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Effects of Increasing Salt Concentration on Growth Performance of 25- to 67-lb Nursery Pigs

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Abstract

A total of 300 pigs (Line 241 × 600; DNA, Columbus, NE; initially 25.0 lb BW) was used in a 34-d growth trial to determine the effects of added dietary salt on the growth performance of nursery pigs weighing 25 to 67 lb. Upon entry to the nursery, pigs were allotted by BW and fed a phase 1 common starter diet (0.50% Na and 0.67% Cl) for 11 d and then a common phase 2 diet (0.35% Na and 0.59% Cl) from day 11 to 25 after weaning. At d 25 after weaning, considered d 0 in the trial, pigs were allotted by pen weight and assigned to 1 of 5 dietary treatments containing either 0.20, 0.35, 0.50, 0.65, or 0.80% salt. This corresponds to calculated dietary Na levels of 0.10, 0.16, 0.22, 0.28, and 0.34%, respectively. Calculated Cl levels were 0.23, 0.32, 0.41, 0.50, and 0.59%, respectively. A common diet containing 0.35% lb/ton salt (0.16% Na and 0.29% Cl), was then fed from d 27 to 34.

From d 0 to 14, ADG, ADFI, and F/G improved (quadratic, $P < 0.001$, 0.089, and 0.012, respectively) as added salt increased from 0.20 to 0.65%, with no further benefits observed thereafter. From d 14 to 27, there was no significant effect on ADG; however, pigs fed 0.50% added salt had numerically the greatest ADG. Average daily feed intake increased (linear, $P < 0.001$) and F/G marginally worsened (linear, $P < 0.095$) with increasing added salt. From d 0 to 27, ADG and F/G improved (quadratic, $P < 0.05$ and 0.054, respectively) using up to 0.5% added salt while ADFI increased (linear, $P < 0.001$). From d 27 to 34, when pigs were fed a common diet, there was no evidence of difference to indicate that previous dietary treatments influenced ADG; however, ADFI, and d 34 BW increased (linear, $P < 0.001$) while F/G worsened (linear, $P < 0.001$) with increasing salt previously fed from d 0 to 27.

In conclusion, results of this study indicate that the pig's Na and Cl requirement estimate changes and that diets for pigs weighing 25 to 45 lb, should be formulated with enough added salt to provide 0.28% Na and 0.48% Cl, which in this study was 0.65%. However, from 45 to 67 lb, 0.20% Na and .39% Cl (0.50% added salt) was sufficient to maximize growth performance.

Keywords

chloride, nursery pig, salt, sodium

Authors

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K-STATE Research and Extension

Swine Day 2017

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D.J. Shawk, M.D. Tokach, J.C. Woodworth, R.D. Goodband, J.M. DeRouchey, S.S. Dritz,[1] and A.B. Clark

Summary

A total of 300 pigs (Line 241 × 600; DNA, Columbus, NE; initially 25.0 lb BW) was used in a 34-d growth trial to determine the effects of added dietary salt on the growth performance of nursery pigs weighing 25 to 67 lb. Upon entry to the nursery, pigs were allotted by BW and fed a phase 1 common starter diet (0.50% Na and 0.67% Cl) for 11 d and then a common phase 2 diet (0.35% Na and 0.59% Cl) from day 11 to 25 after weaning. At d 25 after weaning, considered d 0 in the trial, pigs were allotted by pen weight and assigned to 1 of 5 dietary treatments containing either 0.20, 0.35, 0.50, 0.65, or 0.80% salt. This corresponds to calculated dietary Na levels of 0.10, 0.16, 0.22, 0.28, and 0.34%, respectively. Calculated Cl levels were 0.23, 0.32, 0.41, 0.50, and 0.59%, respectively. A common diet containing 0.35% lb/ton salt (0.16% Na and 0.29% Cl), was then fed from d 27 to 34.

From d 0 to 14, ADG, ADFI, and F/G improved (quadratic, $P < 0.001$, 0.089, and 0.012, respectively) as added salt increased from 0.20 to 0.65%, with no further benefits observed thereafter. From d 14 to 27, there was no significant effect on ADG; however, pigs fed 0.50% added salt had numerically the greatest ADG. Average daily feed intake increased (linear, $P < 0.001$) and F/G marginally worsened (linear, $P < 0.095$) with increasing added salt. From d 0 to 27, ADG and F/G improved (quadratic, $P < 0.05$ and 0.054, respectively) using up to 0.5% added salt while ADFI increased (linear, $P < 0.001$). From d 27 to 34, when pigs were fed a common diet, there was no evidence of difference to indicate that previous dietary treatments influenced ADG; however, ADFI, and d 34 BW increased (linear, $P < 0.001$) while F/G worsened (linear, $P < 0.001$) with increasing salt previously fed from d 0 to 27.

In conclusion, results of this study indicate that the pig's Na and Cl requirement estimate changes and that diets for pigs weighing 25 to 45 lb, should be formulated with enough added salt to provide 0.28% Na and 0.48% Cl, which in this study was 0.65%. However, from 45 to 67 lb, 0.20% Na and .39% Cl (0.50% added salt) was sufficient to maximize growth performance.

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Introduction

Sodium and Cl are key electrolytes that are involved in several of the body's processes, such as osmotic regulation and basic metabolism. When Na and Cl were independently evaluated, Honeyfield and Froseth[2] noted improvements in ADG and F/G up to a Na concentration of 0.18%; however, there were no advantages to increasing Cl concentrations beyond 0.10% in corn-soybean meal diets formulated for pigs weighing approximately 19 to 43 lb. The NRC[3] requirement estimates for Na and Cl are 0.28 and 0.32% for 24- to 55-lb pigs and 0.10 and 0.08% for 55- to 110-lb pigs, respectively. Salt is the most common source of Na and Cl in swine diets. In corn-soybean meal diets, Hagsten and Perry[4] reported that ADG and F/G increased as total dietary salt concentration increased to 0.14% for 26- to 54-lb pigs and 0.13% for 37- to 70-lb pigs. In 20- to 55-lb pigs, Alcantara et al.[5] observed improvement in ADG with up to 0.14% added salt in corn-soybean meal diets. Typically, most Phase 3 diets will contain a fixed amount of 0.35 to 0.50% added salt (0.16 to 0.22% Na and 0.32 to 0.41% Cl, respectively) to meet the requirement estimate. However, even with the Na provided by the added salt, this may result in a diet that is deficient in Na based on the NRC[3] requirement estimate (0.28%). Thus, the objective of this study was to determine the effect of added salt on growth of nursery pigs weighing 25 to 67 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 K-State 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 300 pigs (Line 241 × 600; DNA, Columbus, NE; initially 25.0 lb BW) was used in a 34-d growth trial. Pigs were weaned at 21 d of age and placed into the nursery. Upon entry to the nursery, pigs were allotted to pens of 5 based on their initial BW and fed a phase 1 common starter diet (0.50% Na and 0.67% Cl) for 11 d and then a common phase 2 diet (0.35% Na and 0.59% Cl) from day 11 to 25 after weaning. At d 25 after weaning, considered d 0 in the trial, pigs were randomly assigned to 1 of 5 dietary treatments with 12 replications per treatment. Dietary treatments were fed for 27-d and were corn-soybean meal-based with either 0.20, 0.35, 0.50, 0.65, or 0.80% of added salt; this resulted in calculated dietary Na levels of 0.10, 0.16, 0.22, 0.28, and 0.34%, respectively (Table 1). Calculated Cl levels were 0.23, 0.32, 0.41, 0.50, and 0.59%. Pigs were then fed a common diet from d 27 to 34 (0.16% Na and 0.29% Cl). Pens of pigs were weighed and feed disappearance was recorded on d 0, 7, 14, 21, 27, and 34 to determine ADG, ADFI, and F/G.

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[2] Honeyfield, D. C., and J. A. Froseth. 1985. Effects of dietary sodium and chloride on growth, efficiency of feed utilization, plasma electrolytes and plasma basic amino acids in young pigs. J. of Nutr. 115:1366-1371.

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

[4] Hagsten, I., and T. W. Perry. 1976. Evaluation of Dietary Salt Levels for Swine. I. Effect on Gain, Water Consumption and Efficiency of Feed Conversion. J. Anim. Sci. 42:1187-1190. doi:10.2527/jas1976.4251187.

[5] Alcantara, P. F., L. E. Hanson, and J. D. Smith. 1980. Sodium Requirements, Balance and Tissue Composition of Growing Pigs. J. Anim. Sci. 50:1092-1101. doi:10.2527/jas1980.5061092x.

All experimental diets were fed in meal form and were manufactured at the K-State O.H. Kruse Feed Technology Innovation Center, Manhattan, KS. Experimental diets were achieved by replacing sand with salt. Diet samples were collected from 8 feeders per dietary treatment and subsampled, and submitted for analysis of Na and Cl (Cumberland Valley Analytical Service, Maugansville, MD; 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. Linear and quadratic polynomials were used to evaluate increasing added salt. Results were considered significant at $P \leq 0.05$.

Results and Discussion

Chemical analysis indicated that calculated values for Na and Cl were similar to analyzed values except for the 0.80% added salt diet which had slightly lower Na and Cl than expected. Sodium ranged from 0.11 to 0.30% and Cl ranged from 0.23 to 0.50% (Table 2).

From d 0 to 14, ADG, ADFI, F/G, and d 14 BW all improved (quadratic, $P < 0.001$, 0.089, 0.012, and 0.061, respectively) as added salt increased from 0.20 to 0.65%, with no further benefits observed thereafter.

From d 14 to 27, there was no significant effect on ADG; however, pigs fed 0.50% added salt had numerically the greatest ADG. Average daily feed intake increased (linear, $P < 0.002$) and F/G marginally worsened (linear, $P < 0.095$) with increasing added salt with the best F/G observed with pigs fed 0.50% added salt diets.

From d 0 to 27, ADG and F/G improved (quadratic, $P = 0.005$ and 0.054, respectively), while ADFI increased (linear, $P = 0.001$) with increasing added salt. However little or no improvements were observed above 0.50% added salt. On d 27, BW marginally increased (quadratic, $P < 0.088$) with the greatest change in d 27 BW observed as added salt increased to 0.50%, with little increase thereafter.

From d 27 to 34, when pigs were fed a common diet, there was no evidence of difference to indicate that previously fed dietary treatments influenced ADG. Average daily feed intake and d 34 BW increased (linear, $P < 0.001$) while F/G worsened (linear, $P < 0.001$) when diets previously contained increasing salt from d 0 to 27.

Based on the result of this trial, the optimal amount of added salt for pigs weighing 25 to 45 lb was 0.65%. According to the chemical analysis, the 0.65% added salt diet had an analyzed Na and Cl concentration of 0.28% and 0.51%, respectively. The 0.65% added salt diet's Na concentration would be similar to the NRC[3] Na requirement estimate for 24- to 55-lb pigs (0.28). From d 14 to 27 and the overall treatment period (d 0 to 27), 0.50% added salt appeared to optimize ADG and F/G. The chemical analysis of the 0.50% added salt diet indicated a Na concentration of 0.18% and a Cl concentration of 0.39%. The 0.50% added salt dietary Na concentration would be intermediate when compared to the NRC[3] Na estimate for 24 to 55 and 55- to 110-lb pigs, which is 0.28% and 0.10%, respectively. The 0.50% salt dietary Cl concentration would be

slightly higher than the NRC[3] Na estimate for 24- to 55-lb pigs, which is 0.32% and significantly greater than NRC[3] estimate for 55- to 110-lb pigs which is 0.08%.

In conclusion, results of this study would indicate Na and Cl requirements for pigs from 25 to 67 lb change over time. From approximately 25 to 45 lb, 0.28 and 0.48 Na and Cl, respectively maximized pig growth performance. However, from 45 to 67 lb the response to Na and Cl decreased as 0.18 and 0.39% Na and Cl, respectively was sufficient. These values correspond with NRC[3] estimates for Na and Cl, and in a corn-soybean meal-based diet these estimates can be met with 0.65 and 0.50% added salt for diets fed from 25 to 45 and 45 to 67, respectively.

Table 1. Diet composition (as-fed basis)

Ingredient, %	Experimental[1]	Common grower[2]
Corn	60.12	71.50
Soybean meal (48% CP)[3]	34.66	25.71
Choice white grease	1.30	-
Monocalcium P (21% P)	1.15	0.55
Limestone	0.88	1.13
L-Lys-HCl	0.35	0.31
DL-Met	0.16	0.06
L-Thr	0.14	0.09
L-Trp	0.004	-
L-Val	0.04	-
Trace mineral premix	0.15	0.15
Vitamin premix	0.25	0.15
Phytase[4]	0.02	0.02
Sand	0.60	-
Salt	0.20	0.35
Total	100	100

continued

Table 1, *continued*. Diet composition (as-fed basis)

Ingredient, %	Experimental[1]	Common grower[2]
Calculated analysis		
Standardized ileal digestible (SID) AA, %		
Lys	1.30	1.05
Ile:Lys	61	62
Leu:Lys	124	135
Met:Lys	35	30
Met and Cys:Lys	58	55
Thr:Lys	62	61
Tryp:Lys	18.5	18.0
Val:Lys	69	69
Total Lys, %	1.45	1.18
NE kcal/lb	1,110	1,117
SID Lys:ME, g/Mcal	3.92	3.19
CP, %	22.0	18.5
Ca, %	0.70	0.62
P, %	0.65	0.49
Available P, %	0.43	0.29
Na, %	0.10	0.17
Cl, %	0.23	0.46
K, %	0.97	0.81
Dietary electrolyte balance, mEq/kg[5]	226	154

[1] Experimental diets were fed from approximately 25 to 67 lb. Sand was removed and replaced with salt to create the additional experimental treatment diets.

[2] Common grower diet was fed to all pigs from d 27 to 34.

[3] Na and Cl values from NRC (1998).

[4] HiPhos 2700 (DSM Nutritional Products, Inc., Parsippany, NJ), providing 184.3 phytase units (FTU)/lb and an estimated release of 0.10% available P.

[5] Calculated as = ((Na × 434.98) + (K × 255.74) – (Cl × 282.06)).

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

	Added salt, %				
Item, %[2]	0.20	0.35	0.50	0.65	0.80
Na	0.11	0.14	0.20	0.28	0.30
Cl	0.23	0.29	0.39	0.48	0.50

[1] Multiple samples were collected from each diet throughout the study, homogenized, and then subsampled for analysis.

[2] Samples were submitted to Cumberland Valley Analytical Service (Maugansville, MD).

Table 3. Effects of increasing salt on growth performance of 25 to 67 lb pig[1]

	Added salt, %[2]						Probability, $P <$	
Item	0.20	0.35	0.50	0.65	0.80	SEM	Linear	Quadratic
d 0 to 14								
ADG, lb	1.16	1.31	1.34	1.40	1.39	0.027	0.001	0.001
ADFI, lb	1.86	1.94	1.96	2.03	1.99	0.035	0.001	0.089
F/G	1.61	1.48	1.46	1.45	1.44	0.025	0.001	0.012
d 14 to 27								
ADG, lb	1.78	1.77	1.84	1.80	1.82	0.033	0.213	0.672
ADFI, lb	2.92	2.90	3.00	3.05	3.04	0.044	0.002	0.766
F/G	1.64	1.64	1.63	1.70	1.67	0.019	0.095	0.843
d 0 to 27								
ADG, lb	1.46	1.53	1.58	1.59	1.60	0.022	0.001	0.005
ADFI, lb	2.37	2.40	2.46	2.52	2.49	0.035	0.001	0.211
F/G	1.63	1.57	1.56	1.59	1.56	0.015	0.018	0.054
Post treatment period (27 to 34)								
ADG, lb	2.02	1.94	2.02	1.97	1.94	0.037	0.316	0.884
ADFI, lb	3.69	3.75	3.85	3.92	3.89	0.054	0.001	0.272
F/G	1.83	1.94	1.91	1.99	2.01	0.029	0.001	0.491
BW, lb								
d 0	25.0	24.8	25.0	25.0	25.0	0.473	0.875	0.894
d 14	41.3	43.1	43.8	44.6	44.9	0.744	0.001	0.061
d 27	64.4	66.2	67.7	67.9	68.6	0.984	0.001	0.088
d 34	78.5	79.7	81.9	81.7	82.2	1.042	0.001	0.112

[1] A total of 300 pigs (Line 241 × 600; DNA, Columbus, NE) were used in a 34-d study with 5 pigs per pen and 12 pens per treatment. Pigs were weaned at approximately 21 d, fed a common starter diet for 25 d post-weaning, then placed on experimental diets.

[2] Experimental diets were fed from d 0 to 27 and a common grower diet was fed from d 27 to 34.