MIX TIME AFFECTS DIET UNIFORMITY AND GROWTH PERFORMANCE OF NURSERY AND FINISHING PIGS

S. L. Traylor[1], J. D. Hancock, K. C. Behnke[1], C. R. Stark[1], and R. H. Hines

Summary

Two experiments were conducted to determine the effects of mix time on diet uniformity and growth performance of nursery and finishing pigs. For Exp. 1, 120 weanling pigs (average initial body wt of 12.1 lb) were used in a 27-d growth assay. The same Phase I diet (pelleted) was fed to all pigs for 7 d postweaning, then the pigs were switched to Phase II diet treatments for d 7 to 27. Treatments were mixing times of 0, .5, 2, and 4 min per 1,000 lb batch of complete feed in a double-ribbon mixer. From d 7 to 27, ADG increased by 49% and F/G was improved by 19% as mixing was increased from 0 to 4 min, with most of this effect realized with mixing for only .5 min (i.e., a CV for diet uniformity of 28%). For Exp. 2, 128 finishing pigs (average initial body wt of 124 lb) were fed to an average slaughter wt of 259 lb. All pigs were fed the same corn-soybean meal-based diet not mixed (0 min) or mixed for .5, 2, or 4 min per 1,000 lb batch of complete feed in a double-ribbon mixer. Increasing mix time (i.e., reducing the CV for diet uniformity from 54% to <10%) did not significantly affect ADG, ADFI, or F/G. However, pigs fed the 0 min treatment had, numerically, the poorest rates and efficiencies of gain. Dressing percentage, backfat thickness, and bone strength were not affected by the dietary treatments. In conclusion, the difference in degree of response to diet uniformity for nursery vs finishing pigs probably was due to reduced palatability resulting from uneven distribution of specialty ingredients in poorly mixed nursery diets (e.g., whey, blood meal, and crystalline amino acids). Also, the lower daily food intake of nursery pigs (1.5 lb/d) vs finishing pigs (6.4 lb/d) would decrease the likelihood of weanling pigs meeting their needs for some of the nutrients in a poorly mixed diet.

(Key Words: Mixing, Diet Uniformity, Growth, Bones, Nursery, Finishing.)

Introduction

Mixing is considered one of the most essential and critical operations of feed manufacturing whether on-farm or in a commercial feed manufacturing facility. Lack of diet uniformity can lead to reduced animal performance and the need for overfortification of limiting (often expensive) nutrients to protect against the possibility of deficiencies. Surprisingly, we could find only one report, and that addressed the issue of diet non-uniformity, that was for broiler chicks (McCoy et al., 1994, J. Poultry Science). Controlled research projects have not been reported that demonstrate if, or how much, a poorly mixed diet affects growth performance in pigs. Yet, a CV of <10% has been adopted as the industry standard to represent a uniformly mixed feed. Therefore, the objective of this project was to determine the effects of mix time on diet uniformity and growth performance of nursery and finishing pigs.

[1]Department of Grain Science and Industry.

Procedures

Four batches of test feed were made to establish the mix times necessary to produce the desired levels of diet uniformity for treatments used in the subsequent pig growth assays. Each batch was 1,000 lb, representing the full-load capacity for the double-ribbon mixer (Sprout Waldron, Model B-37, 37 rpm) that was used. A computerized feed batching system was used to weigh ground corn into the main ingredient scale that discharged into the center of the mixer. Salt (3 lb) was added by hand to the corn. After mixing, the corn-salt blend was discharged into a screw conveyor (4 ft long) and lifted by a bucket elevator (65 ft high) before being dropped (49 ft) into a sack-off bin and packaged in paper bags. Thus, some mixing occurred in the handling of the diets. Samples (.5 lb each) were taken from every other bag (10 samples total) during the bagging operation for diet uniformity analyses. Ten grams of each sample were assayed for salt (Quantab® analysis for chloride ion) concentration to allow calculation of a coefficient of variation for each batch. We determined that no mixing and .5, 2, and 4 min mix times would give a suitable spread in CVs (note that the mixer manufacturer suggested a mix time of 3 to 4 min for swine and poultry diets).

For the pig experiments, major (corn and soybean meal) and minor (salt, vitamin premix, trace mineral premix, monocalcium phosphate, and limestone) ingredients were weighed using the computerized batching system. Remaining ingredients (e.g., dried whey, spray-dried blood meal, and synthetic amino acids in the nursery diets) were hand weighed and added via a hopper positioned near the center of the mixer. The major ingredients were discharged from the main batching scale, and the minor ingredients were discharged from the micro ingredient system while the mixer motor was stopped. The ingredients were not mixed (0 min) or mixed for .5, 2, and 4 min for the nursery and finishing experiments; the mixer was stopped; and the discharge gate was opened. The feed was bagged through the same system used for the mixer evaluation; however, the feed was discharged by starting and stopping the mixer to allow packaging in a sequential manner.

For Exp. 1, 120 weanling pigs (average initial body wt of 12.1 lb) were used in a 27-d growth assay. The pigs were blocked by weight and allocated to pens based on sex and ancestry. There were five pigs per pen (three barrows and two gilts or two barrows and three gilts) and six pens per treatment. The pigs were fed the same Phase I diet from d 0 to 7 postweaning and switched to the Phase II treatments for d 7 to 27 (Table 1). The Phase I diet was formulated to 1.5% lysine, .4% methionine, .9% Ca, and .8% P, and fed in pelleted form. Phase II diets were formulated to 1.25% lysine, .3% methionine, .9% Ca, and .8% P and were fed in meal form. The pigs were housed in 4 ft × 5 ft pens with wire-mesh flooring. Each pen had a self-feeder and nipple waterer to allow ad libitum consumption of feed and water. Pigs and feeders were weighed on d 7 and 27 to allow calculation of ADG, ADFI, and F/G. Because there were multiple sources of salt (e.g., spray-dried blood meal, dried whey, and salt) in the Phase II treatments, chromic oxide was added to allow calculation of CVs for diet uniformity. Data were analyzed as a randomized complete block design with pen as the experimental unit.

For Exp. 2, 128 finishing pigs (average initial body wt of 124 lb) were blocked by weight and allocated to pens based on sex and ancestry. There were eight pigs per pen (four barrows and four gilts) and four pens per treatment. The diets were corn-soybean meal-based and formulated to .65% lysine, .65% Ca, and .55% P. No crystalline amino acids were used in the diets for finishing pigs. The pigs were housed in a modified open-front building, with 50% solid concrete and 50% concrete slat flooring. Each pen (6 ft × 16 ft) had a self-feeder and nipple waterer to allow ad libitum consumption of feed and water. Pigs and feeders were weighed at initiation and conclusion of the growth assay to allow calculation of ADG, ADFI, and F/G.

When pigs in a weight block reached an average body wt of 260 lb, the entire block was removed from the growth assay. Two blocks reached the end weight on d 74 and two blocks on d 81 of the experiment. The barrows were slaughtered at a commercial slaughter facility and hot carcass weights were recorded for calculation of dressing percentage. Last rib backfat thickness was measured with a ruler on both sides of the split carcass at the midline. Metacarpals from the right front foot were collected from each of the barrows for determination of bone breaking strength. These data were collected to determine if poorly mixed diets could result in soft bones because of inadequate mineral consumption. Data were analyzed as a randomized complete block design with pen as the experimental unit.

Results and Discussion

For the nursery experiment, increasing mix time from 0 to .5 min decreased the CV for chromium concentration from 106.5 to 28.4%. Diet uniformity improved further as mix time was increased, with a CV of 12.3% for the diet mixed for 4 min. Rate of gain increased markedly as mix time was increased from 0 to .5 min and continued to increase at a lower rate as mix time was increased further (quadratic and cubic effects, $P<.02$). Likewise, ADFI increased as mix time was increased from 0 to 4 min (1.32 lb/d vs 1.59 lb/d, respectively), but most of the response occurred as mix time was increased from 0 to only .5 min (quadratic and cubic effects, $P<.08$). Efficiency of gain improved (quadratic and cubic effects, $P<.03$) by 16% as mix time was increased from 0 min to .5 min and by 19% overall (i.e., as mix time was increased for 0 to 4 min). These data indicate that, although most of the growth improvement was achieved with a diet CV of 28.4%, nursery pigs need a CV of <12.3% to maximize growth performance.

For the finishing experiment, mix time had no statistically significant effects on growth performance or bone strength ($P>.13$). However, rate and efficiency of gain had numerical increases of 4% and 5%, respectively, as mix time was increased from 0 to .5 min. Carcass backfat thickness decreased as mix time was increased from 0 to .5 min but plateaued and began to increase as mix time was further increased to 4 min (quadratic and cubic effects, $P<.04$).

In conclusion, increased mix time improved diet uniformity and performance of nursery pigs. Finishing pigs were less sensitive to diet nonuniformity, with growth performance affected only slightly as mix time was increased from 0 to 4 min. The finishing pigs were quite tolerant of CVs to a least 15% and even up to 54%. Thus, our data suggest that feedmill throughput could be increased by reducing mix time of diets for finishing pigs. However, we must emphasize that some mixing occurred as the feed was moved through our feed plant, and that a simpler system (e.g., a grinder-mixer) with 0 min mix time could yield a CV considerably greater than 54%. Thus, it is the CV of the diet, and not the mix time per se, that is likely to determine growth performance. Also, caution should be taken when using a medicated feed article. According to the Good Manufacturing Practices set forth by the FDA, all feed manufacturers (commercial, on-farm, and integrated operations) must demonstrate the ability to produce uniform diets with the intended potency of any regulated feed additive. Finally, Kansas feed regulations stipulate that any feed or feed article for sale is considered adulterated if a representative sample fails to conform to the label guarantees. Nonetheless, under these experimental conditions, our data demonstrate acceptable growth performance at considerably greater CVs for diet uniformity than once deemed necessary.

Table 1. Diet Composition for Nursery and Finishing Pig Experiments

Ingredient	Nursery experiment Phase I[a]	Nursery experiment Phase II[b]	Finishing experiment[c]
	%		
Corn	37.11	58.75	83.18
Soybean meal (48% CP)	15.95	25.00	14.17
Spray-dried blood meal	2.50	2.50	--
Spray-dried porcine plasma	7.50	--	--
Dried whey	20.00	10.00	--
Lactose	10.00	--	--
Soybean oil	3.00	--	--
Monocalcium phosphate (21% P)	2.01	1.87	1.08
Limestone	.74	.99	1.02
Salt	--	.20	.30
Lysine-HCl	.10	.06	--
DL-methionine	.11	--	--
Chromic oxide	--	.15	--
KSU vitamin premix	.25	.25	.15
KSU trace mineral premix	.15	.15	.10
Copper sulfate	.08	.08	--
Antibiotic[d]	.50	--	--

[a]The Phase I diet was formulated to 1.5% lysine, .4% methionine, .9% Ca, and .8% P.
[b]Phase II diets were formulated to 1.25% lysine, .32% methionine, .9% Ca, and .8% P.
[c]Finishing diets were formulated to .7% lysine, .65% Ca, and .55% P.
[d]Provided 100 g/ton chlortetracycline, 100 g/ton sulfathiazole, and 50 g/ton penicillin.

Table 2. Effects of Mix Time on Diet Uniformity and Growth Performance of Nursery Pigs[a]

	Mix time, min					Probability value, P<		
Item	0	.5	2	4	CV	Linear	Quad	Cubic
CV for Cr, %[b]	106.5	28.4	16.1	12.3	N/A[c]	N/A	N/A	N/A
ADG, lb	.59	.83	.84	.88	12.0	.01	.02	.01
ADFI, lb	1.32	1.57	1.55	1.59	7.9	.01	.08	.02
F/G	2.24	1.89	1.85	1.81	9.1	.01	.03	.02

[a]A total of 120 weanling pigs with an average initial body wt of 12.1 lb (five pigs/pen and six pens/treatment).
[b]Coefficient of variation for Cr was determined from ten samples for each 1,000 lb of feed.
[c]Not applicable for mix analyses.

Table 3. Effects of Mix Time on Diet Uniformity and Growth Performance of Finishing Pigs[a]

	Mix time, min					Probability value, P<		
Item	0	.5	2	4	CV	Linear	Quad	Cubic
CV for salt, %[b]	53.8	14.8	12.5	9.6	N/A[c]	N/A	N/A	N/A
ADG, lb	1.71	1.78	1.75	1.73	3.7	--[d]	--	--
ADFI, lb	6.49	6.40	6.36	6.35	3.7	--	--	--
F/G	3.80	3.60	3.63	3.67	3.5	--	--	.13
Dressing percentage	73.7	73.3	73.1	73.0	.6	.04	--	--
Last rib fat thickness, in	1.20	1.09	1.14	1.18	3.3	--	.04	.01
Bone breaking strength, kg of peak force	230	236	239	218	16.9	--	--	--

[a]A total of 128 pigs with an average initial body wt of 124 lb (eight pigs/pen and four pens/treatment).
[b]Coefficient of variation for salt was determined from ten samples for each 1,000 lb of feed.
[c]Not applicable for mix analyses.
[d]Dashes indicate P>.15.