Na and Cl for 15 to 24 lb nursery pigs [1]

	Experimental diets					
Item	12 lb/ton added salt, dried whey	7 lb/ton added salt, lactose	15.5 lb/ton added salt, lactose	KCl and $NaHCO_3$, lactose	SEM	Probability, $P <$
d 0 to 14						
ADG, lb	0.62[a]	0.55[b]	0.63[a]	0.60[ab]	0.021	0.038
ADFI, lb	0.98[a]	0.86[c]	0.94[ab]	0.90[bc]	0.025	0.004
F/G	1.59[x]	1.56[xy]	1.50[y]	1.52[xy]	0.031	0.086
BW, lb						
d 0	15.3	15.3	15.3	15.3	0.13	0.999
d 7	18.3	17.8	18.3	18.0	0.23	0.374
d 14	23.9[xy]	23.0[x]	24.2[y]	23.6[xy]	0.34	0.080

[ab] Means with common superscripts differ $P < 0.05$.

[xy] Means with common superscripts differ $P < 0.10$.

[1] A total of 360 barrows (Line 241 × 600; DNA, Columbus, NE) were used in a 14-d study with 6 pigs per pen and 15 pens per treatment. Pigs were weaned at approximately 21 d, fed a common starter diet for 7 d post-weaning, then placed on experimental diets.