The Effects of Wheat and Crystalline Amino Acids on Nursery and Finishing Pig Growth Performance and Carcass Characteristics[1]

D. L. Goehring, J. M. DeRouchey, M. D. Tokach, J. L. Nelssen, S. S. Dritz,[2] and R. D. Goodband

Summary

Two experiments were conducted to evaluate the effects of wheat and crystalline amino acids on growth performance of nursery and finishing pigs. In Exp. 1, a total of 192 pigs (PIC, 337 × 1050, initially 26.7 lb BW) were used in a 21-d nursery study. Pigs were allotted to pens by initial BW, and pens were assigned to 1 of 4 dietary treatments in a completely randomized design with 6 pigs per pen and 8 replications per treatment. Treatments included: (1) corn-soybean meal diet, (2) diet 1 with wheat replacing approximately 50% of the corn, (3) wheat replacing 100% of the corn in diet 1 with high amounts of crystalline amino acids, and (4) diet 3 with 5% more SBM and lower crystalline amino acids. Overall, (d 0 to 20), no growth performance differences were found when replacing 50% of corn with wheat ($P > 0.75$), but tendencies for reduced ADG (linear, $P < 0.08$) were observed when replacing 100% corn with wheat. Replacing 100% of corn with wheat improved (linear, $P < 0.05$) caloric efficiency on an ME basis and tended to improve (linear, $P < 0.07$) caloric efficiency on an NE basis. Adding more soybean meal to all wheat diets tended to improve ($P < 0.07$) F/G and improved ($P < 0.03$) caloric efficiency on an NE basis.

In Exp. 2, 288 pigs (PIC 327 × 1050, initially 159.5 lb BW) were used in a 61-d finishing study. Pens of pigs (8 or 7 pigs per pen) were randomly allotted by initial BW to 1 of 4 dietary treatments with 9 replications per treatment. Treatments were fed in two phases and were similar to Exp. 1 with: (1) corn-soybean meal diet, (2) diet 1 with wheat replacing approximately 50% of the corn, (3) wheat replacing 100% of the corn in diet 1 with high amounts of crystalline amino acids, and (4) diet 3 with soybean meal replacing a portion of the crystalline amino acids in diet 3. Overall (d 0 to 61), pigs fed increasing wheat had decreased ADG (linear, $P < 0.04$) and poorer F/G (linear, $P < 0.003$), which was primarily due to worsening of each when wheat was fed at 100% compared with 50% of the diet. Replacing corn with wheat tended to improve (linear, $P < 0.08$) caloric efficiency on an ME basis, but not on an NE basis. Adding more soybean meal to low amount of crystalline amino acids in wheat-based diets had no effect ($P > 0.32$) on growth performance.

A tendency for increased backfat ($P < 0.08$) was observed for pigs fed 50% wheat compared with 100% corn. Jowl fat iodine value (IV) decreased (linear, $P < 0.001$) with increasing wheat.

---

[1] Appreciation is expressed to Triumph Foods LLC (St. Joseph, MO) for collecting jowl fat and conducting the iodine value analysis and to Jerry Lehenbauer, David Donovan, Derek Petry, Ann Smith, and Brad Knadler for technical assistance.

[2] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University

In summary, wheat can be used to replace 50% of corn in finishing pig diets without negatively affecting growth performance; at the same time, pigs fed wheat-based diets had improved carcass fat IV. Use of high levels of crystalline amino acids in wheat-based diets did not influence growth performance of nursery or finishing pigs.

Key words: amino acids, finishing pig, nursery pig, wheat

Introduction

With near-record drought conditions in the Midwest causing increases in the price of corn and soybean meal, wheat has potential to become a more common ingredient in swine diets. Wheat is routinely used in diets in other countries. Wheat has higher standardized digestibility of certain amino acids, such as lysine and tryptophan, along with a higher CP and available P; however, due to low oil content, wheat is lower in dietary energy than corn. Wheat has an amino acid profile that allows for higher inclusion rates of crystalline amino acids than in corn-based diets; in fact, crystalline amino acids can be used to replace all of the soybean meal in late finishing diets. Little data with current genetics is available on the effects of these high inclusion rates of crystalline amino acids in wheat-based diets, so these experiments were conducted to determine the effects of replacing corn with wheat and the influence of crystalline amino acid levels in wheat diets on growth performance of nursery and finishing pigs.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in both experiment. The both studies were conducted at the K-State Swine Teaching and Research Center in Manhattan, KS. Wheat and corn samples used in both experiments were collected and submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis (Table 1).

In Exp. 1, a total of 192 pigs (PIC 327 × 1050, initially 26.7 lb) were used in a 21-d growth trial. Pigs were allotted to pens by initial BW, and pens were assigned to 1 of 4 dietary treatments in a completely randomized design with 6 pigs per pen and 8 replications per treatment. Dietary treatments included: (1) a corn-soybean meal diet, (2) diet 1 with wheat replacing approximately 50% of the corn, (3) wheat replacing 100% of the corn in diet 1 with high levels of crystalline amino acids, and (4) diet 3 with 5% more soybean meal and low crystalline amino acids (Table 2). Crystalline amino acids (lysine, threonine, and methionine) were added to the corn and wheat diets (diets 1 and 3) until another amino acid became limiting. Tryptophan was the fourth limiting amino acid in the corn-based diet, and valine was the fourth limiting amino acid in the wheat-based diet. Then, diet 2 was formed to have similar levels of corn and wheat in both diets. The soybean meal level was increased by 5% in diet 4 to reduce the level of crystalline amino acids. All diets were formulated to a constant standardized ileal digestible (SID) lysine level of 1.26% as required by diet 1 (highest-energy diet). Pig weight and feed disappearance were measured on d 0, 7, 14, and 21 of the trial to determine ADG, ADFI, and F/G. Each pen contained a 4-hole, dry self-feeder and a nipple water to provide ad libitum access to feed and water. Pens had wire-mesh floors and allowed approximately 3 ft^2/pig.

In Exp. 2, a total of 288 pigs (PIC 327 × 1050, initially 159.5 lb BW) were used in a 61-d growth trial. Pens of pigs (7 or 8 pigs per pen) were randomly allotted by initial BW to 1 of 4 dietary treatments with 9 replications per treatment. Dietary treatments were similar to Exp. 1 and included: (1) corn-soybean meal diet, (2) diet 1 with wheat replacing approximately 50% of the corn, (3) wheat replacing 100% of the corn in diet 1 with high amounts of crystalline amino acids, and (4) diet 3 with soybean meal replacing a portion of the crystalline amino acids. Diets were fed in 2 approximately 30-d phases from 150 to 210 lb and 210 to 280 lb (Table 3). All diets were formulated to a constant SID lysine level within phase. Diets were fed via the FeedPro system (Feedlogic Corp, Willmar MN). Pigs and feeders were weighed approximately every 2 wk to calculate ADG, ADFI, and F/G. On d 61, all pigs were individually weighed and tattooed for carcass data collection and transported to Triumph Foods LLC, St. Joseph, MO. Hot carcass weights were measured immediately after evisceration and each carcass was evaluated for percentage yield, backfat, loin depth, and percentage lean. Jowl fat samples were collected and analyzed by Near Infrared Spectroscopy at the plant for IV. Percentage yield was calculated by dividing HCW at the plant by live weight at the farm.

All diets were fed in meal form and prepared at the K-State Animal Science Feed Mill in Manhattan, KS. Feed samples were collected from all feeders during each phase and subsampled into composite samples of each treatment for each phase to measure bulk densities (Tables 2 and 3).

Data were analyzed as a completely randomized design using the PROC MIXED procedure (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. Linear and quadratic contrasts were used to determine the effects of wheat replacing 50 or 100% of the corn (Treatments 1, 2, and 3) and the effects of low vs. high amounts of crystalline amino acids in wheat diets (Treatments 3 vs. 4) and the corn diet compared with the 50% wheat replacement (Treatment 1 vs. 2). Analysis of backfat depth, loin depth, and percentage lean were adjusted to a common carcass weight using HCW as a covariate. Results were considered significant at $P \leq 0.05$ and considered a trend at $P \leq 0.10$.

Results and Discussion

The analyzed nutrient levels of the wheat and corn used in the experiment were similar to those used in diet formulation (Table 1). Adding increasing amounts of wheat to the diets increased the bulk densities of the diets in both experiments.

In Exp. 1, no differences ($P > 0.75$) in growth performance were observed for the overall trial (d 0 to 21) when replacing 50% of corn with wheat (Table 4). Tendencies were observed for reduced ADG (linear, $P < 0.08$) when replacing 100% of corn with wheat, because dietary energy decreased (Tables 3 and 4) with increasing wheat. Replacing 100% of corn with wheat improved (linear, $P < 0.05$) caloric efficiency on an ME basis and tended to improve (linear, $P < 0.07$) caloric efficiency on an NE basis. Adding more soybean meal to the wheat-based diets tended to improve ($P < 0.07$) F/G and improved ($P < 0.03$) caloric efficiency on an NE basis, indicating that either NE was underestimated in the diet containing extra soybean meal or the extra soybean meal increased the SID amino acids that come from the addition of soybean meal, such as valine or tryptophan, which were beneficial to the nursery pigs.

Overall (d 0 to 61) in Exp. 2, increasing levels of wheat decreased (linear, $P < 0.04$) ADG and worsened (linear, $P < 0.003$) F/G, which was caused by the decrease in dietary energy when increasing amounts of wheat were included (Table 5). Caloric efficiency tended to be improved (linear, $P < 0.08$) on an ME basis with increasing amounts of wheat, but not on an NE basis, suggesting that NE was a more appropriate measure of dietary energy. Adding soybean meal to the wheat-based diets to lower the levels of crystalline amino acids had no effect ($P > 0.32$) on growth performance.

A tendency was observed for pigs fed 50% wheat to have increased ($P < 0.08$) backfat depth compared with pigs fed the corn-based diet. Due to the low oil content in wheat, increasing wheat in the diet reduced (linear, $P < 0.001$) jowl fat IV. Differing levels of crystalline amino acids had no effect on carcass characteristics.

In summary, wheat can be used to replace 50% of corn in nursery or finishing swine rations without negatively affecting growth performance or carcass characteristics; however, growth rate and feed efficiency were worse when wheat completely replaced corn in the diet. These data also showed that adding maximum levels of crystalline amino acids (lysine, methionine, and threonine until the next limiting amino acid is reached) does not have a major influence on pig performance. Further investigation in nursery diets may be warranted due to the numerically poorer feed efficiency at the highest crystalline amino acid inclusion. Finally, feeding wheat lowers carcass fat IV compared with feeding corn, thus creating a more saturated fat that is more desired by processors.

Table 1. Chemical analysis of wheat (as-fed basis)

	Corn	Wheat	
Item	Exp. 1 and 2	Exp. 1	Exp. 2
Nutrient, %			
DM	88.01	89.1	89.2
CP	8.2 (8.5)[1]	12.3 (13.5)[1]	12.3 (13.5)
Fat (oil)	3.3 (3.9)	1.8 (2.0)	1.9 (2.0)
Crude fiber	1.7 (2.2)	2.6 (2.2)	2.5(2.2)
ADF	2.5	3.8	3.2
NDF	7.9	11.1	9.0
Ca	0.05 (0.03)	0.06 (0.06)	0.06 (0.06)
P	0.32 (0.28)	0.39 (0.37)	0.40 (0.37)

[1] Values in parentheses indicate those used in diet formulation.

Table 2. Diet composition in Exp. 1 (as-fed basis)

	Wheat replacement of corn, %:			
Ingredient, %	0	50	100	100 + SBM[1]
Corn	62.42	33.62	--	--
Soybean meal, 46.5% CP	32.08	29.16	25.45	30.46
Hard red winter wheat	--	33.70	70.80	66.30
Monocalcium P, 21% P	1.05	0.95	0.75	0.80
Limestone	1.00	1.05	1.15	1.08
Salt	0.35	0.35	0.35	0.35
Vitamin premix	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15
L-lysine HCl	0.33	0.39	0.475	0.318
DL-methionine	0.125	0.115	0.095	0.055
L-threonine	0.125	0.145	0.160	0.100
Phyzyme 600[2]	0.125	0.125	0.125	0.125
Total	100.0	100.0	100.0	100.0
Calculated analysis				
Standardized ileal digestible (SID) amino acids, %				
Lysine	1.26	1.26	1.26	1.26
Isoleucine:lysine	61	61	59	66
Leucine:lysine	129	120	109	119
Methionine:lysine	33	32	30	29
Met & Cys:lysine	58	58	58	58
Threonine:lysine	63	63	63	63
Tryptophan:lysine	17.5	18.5	19.4	21.2
Valine:lysine	68	68	66	73
Total lysine, %	1.39	1.39	1.38	1.39
ME, kcal/lb	1,503	1,472	1,435	1,442
NE, kcal/lb	1,074	1,053	1,029	1,021
SID lysine:ME, g/Mcal	3.80	3.88	3.98	3.96
CP, %	20.9	21.5	22.0	23.5
Crude fiber, %	2.7	2.6	2.6	2.6
ADF	3.5	3.9	4.2	4.3
NDF	9.0	10.4	11.8	11.7
Ca, %	0.70	0.70	0.70	0.70
P, %	0.62	0.62	0.60	0.62
Available P, %	0.42	0.42	0.42	0.42
Bulk density, lb/bu[3]	58.1	59.6	61.4	62.6

[1] SBM: soybean meal.
[2] Phyzyme 600 (Danisco, Animal Nutrition, St. Louis, MO), providing 231 phytase units (FTU)/lb, with a release of 0.10% available P.
[3] Diet samples collected from the top of each feeder during each phase.

Table 3. Diet composition in Exp. 2 (as-fed basis)

	Phase 1[1]				Phase 2[1]			
Wheat replacement of corn, %:	0	50	100	100 + SBM[2]	0	50	100	100 + SBM
Ingredient, %								
Corn	81.89	44.39	--	--	85.97	46.58	--	--
SMB, 46.5% CP	16.04	9.15	1.57	2.50	12.06	4.86	--	2.51
Hard red winter wheat	--	44.30	96.05	95.20	--	46.50	97.85	95.45
Monocalcium P, 21% P	0.24	0.06	--	--	0.21	0.03	--	--
Limestone	1.01	1.03	1.09	1.09	0.99	1.00	1.09	1.09
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix	0.10	0.10	0.10	0.10	0.08	0.08	0.08	0.08
Trace mineral premix	0.10	0.10	0.10	0.10	0.08	0.08	0.08	0.08
L-lysine HCl	0.150	0.330	0.525	0.496	0.150	0.338	0.446	0.368
DL-methionine	--	0.005	0.025	0.023	--	--	0.013	--
L-threonine	--	0.065	0.130	0.120	--	0.068	0.098	0.065
Phyzyme 600[3]	0.125	0.125	0.038	0.038	0.125	0.125	0.028	0.028
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis								
Standardized ileal digestible amino acids, %								
Lysine	0.72	0.72	0.72	0.72	0.62	0.62	0.62	0.62
Isoleucine:lysine	71	62	53	55	71	61	58	64
Methionine:lysine	31	29	29	29	33	30	30	30
Met & Cys:lysine	64	63	65	66	68	67	72	73
Threonine:lysine	63	63	63	63	65	65	65	65
Tryptophan:lysine	18.8	18.8	19.3	19.9	18.4	18.5	21.3	23.2
Valine:lysine	83	75	66	68	86	76	73	80
Total lysine, %	0.82	0.80	0.79	0.79	0.71	0.69	0.68	0.69
ME, kcal/lb	1,519	1,482	1,436	1,437	1,522	1,482	1,435	1,436
NE, kcal/lb	1,132	1,115	1,092	1,090	1,145	1,127	1,096	1,090
CP, %	14.6	14.4	14.3	14.6	13.1	12.9	13.7	14.5
Crude fiber, %	2.4	2.3	2.2	2.2	2.4	2.2	2.2	2.2
ADF	3.2	3.5	3.9	3.9	3.1	3.4	3.9	4.0
NDF	9.3	11.1	13.1	13.1	9.3	11.2	13.2	13.1
Ca, %	0.51	0.47	0.48	0.48	0.48	0.44	0.47	0.48
P, %	0.39	0.36	0.37	0.37	0.37	0.34	0.36	0.37
Available P, %	0.11	0.13	0.18	0.18	0.10	0.12	0.18	0.18
Bulk density, lb/bu[4]	56.0	59.6	62.7	62.2	56.0	59.9	62.4	64.0

[1] Phase 1 diets were fed from d 0 to d 30; Phase 2 from d 30 to 61.
[2] SBM: soybean meal.
[3] Phyzyme 600 (Danisco, Animal Nutrition, St. Louis, MO), providing 231 phytase units (FTU)/lb, with a release of 0.10% available P.
[4] Diet samples collected from the top of each feeder during each phase.

Table 4. Effects of wheat and crystalline amino acids on nursery pig performance[1]

	Wheat replacement of corn, %					Probability, $P<$			
						Wheat			
Item	0	50	100	100 + SBM[2]	SEM	Linear[3]	Quadratic[4]	0 vs. 50%	Extra SBM[5]
d 0 to 21									
ADG	1.21	1.22	1.15	1.19	0.021	0.08	0.16	0.75	0.23
ADFI	1.90	1.92	1.84	1.84	0.037	0.25	0.32	0.77	0.99
F/G	1.57	1.57	1.59	1.55	0.018	0.44	0.70	0.99	0.07
Caloric efficiency[6]									
ME	2,364	2,315	2,285	2,227	26.6	0.05	0.78	0.21	0.13
NE	1,689	1,656	1,639	1,577	19.0	0.07	0.75	0.24	0.03
Wt, lb									
d 0	26.7	26.7	26.7	26.7	2.7	0.99	0.99	0.99	0.98
d 21	52.1	52.3	50.9	51.7	4.1	0.24	0.36	0.84	0.42

[1] A total of 192 pigs (PIC 327 × 1050, initially 26.7 lb) were used in a 21-d study with 8 replications per treatment.
[2] SBM: soybean meal. Similar to diet with wheat replacing 100% of corn, except more SBM and lower crystalline amino acid levels were used.
[3] Comparison of 0%, 50%, and 100% with high amino acids.
[4] Comparison of 0%, 50%, and 100% with high amino acids.
[5] 100% vs. 100% + SBM.
[6] Caloric efficiency is expressed as kcal/lb gain.

Table 5. Effects of wheat and crystalline amino acids on finishing pig performance[1]

Item	Wheat replacement of corn, %					Probability, P<			
						Wheat			
	0	50	100	100 + SBM[2]	SEM	Linear[3]	Quadratic[4]	0 vs. 50%	Extra SBM[5]
d 0 to 61									
ADG	1.83	1.81	1.74	1.73	0.028	0.04	0.49	0.64	0.80
ADFI	5.96	5.97	5.89	5.83	0.086	0.56	0.69	0.94	0.61
F/G	3.26	3.30	3.39	3.37	0.029	0.003	0.50	0.32	0.73
Wt, lb									
d 0	159.2	159.5	159.5	159.8	1.89	0.91	0.83	0.90	0.98
d 61	270.9	270.1	265.8	266.1	3.14	0.95	0.29	0.86	0.68
Caloric efficiency[6]									
ME	4,954	4,884	4,850	4,837	40.4	0.08	0.72	0.23	0.82
NE	3,710	3,695	3,696	3,670	30.6	0.76	0.82	0.73	0.55
Carcass characteristics									
Carcass yield, %[7]	73.4	73.5	73.4	73.1	0.19	0.37	0.40	0.51	0.21
HCW, lb	201.9	202.0	198.1	197.4	2.34	0.82	0.18	0.98	0.42
Backfat depth, in.	0.78	0.83	0.83	0.82	0.020	0.15	0.25	0.08	0.78
Loin depth, in.	2.3	2.3	2.3	2.3	0.03	0.87	0.19	0.29	0.42
Lean, %	52.3	52.0	51.9	51.8	0.27	0.31	0.94	0.56	0.75
Jowl fat iodine value	68.9	67.7	67.1	67.4	0.24	0.001	0.35	0.002	0.27

[1] A total of pigs 288 (PIC 327 × 1050, initially 159.5 lb) were used in a 61-d study with 8 replications per treatment.
[2] SBM: soybean meal. Similar to diet with wheat replacing 100% of corn, except more SBM and lower crystalline amino acid levels were used.
[3] Comparison of 0%, 50%, and 100% with high amino acids.
[4] Comparison of 0%, 50%, and 100% with high amino acids.
[5] 100% vs. 100% + SBM.
[6] Caloric efficiency is expressed as kcal/lb gain.
[7] Percentage carcass yield was calculated by dividing HCW by the live weights obtained at the farm before transported to the packing plant.