Kansas Agricultural Experiment Station Research Reports

Volume 2
Issue 8 *Swine Day*

Article 33

January 2016

Effects of Dietary Electrolyte Balance and Crude Protein Level on Growth Performance, Carcass Characteristics, and Blood Analytes of Finishing Pigs

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Recommended Citation

Soto, J.; Tokach, M. D.; Dritz, S. S.; Woodworth, J. C.; DeRouchey, J. M.; and Goodband, R. D. (2016) "Effects of Dietary Electrolyte Balance and Crude Protein Level on Growth Performance, Carcass Characteristics, and Blood Analytes of Finishing Pigs," *Kansas Agricultural Experiment Station Research Reports*: Vol. 2: Iss. 8. https://doi.org/10.4148/2378-5977.1310

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Abstract

A total of 288 finishing pigs (PIC 327 × 1050, initially 243.5 lb) were used in a 20-d trial to determine if dietary electrolyte balance (dEB) in conjunction with low protein, amino acid fortified diets has any influence on growth performance. Pens of 8 pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments with 9 replications per treatment. Treatments were arranged in a 2 × 2 factorial with main effects of CP (10 or 13%) and dEB (48 or 107 mEq/kg). At d 20, the pigs were transported to a packing plant for processing and carcass data collection. Pigs fed 13% CP diets had greater ($P = 0.001$) ADG, heavier ($P = 0.037$) final body weight, and improved ($P < 0.001$) feed efficiency compared with pigs fed the 10% CP diets. A tendency for a CP × dEB interaction was observed for ADFI because intake numerically decreased when dEB was increased for pigs fed 10% CP, whereas intake increased as dEB was increased for pigs fed 13% CP diets. For carcass performance, pigs fed the diets with 13% CP had increased ($P = 0.001$) HCW and HCW ADG and improved ($P = 0.001$) HCW F/G compared with pigs fed the 10% CP diets. In conclusion, reduced performance observed in pigs fed the low crude protein diets with high supplemental crystalline AA was not influenced by dEB ranging from 48 to 107 mEq/kg. Dietary electrolyte balance in the range tested had no effects on growth performance, HCW, yield, or carcass performance during late finishing. Appropriate levels of dietary CP are critical to ensure optimal late finishing performance.

Keywords

crude protein, electrolyte balance, late finishing

Authors

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Effects of Dietary Electrolyte Balance and Crude Protein Level on Growth Performance, Carcass Characteristics, and Blood Analytes of Finishing Pigs

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Summary

A total of 288 finishing pigs (PIC 327 × 1050, initially 243.5 lb) were used in a 20-d trial to determine if dietary electrolyte balance (dEB) in conjunction with low protein, amino acid fortified diets has any influence on growth performance. Pens of 8 pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments with 9 replications per treatment. Treatments were arranged in a 2 × 2 factorial with main effects of CP (10 or 13%) and dEB (48 or 107 mEq/kg). At d 20, the pigs were transported to a packing plant for processing and carcass data collection. Pigs fed 13% CP diets had greater ($P = 0.001$) ADG, heavier ($P = 0.037$) final body weight, and improved ($P < 0.001$) feed efficiency compared with pigs fed the 10% CP diets. A tendency for a CP × dEB interaction was observed for ADFI because intake numerically decreased when dEB was increased for pigs fed 10% CP, whereas intake increased as dEB was increased for pigs fed 13% CP diets. For carcass performance, pigs fed the diets with 13% CP had increased ($P = 0.001$) HCW and HCW ADG and improved ($P = 0.001$) HCW F/G compared with pigs fed the 10% CP diets. In conclusion, reduced performance observed in pigs fed the low crude protein diets with high supplemental crystalline AA was not influenced by dEB ranging from 48 to 107 mEq/kg. Dietary electrolyte balance in the range tested had no effects on growth performance, HCW, yield, or carcass performance during late finishing. Appropriate levels of dietary CP are critical to ensure optimal late finishing performance.

Key words: crude protein, electrolyte balance, late finishing

Introduction

Economic and environmental pressures have obligated nutritionists to develop low protein, amino acid fortified diets that deliver performance equivalent to traditional formulations. However, in some studies, low protein diets lead to poorer performance

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in late finishing pigs.[2] By lowering crude protein, dietary electrolyte balance decreased proportionally. Dietary electrolyte balance (dEB) represents the net balance between fixed cations and anions (Na +K-Cl in mEq/kg of diet) and determines the net acid or alkaline load contributed by the diet. It is well known that dEB alters the acid-base status and subsequently may impact animal performance. Extensive research performed with dairy cattle, laying hens and lactating sows would indicate positive metabolic effects when dietary dEB is modified (DeRouchey et al., 2003[3]). In postweaned pigs, Guzman-Pino et al. (2015)[4] reported increased ADG and BW when dEB was increased from 16 to 133 mEq/kg. In finishing pigs, Patience et al. (1987)[5] reported increased ADFI when dEB was increased from 68 to 346 mEq/kg, although Wondra et al. (1995)[6] reported no changes in performance as dEB increased from 177 to 399 mEq/kg. Because the dEB is decreased when crystalline amino acids replace soybean meal in low crude protein diets, there is a need to establish whether dEB has any influence on finishing performance. Therefore, the objective of the present study is to determine the effects of dEB in diets with different levels of crude protein on growth performance, carcass characteristics, and blood analytes of pigs between 250 and 285 lb.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. This study was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. The facility was totally enclosed and environmentally regulated, containing 36 pens. Each pen was equipped with a dry single-sided feeder (Farmweld, Teutopolis, IL) and a 1-cup waterer. Pens were located over a completely slatted concrete floor with a 4-ft pit underneath for manure storage. A robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) was used to deliver and record daily feed additions to each individual pen.

A total of 288 pigs (PIC 327 × 1050, initially 243.5 lb) were used in a 20-d trial. There were 8 pigs per pen (4 barrows and 4 gilts) at a floor space of 7.83 ft^2 per pig and 9 replications per treatment. Pens were equipped with adjustable gates to allow space allowances per pig to be maintained if a pig died or was removed from a pen during the experiment. Pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments in a completely randomized block design. Treatments were arranged in a 2 × 2 factorial with main effects of CP (10 or 13%) and dEB (48 or 107 mEq/kg).

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[2] Vonderohe, C.E., K.M. Mills, M. D., Asmus, E. R. Otto-Tice, C.V. Maxwell, B.T., Richert, and J.S. Radcliffe. 2016. Comparison of the effects of reduced CP, amino acid supplemented diets on growth performance in swine J. Anim. Sci. 94:16 (Abstract).

[3] DeRouchey, J.M., J.D. Hancock, R.H. Hines, K.R. Cummings, D.J. Lee, C.A. Maloney, D.W. Dean, J.S. Park, and H. Cao. 2003. Effects of dietary electrolyte balance on the chemistry of blood and urine in lactating sows and sow litter performance. J. Anim. Sci. 81:3067-3074.

[4] Guzmán-Pino, S.A., D. Sola-Oriol, R. Davin, E. G. Manzanilla, and J. F. Pérez. 2015. Influence of dietary electrolyte balance on feed preference and growth performance of post weaned piglets. J. Anim. Sci. 2015. 93:2840-2848.

[5] Patience, J.F., R.E. Austic, and R.D. Boyd. 1987. Effect of dietary electrolyte balance on growth performance and acid-base status in swine J. Anim. Sci. 64: 457-466.

[6] Wondra, K.J., J.D. Hancock, K.C. Behnke, and R.H. Hines. 1995. Effect of dietary buffers on growth performance, nutrient digestibility, and stomach morphology in finishing pigs. J. Anim. Sci. 73: 414-420.

To formulate the experimental diets, a 13% CP corn-soybean meal diet was formulated to include a moderate level (0.23%) of L-lysine HCl with all other amino acids at or above minimum ratios relative to lysine. Dietary electrolyte balance in this diet was 107 mEq/kg. Then the CP was decreased to 10% by increasing the inclusion of crystalline amino acids resulting in a diet with a dEB of 48 mEq/kg. Again, all amino acids were at or above minimum ratios relative to lysine. To complete the factorial, calcium chloride was added (0.43%) to the 13% CP diet to lower dEB from 107 to 48 mEq/kg and sodium bicarbonate was added (0.51%) to the 10% CP diet to increase dEB from 48 to 107 mEq/kg (Table 1).

Pigs were weighed on d 0, 7, 14, and 20 of the trial to determine ADG, ADFI, and F/G. At d 19 of the trial, blood samples of 72 pigs (2 gilts per pen, 18 gilts per treatment) were collected and submitted to the Kansas State Veterinary Diagnostic Laboratory to determine blood urea nitrogen (mg/dl), Ca (mg/dl), Na (mmol/L), K (mmol/L), and Cl (mmol/L). Blood was collected from the jugular vein. Bleeding was started at 0700 and all pigs were bled within 60 min. Feed was not withheld before the bleeding period. For all blood analytes, the Roche Cobas c501 analyzer was used (Roche Diagnostics Corporation, Indianapolis, IN). The blood urea nitrogen (BUN) and Ca concentrations were determined photometrically and Na, K, and Cl electrical potential were measured by ion selective electrodes. At d 20, the pigs were individually tattooed with a unique ID number to allow carcass measurements to be recorded on a pig basis. On d 20, final pen weights and individual weights were taken, and pigs were transported to a commercial packing plant (Farmland Crete, NE) for processing and determination of HCW.

Diet samples were taken from 6 feeders per dietary treatment 3 d after the beginning and 3 d before the end of the experiment and stored at -4°F until they were homogenized, subsampled, and submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis of DM, CP, Ca, P, crude fat, and ash (Table 2).

Data were analyzed using the PROC GLIMMIX procedure in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit and initial BW as a blocking factor. Dietary treatments were the fixed effect and block served as the random effect in the analysis. Statistical significance was determined at $P < 0.05$ and tendencies at $P < 0.10$.

Results and Discussion

The analyzed DM, CP, Ca, P, fat, ash, and dEB contents of experimental diets were reasonably consistent with formulated estimates (Table 2).

For overall growth performance (d 0 to 20), pigs fed diets with 13% CP had increased ($P = 0.001$) ADG compared with pigs fed diets with 10% CP which resulted in a heavier ($P = 0.037$) final BW. Pigs fed the diets with 13% CP had improved ($P < 0.001$) F/G compared with pigs fed the 10% CP diets. A tendency for a CP × dEB interaction was observed for ADFI ($P = 0.081$) because intake was numerically reduced when dEB increased for the pigs fed 10% CP, whereas intake increased as dEB was increased for the pigs fed 13% CP. The grams of SID Lys intake per kilogram of gain were lower ($P < 0.001$) for pigs fed the diets with 13% CP in comparison with pigs fed the diets fed 10% CP. For both levels of CP, the grams of SID Lys intake were on the higher end of the NRC (2012) requirements estimates of 14.6 to 24.7 g per kilogram of gain for finishing pigs.

For carcass performance, pigs fed the diets with 13% CP had increased ($P = 0.001$) HCW ADG compared with pigs fed the 10% CP diets. Pigs fed the diets with 13% CP had improved ($P = 0.001$) HCW F/G compared with pigs fed the 10% CP diets. No main effects for either CP or dEB were observed for HCW and carcass yield.

For blood analytes, a CP × dEB interaction ($P = 0.029$) was observed for BUN. The interaction was similar to the interaction for ADFI with BUN numerically decreasing for pigs fed 10% CP as dEB was increased, while BUN increased as dEB increased for pigs fed 13% CP. Pigs fed the diets with 10% CP had increased ($P = 0.002$) Na compared with pigs fed diets with 13% CP. Pigs fed the diets with 48 mEq/kg of dEB had increased ($P = 0.048$) Cl compared with pigs fed diets with 107 mEq/kg of dEB.

In conclusion, reduced performance observed in pigs fed the low CP diets with higher supplemental crystalline AA was not influenced by dEB ranging from 48 to 107 mEq/kg. Dietary electrolyte balance had no effects on growth performance, HCW, yield, or carcass characteristics during late finishing. The reason for the low performance of pigs fed diets containing 10% CP is unknown, but does not appear to be related to dEB. Appropriate levels of dietary CP are critical to ensure optimal late finishing performance.

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

Crude protein, %:	10		13	
Ingredient, % dEB, mEq/kg:	48	107	48	107
Corn	92.64	91.82	82.77	83.00
Soybean meal, (46.5% CP)	3.29	3.35	12.51	12.49
Choice white grease	0.55	0.80	2.00	1.90
Monocalcium P, (21% P)	0.50	0.50	0.45	0.45
Limestone	1.35	1.35	0.98	1.30
Salt	0.35	0.35	0.35	0.35
L-Lys-HCl	0.51	0.51	0.23	0.23
DL-Met	0.08	0.08	0.03	0.03
L-Thr	0.19	0.19	0.06	0.06
L-Trp	0.06	0.06	0.01	0.01
L-Val	0.15	0.15	0.00	0.00
L-Ile	0.15	0.15	0.00	0.00
Trace mineral premix	0.10	0.10	0.10	0.10
Vitamin premix	0.08	0.08	0.08	0.08
Phytase[2]	0.02	0.02	0.02	0.02
Calcium chloride	0.00	0.00	0.43	0.00
Sodium bicarbonate	0.00	0.51	0.00	0.00
Total	100	100	100	100
Calculated analysis				
Standardized ileal digestible amino acids, %				
Lys	0.66	0.66	0.66	0.66
Ile:Lys	64	64	65	65
Leu:Lys	133	132	165	165
Met:Lys	36	36	34	34
Met and Cys:Lys	60	60	64	64
Thr:Lys	66	67	66	66
Trp:Lys	19	19	19	19
Val:Lys	75	75	76	76
SID Lys: NE, g/Mcal	2.51	2.51	2.51	2.51
NE, kcal/lb	1,191	1,191	1,191	1,191
CP, %	10.1	10.1	13.1	13.1
Ca, %	0.61	0.61	0.61	0.61
P, %	0.37	0.37	0.40	0.40
Available P, %	0.25	0.25	0.25	0.25
Standardized digestible P, %	0.28	0.28	0.29	0.29

[1]Diets were fed from d 0 to 20.
[2] Ronozyme Hiphos (GT) 2700 (DSM Nutritional Products, Inc, Parsippany, NJ). Provided 181.8 phytase units (FYT) per pound of diet and an estimated release of 0.10% available P.

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

Crude protein, %:	10		13	
Item dEB, mEq/kg:	48	107	48	107
DM, %	87.7	86.9	87.5	87.5
CP, %	9.8	9.2	11.9	12.6
Ca, %	0.60	0.75	0.63	0.63
P, %	0.42	0.42	0.41	0.42
Na, %	0.12	0.33	0.17	0.14
Cl, %	0.36	0.42	0.56	0.30
K, %	0.44	0.41	0.55	0.54
Ether extract, %	4.1	3.9	4.8	4.5
Ash, %	2.41	3.07	3.07	2.97
Analyzed dEB, mEq/kg[2]	63	114	57	130

[1]Multiple diet samples were collected from each diet throughout the study, homogenized, then subsampled for analysis at Ward Laboratories, Inc. (Kearney, NE).
[2]dEB, mEq/kg = (Na% × 434.98) + (K% × 255.74) - (Cl% × 282.06).

Table 3. Effects of dietary electrolyte balance and crude protein level on growth performance, carcass characteristics, and blood analytes of finishing pigs[1,2]

Crude protein, %:	10		13			Probability, *P* <		
dEB, mEq/Kg:	48	107	48	107	SEM	CP × dEB	CP	dEB
BW, lb								
d 0	243.6	243.5	243.5	243.5	1.26	0.178	0.699	0.247
d 20	274.1	273.3	275.5	277.5	1.57	0.291	0.037	0.657
BW CV, %								
d 0	8.25	8.75	8.57	8.84	0.650	0.858	0.758	0.554
d 20	8.13	7.81	8.41	8.10	0.647	0.997	0.657	0.628
D 0 to 20								
ADG, lb	1.58	1.56	1.69	1.78	0.046	0.236	0.001	0.442
ADFI, lb	6.24	6.12	6.06	6.38	0.138	0.083	0.730	0.451
F/G	3.96	3.93	3.60	3.57	0.087	0.948	<0.001	0.734
SID Lys, g/kg gain	26.1	25.9	23.7	23.7	0.57	0.967	<0.001	0.742
Carcass characteristics								
HCW, lb	209.9	209.7	210.1	212.1	1.45	0.420	0.329	0.511
Carcass yield, %	74.09	74.28	73.95	73.96	0.224	0.690	0.304	0.651
HCW CV, %	8.73	8.33	9.80	8.30	0.712	0.445	0.465	0.191
Carcass performance								
HCW ADG, lb	1.17	1.16	1.25	1.32	0.034	0.263	0.002	0.386
HCW F/G	5.34	5.29	4.86	4.84	0.119	0.898	<0.001	0.709
Blood analytes								
Na mmol/L	147.1	147.4	145.8	146.4	0.37	0.726	0.002	0.123
K mmol/L	5.2	5.1	5.0	5.0	0.11	0.754	0.190	0.613
Cl mmol/L	102.0	101.4	101.7	100.8	0.36	0.598	0.205	0.048
Ca mg/dL	11.3	11.4	11.2	11.3	0.09	0.883	0.212	0.174
BUN mg/dL	5.7	4.1	9.3	10.1	0.56	0.029	<0.001	0.488

[1]A total of 288 pigs (PIC 1050 × 327; initially 243.5 lb) were used in a 20-d experiment with 8 pigs per pen and 9 pens per treatment.
[2]Sodium bicarbonate was added to the diet with 10% CP to increase dEB to 107 mEq/kg. Calcium choloride was added to the diet with 13% CP to lower dEB to 48 mEq/kg.