Effects of Increasing Dietary Wheat Middlings on Nursery Pig Performance from 15 to 50 lb

J. A. De Jong, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, S. S. Dritz[1]*, and J. L. Nelssen*

Summary
A total of 210 pigs (PIC 327 × 1050, initially 15.12 lb BW) were used in a 35-d trial to evaluate the effects of increasing dietary wheat middlings (midds) on growth performance of 15- to 50-lb nursery pigs. Pens of pigs were balanced by initial BW and randomly allotted to 1 of 5 dietary treatments with 6 replications per treatment. The 5 corn-soybean meal–based diets contained 0, 5, 10, 15, or 20% midds. Pigs were fed in a 2-phase feeding program from d 0 to 14 and d 14 to 35. Diets were not balanced for energy; thus, as midds increased, dietary energy concentrations decreased.

From d 0 to 14, midds had no effect on growth performance; however, from d 14 to 35, pigs fed increasing midds had decreased ADG (linear, $P < 0.02$) and poorer F/G (linear, $P < 0.004$). Furthermore, pigs fed increasing midds had lower (linear, $P < 0.05$) feed cost/pig, revenue/pig, and income over feed cost (IOFC), and a tendency for increased (quadratic, $P < 0.07$) feed cost/lb gain. Overall (d 0 to 35), increasing dietary midds worsened F/G (quadratic, $P < 0.01$), driven by poorer F/G for pigs fed 15 and 20% midds. We also observed a quadratic effect ($P < 0.004$) for feed cost/lb gain, with inclusion rates of 0 and 20% having the highest value. Caloric efficiency responded in a quadratic manner ($P < 0.01$) on both an ME and NE basis with improved caloric efficiencies at intermediate levels (mainly 5%) of dietary middlings compared with 0 and 20% inclusions.

These data suggest that the inclusion of midds at levels up to 15% do not negatively affect performance in 15- to 50-lb nursery pigs. Although we observed a linear decrease in overall IOFC, both inclusion rates of 5 and 10% were numerically more profitable than the control.

Key words: growth, nursery pig, wheat middlings

Introduction
Wheat middlings are a wheat milling by-product that consist of fine particles of wheat bran, wheat shorts, wheat germ, and wheat flour; midds contain no more than 9.5% crude fiber (CF). With the sudden increase in the price of corn and soybean meal, wheat midds have become a more common ingredient in swine diets. Wheat midds have higher CP and CF but lower dietary energy than corn (corn ME = 1,551 kcal/lb; wheat middlings ME = 1,372 kcal/lb; NRC, 1998[2]), which must be accounted for when used in swine diets.

---

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

[2] NRC. 1998. Nutrient Requirements of Swine, 10th ed. Natl. Acad. Press, Washington DC.

Although extensive research has been conducted with midds and their effects on growing and finishing pigs[3], little data is available on its effects in corn-soybean meal–based early nursery diets. In a recent study with nursery pigs fed midds from 25 to 50 lb BW, midds had no effect on performance when included up to 15% of the diet. Thus, although the effects in mid-to-late nursery phases have been quantified, research needs to be completed with younger nursery pigs to determine if a similar response exists throughout all nursery phases.

The objective of this study was to determine the effects of increasing dietary wheat midds (0, 5, 10, 15, and 20%) on growth performance, caloric efficiency, and economics of nursery pigs from 15 to 50 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.

A total of 210 pigs (PIC 327 × 1050, initially 15.12 lb BW and 26 d of age) were used in a 35-d growth trial to determine the effects of dietary midds on pig growth performance, caloric efficiency, and economics. Pigs were allotted to pens by initial BW, and pens were assigned to treatments in a completely randomized design with 7 pigs per pen and 6 replications per treatment. The 5 treatment diets included 0, 5, 10, 15, or 20% midds (Tables 1 and 2). Diets were not balanced for energy, so as the level of midds increased, dietary ME decreased. The ME value for midds used in diet formulation was 1,372 kcal/lb (NRC, 1998), and the NE value was 1,850 (INRA, 2004[4]). All diets were formulated to a constant standardized ileal digestible lysine level to ensure changes in performance were due to dietary energy differences rather than differences in amino acid concentrations. Diets were fed in two phases, with Phase 1 from d 0 to 14 and Phase 2 from d 14 to 35. All diets were fed in meal form and were prepared at the K-State Animal Science Feed Mill.

Each pen contained a 4-hole, dry self-feeder and a nipple waterer to provide ad libitum access to feed and water. Pens had wire-mesh floors and allowed approximately 3 ft^2/pig. Pig weight and feed disappearance were measured on d 0, 7, 14, 21, 28, and 35 of the trial to determine ADG, ADFI, and F/G.

Wheat midds and complete diet samples were collected and submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis of DM, CP, ADF, NDF, CF, Ca, P, crude fat, and ash (Tables 3 and 4). Bulk density and particle size of the midds and complete diets were also measured. Caloric efficiencies of pens was determined on an ME and NE (INRA, 2004[5]) basis. Efficiencies were calculated by multiplying total intake by the energy level in the feed (kcal/lb) and dividing by total gain. Lastly, feed cost/pig, feed

[3] Barnes et al., Swine Day 2010, Report of Progress 1038, pp. 104–114.

[4] INRA (Institut National de la Recherche Agronomique). 2004. Tables of composition and nutritional value of feed materials, Sauvant, D., J-M. Perez and G. Tran, Eds. Wageningen Academic Publishers, The Netherlands and INRA, Paris, France.

[5] INRA (Institut National de la Recherche Agronomique). 2004. Tables of composition and nutritional value of feed materials, Sauvant, D., J-M. Perez and G. Tran, Eds. Wageningen Academic Publishers, The Netherlands and INRA, Paris, France.

cost/lb gain, revenue/pig, and IOFC were also calculated. Diet costs were determined with the following ingredient costs: corn = \$0.14/lb; soybean meal = 0.24/lb; midds = 0.12/lb; DDGS = 0.14/lb. Feed cost/pig was determined by total feed intake × cost/lb feed. Feed cost/lb gain was calculated using F/G × feed cost/lb. Revenue/pig was determined by total gain × \$0.65/lb live gain, and IOFC was calculated using revenue/pig – feed cost/pig.

Data were analyzed as a completely randomized design using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. Contrasts were used to compare linear and quadratic effects of increasing wheat midds. Statistics were considered significant at $P < 0.05$ and tendencies at $P > 0.05$ but < 0.10.

Results and Discussion

The chemical analysis of the midds (Table 3) revealed that CP, CF, Ca, and P were all slightly higher than the formulated values, whereas the fat content was slightly lower than formulated values. The analysis of the dietary treatments showed that fiber analysis of ADF, NDF, and CF increased as expected as dietary wheat midds increased in the diet (Table 4). Diet bulk density also decreased as midds inclusion levels increased as expected, but they decreased slightly for Phase 2 compared with Phase 1 diets in this experiment.

From d 0 to 14, midds level had no effect on growth performance (Table 5); however, from d 14 to 35, pigs fed increasing midds had decreased (linear, $P < 0.02$) ADG and worse (linear, $P < 0$ .004) F/G. Subsequently, pigs fed increasing midds had lower (linear, $P < 0.05$) feed cost/pig, revenue/pig, and IOFC but a tendency for increased (quadratic, $P < 0.07$) feed cost/lb gain (Table 6).

Overall, (d 0 to 35), as dietary midds increased, F/G became poorer (quadratic, $P < 0.01$). This effect was mainly attributed to a notable increase for pigs fed 20% midds. For caloric efficiency, the response was quadratic ($P < 0.01$) on an ME and NE basis as the level of midds increased in the diet. The quadratic response is supported by the worst caloric efficiencies observed for both ME and NE at 0 and 20% inclusion rates. A quadratic effect ($P < 0.004$) also occurred for feed cost/lb gain, with inclusion rates of 0 and 20% having the highest value. Notably, the highest numerical IOFC occurred at 5 and 10% midds inclusion rates.

These data support other recent data in that midds inclusion levels up to 15% do not affect nursery pig performance, even when not formulated to a constant energy level. More research is needed to further explain the lack of negative effect when feeding up to 15% midds in nursery diets. These data support the potential use of midds in diets for 15- to 50-lb nursery pigs to improve net returns.

Table 1. Phase 1 and 2 diet composition (as-fed basis)[1]

	Phase 1					Phase 2				
Item Wheat middlings, %:	0	5	10	15	20	0	5	10	15	20
Ingredient, %										
Corn	54.77	51.01	47.25	43.49	39.73	63.74	59.97	56.22	52.45	48.71
Soybean meal (46.5% CP)	29.32	28.09	26.86	25.63	24.40	32.79	31.56	30.33	29.10	27.87
Wheat middlings	---	5.00	10.00	15.00	20.00	---	5.00	10.00	15.00	20.00
Select menhaden fish meal	3.00	3.00	3.00	3.00	3.00	---	---	---	---	---
Spray-dried whey	10.00	10.00	10.00	10.00	10.00	---	---	---	---	---
Monocalcium phosphate (21% P)	0.650	0.575	0.500	0.425	0.350	1.050	1.000	0.900	0.825	0.750
Limestone	0.875	0.913	0.950	0.988	1.025	0.950	0.975	1.025	1.075	1.100
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
L-lysine HCl	0.25	0.27	0.29	0.31	0.33	0.33	0.35	0.37	0.39	0.41
DL-methionine	0.130	0.130	0.130	0.130	0.130	0.135	0.135	0.135	0.135	0.135
L-threonine	0.125	0.138	0.140	0.148	0.155	0.125	0.135	0.140	0.145	0.155
Phytase[2]	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Total	100	100	100	100	100	100	100	100	100	100

[1]Phase 1 diets were fed from d 0 to 14, and Phase 2 diets were fed from d 14 to 35.

[2] Phyzyme 600 (Danisco Animal Nutrition, St. Louis, MO) provided 340.5 phytase units (FTU)/lb, with a release of 0.12% available P.

Table 2. Phase 1 and 2 calculated nutrient profile (as-fed basis)[1]

		Phase 1					Phase 2				
Item	Wheat middlings, %:	0	5	10	15	20	0	5	10	15	20
Calculate analysis											
Standard ileal digestible (SID) amino acids, %											
Lysine		1.32	1.32	1.32	1.32	1.32	1.28	1.28	1.28	1.28	1.28
Isoleucine:lysine		62	62	61	60	60	61	61	60	59	59
Leucine:lysine		127	125	123	121	119	129	127	125	123	121
Methionine:lysine		34	34	34	34	34	34	34	33	33	33
Met & Cys:lysine		58	58	58	58	58	58	58	58	58	58
Threonine:lysine		65	65	65	65	65	63	63	63	63	63
Tryptophan:lysine		17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5
Valine:lysine		68	68	68	68	67	68	68	67	67	67
Total lysine, %		1.46	1.46	1.45	1.45	1.45	1.42	1.41	1.41	1.41	1.40
ME, kcal/lb		1,500	1,492	1,484	1,476	1,468	1,504	1,495	1,487	1,479	1,471
NE Nobet, kcal/lb		1,091	1,077	1,063	1,049	1,035	1,073	1,059	1,045	1,031	1,017
SID lysine:ME, g/Mcal		3.99	4.01	4.04	4.06	4.08	3.86	3.88	3.90	3.93	3.95
CP, %		21.8	21.7	21.6	21.6	21.5	21.2	21.1	21.0	20.9	20.9
Crude fiber, %		2.3	2.6	2.8	3.0	3.2	2.7	2.9	3.1	3.3	3.6
NDF, %		3.6	4.2	4.8	5.4	5.9	4.1	4.7	5.3	5.9	6.5
ADF, %		1.4	1.6	1.7	1.9	2.1	1.6	1.8	1.9	2.1	2.3
Ca, %		0.80	0.80	0.80	0.80	0.80	0.69	0.69	0.69	0.69	0.69
P, %		0.66	0.67	0.68	0.69	0.70	0.63	0.64	0.65	0.66	0.67
Available P, %		0.48	0.48	0.48	0.48	0.48	0.42	0.42	0.42	0.42	0.42

[1]Phase 1 diets were fed from d 0 to 14, and Phase 2 diets were fed from d 14 to 35.

Table 3. Chemical analysis of wheat middlings (as-fed basis)[1]

Item	Percentage
DM, %	91.37
CP, %	16.10 (15.90)
ADF, %	11.00
NDF, %	33.70
Crude fiber, %	8.50 (7.00)
NFE, %	57.00
Ca, %	0.15 (0.12)
P, %	1.12 (0.93)
Fat, %	3.90 (4.20)
Ash, %	5.50
Particle size, µ	532
Bulk density, lb/bu	22.26

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

Table 4. Chemical analysis of diets containing wheat middlings (as-fed basis)[1]

	Phase I					Phase II				
Item Wheat middlings, %:	0	5	10	15	20	0	5	10	15	20
DM, %	89.51	89.82	90.49	89.83	90.60	88.73	88.62	89.01	88.66	89.45
CP, %	22.20	21.30	22.00	24.00	20.90	21.40	20.90	21.10	21.30	21.10
ADF, %	3.10	3.20	4.10	4.70	4.10	3.30	4.10	5.00	5.10	5.60
NDF, %	6.70	8.00	9.10	11.40	11.20	7.60	9.10	14.10	11.90	14.00
Crude fiber, %	1.80	2.20	2.60	3.00	2.90	2.40	2.70	3.40	3.30	3.70
NFE, %	57.20	57.70	57.10	53.90	58.10	57.50	57.80	56.00	55.40	56.50
Ca, %	1.12	1.17	1.18	1.10	1.11	0.77	0.81	0.92	1.17	0.79
P, %	0.67	0.63	0.73	0.71	0.71	0.62	0.63	0.71	0.74	0.72
Fat, %	2.30	2.20	2.40	2.50	2.50	2.60	2.50	2.80	2.50	2.90
Ash, %	5.93	6.35	6.31	6.39	6.26	4.78	4.79	5.66	6.17	5.20
Bulk density lb/bu	62.59	59.48	55.74	52.15	50.24	58.03	54.12	49.77	48.79	46.66

[1] A composite sample consisting of 6 subsamples was used for analysis.

Table 5. The effects of increasing wheat middlings on nursery pig growth performance[1]

	Wheat middlings, %						Probability, $P<$	
Item	0	5	10	15	20	SEM	Linear	Quadratic
d 0 to 14								
ADG, lb	0.45	0.46	0.47	0.44	0.46	0.03	0.99	0.89
ADFI, lb	0.72	0.69	0.70	0.70	0.74	0.03	0.76	0.30
F/G	1.61	1.50	1.53	1.61	1.60	0.06	0.69	0.25
d 14 to 35								
ADG, lb	1.29	1.29	1.27	1.26	1.20	0.03	0.02	0.26
ADFI, lb	1.93	1.90	1.94	1.90	1.90	0.04	0.55	0.93
F/G	1.50	1.47	1.52	1.51	1.58	0.02	0.004	0.07
d 0 to 35								
ADG, lb	0.95	0.96	0.95	0.93	0.90	0.03	0.11	0.39
ADFI, lb	1.45	1.42	1.44	1.42	1.43	0.04	0.69	0.81
F/G	1.52	1.48	1.52	1.53	1.58	0.02	0.004	0.01
ME/G, kcal/lb	2,286	2,207	2,256	2,258	2,330	25.5	0.10	0.01
NE/G, kcal/lb	1,637	1,569	1,591	1,580	1,617	17.9	0.61	0.01
BW, lb								
d 0	15.13	15.13	15.11	15.10	15.11	0.13	0.88	0.93
d 14	21.45	21.61	21.69	21.28	21.57	0.48	0.93	0.90
d 35	48.52	48.70	48.43	47.64	46.91	0.90	0.15	0.49

[1] A total of 210 pigs (PIC 327 × 1050, initially 25.2 lb BW and 26 d of age) were used in a 35-d growth trial with 7 pigs per pen and 6 pens per treatment.

Table 6. Economics of increasing wheat middlings in nursery pig diets[1]

	Wheat middlings, %						Probability, *P*<	
Item	0	5	10	15	20	SEM	Linear	Quadratic
d 0 to 14								
Feed cost/pig, $	2.51	2.38	2.38	2.38	2.48	0.117	0.85	0.30
Feed cost/lb gain, $[2]	0.40	0.37	0.37	0.39	0.39	0.014	0.86	0.24
Total revenue/pig, $[3,4]	4.11	4.21	4.27	4.02	4.20	0.299	0.99	0.88
IOFC[5]	1.60	1.83	1.89	1.64	1.72	0.197	0.93	0.40
d 14 to 35								
Feed cost/pig,$	5.10	4.97	5.02	4.86	4.81	0.107	0.05	0.93
Feed cost/lb gain, $	0.19	0.18	0.19	0.18	0.19	0.002	0.19	0.07
Total revenue/pig, $	17.59	17.61	17.39	17.14	16.47	0.363	0.03	0.32
IOFC	12.49	12.64	12.37	12.28	11.66	0.285	0.03	0.22
d 0 to 35								
Feed cost/pig,$	7.62	7.35	7.40	7.24	7.29	0.205	0.25	0.58
Feed cost/lb gain, $	0.23	0.22	0.22	0.22	0.23	0.003	0.56	0.004
Total revenue/pig, $	21.70	21.82	21.66	21.16	20.67	0.578	0.15	0.48
IOFC	14.09	14.47	14.26	13.92	13.38	0.409	0.14	0.21

[1] A total of 210 pigs (PIC 327 × 1050, initially 25.2 lb BW and 26 d of age) were used in a 35-d growth trial with 7 pigs per pen and 6 pens per treatment.

[2] Feed cost/lb gain = feed cost/lb × F/G, assuming grinding = $5/ton, mixing = $3/ton, and delivery and handling = $7/ton.

[3] One pound of carcass gain was considered to be worth $0.65.

[4] Total revenue/pig = total gain/pig × $0.65.

[5] Income over feed cost = total revenue/pig – feed cost/pig.