Growth Performance and Carcass Quality of Pigs Housed in Hoop Barns Fed Diets Containing Alternative Ingredients

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Abstract

Raising pigs in large groups in deep bedded hoop barns is receiving increased attention from producers and consumers interested in systems that are perceived to provide improved welfare for pigs. Unfortunately, these systems usually produce pigs that are fatter than similar pigs raised in conventional confinement housing systems. So, our objectives were to determine if dietary manipulation may be a useful tool for controlling increased carcass fat often observed in pigs raised in hoop barns and to assess the effect of housing and feeding system on pork quality. Specifically, we wanted to determine if a diet based on alternative grains (AG; barley, oats, buckwheat, field peas, and expeller soybean meal) would decrease carcass fatness and support growth performance of pigs housed in hoop barns (H) similar to pigs fed diets based on corn and soybean meal (CS) that were housed in an environmentally-controlled confinement barn (C). To achieve this objective, pigs (74 lb) were housed in pens in hoop barns (20 ft by 80 ft; 80 mixed sex pigs/pen) or in a confinement barn (10 ft by 15.5 ft; 15 mixed sex pigs/pen). Pigs housed in hoop barn were fed CS or isolysinic diets containing AG in a three-phase feeding program. Pigs housed in the confinement barn only received CS diets. Housing and dietary treatments were replicated over winter and summer seasons for a total of 4, 4, and 14 pens/treatment for HCS, HAG, and CCS treatments, respectively. Pigs were marketed individually when they reached 250 lb body weight. The housing and dietary treatments had similar effects on pigs regardless of the season in which the trial was conducted. Average daily gain (1.91, 1.94, 1.75 lb; MSE = .002) and feed/gain (2.97, 3.16, 3.51; MSE = .026) to the date when the first pigs were marketed for CCS, HCS, and HAG, respectively, were depressed ($P < .03$) by HAG compared with HCS while ADFI (5.69, 6.10, 6.13 lb; MSE = .08) was greater ($P < .05$) for HCS compared with CCS pigs. Last rib fat depth (.93, 1.02, .92 in; MSE = .002) was greatest ($P < .05$) for HCS pigs, while percentage carcass lean (54.42, 55.16, 55.48; MSE = .63) tended to be less ($P < .07$) in HCS vs CCS pigs. A trained sensory taste panel detected no differences in tenderness, juiciness, or overall desirability of pork loins (r = 20/treatment) collected from pigs harvested on the same day during the winter season. Inclusion of alternative grains in diets for pigs housed in hoop barns depressed growth performance and elicited minor improvements in carcass quality. Eating quality of pork was not influenced by housing system or inclusion of alternative grains in the diet.

Introduction

Raising pigs in deep bedded hoop barns is considered to be welfare-friendly by markets that are interested in such issues. Production of pigs in hoop barns is a fairly new approach for Midwestern pork producers. Consequently, there is very little replicated data comparing this system to standard confinement approaches to raising pigs. While hoop barns are inexpensive to build and operate compared to confinement barns, they require a large amount of bedding, and often do not support pig performance equal to confinement systems. Brumm et al. (1997) estimated that feed efficiency is .1 to .3 units worse and last rib backfat depth is .1 inches greater in pigs raised in hoop barns compared with similar pigs raised in confinement. Likewise, Penner et al. (2000) reported a lower percent lean for pigs raised in hoop barns compared to confinement-reared pigs. For the same set of pigs, efficiency of gain was poorer in winter but better in summer compared with pigs raised in confinement (Larson et al., 2000). Fatter carcasses may be the result of higher feed intakes of hoop-reared pigs compared to those in confinement (Brumm et al., 1997).

Effective management of pigs in hoop barns requires a large amount of bedding. Cropping systems that rely on small grains generate both bedding for use in hoop barns and grains that can be fed to pigs. Producers are interested in diversified farming systems that allow pork production and crop production to compliment each other. In addition, small grains generally are lower in energy and higher in fiber than corn (NRC, 1998). Lower energy grains may reduce fattening of finishing pigs raised in hoop barns.

Objectives

We had three objectives in this experiment. Our first objective was to determine the growth performance and carcass characteristics of finishing pigs fed a diet based on alternative ingredients and housed in hoop barns compared to typical confinement production. Secondly, we wanted to determine if dietary manipulations can reduce fat accumulation in finishing pigs fed in hoop barns. Finally, we wanted to estimate the economic performance of pigs housed in hoop barns compared with an environmentally-controlled confinement barn.

Materials and Methods

This experiment was conducted at the West Central Research and Outreach Center in Morris, MN. Two trials were conducted. The winter trial commenced on December 4, 2002 and ended on March 5, 2003. The summer trial began on April 30, 2003 and ended on August 27, 2003. For the winter trial, the University of Minnesota's Southern Research and Outreach Center in Waseca, MN provided mixed sex pigs produced by mating Duroc boars (Compart's Boar Store) to maternal-line sows (GAP, Manitoba, Canada). A PRRS outbreak at the Southern Research and Outreach Center in January, 2003 interrupted the flow of pigs. For the summer trial, maternal-line barrows (Genetiporc, USA) were provided by Coyote Ridge Farms in Platte, SD.

Eight hundred, forty eight pigs with an initial weight of 74 lbs were assigned to one of two housing systems. The confinement housing system was a mechanically-ventilated barn with deep (8 ft.) anaerobic manure pits located under totally slotted, concrete floors. Fifteen pigs were housed in each pen which measured 10 ft x 15.5 ft providing approximately 10 sq. ft. per pig. Each pen was equipped with one nipple waterer and one four-hole feeder manufactured by Smidley Co. Neither drip nor spray-cooling were provided for pigs in the confinement housing system. The hoop housing system consisted of two hoop barns measuring 40 ft. by 80 ft. Each barn was divided along the length of the barn to create two pens measuring 20 ft. by 80 ft. Each pen was equipped with one 12-hole, round feeder (Big O Sioux Feeder) and a four-hole, heated, water fountain manufactured by Smidley Co. The feeder and water fountain were located on a concrete floor that measured 20 ft. by 20 ft. The sleeping area had a packed clay floor that measured 20 ft. by 60 ft. The sleeping area was bedded with wheat straw as needed to provide a dry place for pigs to sleep. Eighty pigs were placed in each pen that provided approximately 19 sq. ft. per pig.

The experimental treatments were a combination of housing system and diet. Pigs housed in the confinement barn received a vitamin and mineral fortified diet (Table 1) based on corn and soybean meal (CCS). Pigs housed in each hoop barn received the corn-soybean meal diet (HCS) or isolysinic diets (Table 2) containing alternative grains (HAG). Alternative grains diets were manufactured and delivered to the research center by the Buckwheat Growers Association of Minnesota from their feedmill in Wadena, MN. Control diets were manufactured at the West Central Research and Outreach Center. A three-phase feeding program was used for all diets. Pigs were assigned randomly to housing system and diet within housing system.

Pigs remained on their assigned treatments from initiation of the experiment until market weight of 250 lb. Weight of feed placed in each feeder was recorded at the time of delivery. Pigs were weighed biweekly and weight of unconsumed feed in feeders was recorded. Average daily gain, average daily feed intake, and feed efficiency were calculated. Number of sick and dead pigs was recorded. In addition, labor required for feeding, pig care, bedding, building maintenance and miscellaneous activities were recorded on a barn basis. Labor required for manure removal was not recorded. There was no attempt to determine differential labor requirements for Control vs Alternative diets in the hoop barns. The amount of bedding provided to each pen in the hoop barns was recorded.

Pigs were marketed to Hormel Foods in Austin, MN when they reached a body weight of 250 $\pm$ 5 lb. Hot carcass weight, midline backfat depth at the 10th and last ribs, loineye area, and percent carcass lean were recorded for each pig. Whole, bone-in, loins from 20 pigs per treatment in the winter trial (60 loins in total) were selected randomly from pigs marketed on the same day for meat quality evaluation. Meat quality evaluations were conducted by Dr. Duane Wulf at the South Dakota State University Meats Laboratory. Loins were evaluated for pH, subjective and objective color score, marbling, purge loss, and tenderness. Furthermore, tenderness, juiciness, pork flavor, and overall desirability of loins were determined by a human taste panel.

Table 1. Composition and nutrient analysis of control diets

Ingredient	55-125# BW	126-190# BW	191-Mkt
		%	
Corn	67.4	77.10	81.725
Soybean meal 46%	28.95	20.0	15.75
Dicalcium phosphate	1.68	1.32	1.20
Limestone	1.08	.85	.78
Salt	.45	.35	.32
Vit./Min. premix	.25	.20	.18
L-lysine HCl	.1	.1	-.-
Tylan 40 g/lb	.05	.05	.025
Animal fat	.04	.03	.02
Total	100.00	100.00	100.00
Calculated analysis:			
ME, kcal/lb	1451	1461	1469
Crude protein, %	19.2	16.0	14.5
Lysine, %	1.10	.85	.65
Calcium, %	.87	.68	.62
Phosphorus, %	.68	.58	.55
Laboratory analysis:			
Crude protein, %	19.06	15.22	13.43
Lysine, %	1.14	.86	.64
Calcium, %	.87	.64	.52
Phosphorus, %	.55	.47	.40
ADF, %	2.64	2.41	3.15
NDF, %	7.06	7.57	7.99

Data were analyzed by least squares analysis of variance using the GLM procedure of SAS (SAS Institute, Cary, NC). The statistical model included the effects of treatment, season (winter or summer), and the interaction of treatment and season. Due to the extreme unbalanced nature of the data (14 pens for CCS; 4 pens for HCS; and 4 pens for HAG), heterogeneous variance was detected for many response variables. Square root transformation of raw data corrected the heterogeneous variance problems for some but not all of the response variables. Since the homogeneous variance assumption for analysis of variance was not satisfied in our data set, we used a nonparametric procedure based on Wilcoxon scores to determine the accuracy of probability levels derived from the GLM procedure. The NPAR1WAY procedure of SAS was used for nonparametric analysis. This procedure confirmed probability levels derived from the GLM procedure performed on square root transformed data. Mean separation was accomplished by non-orthogonal comparison of means for CCS to HCS and HCS to HAG using the Contrast procedure of SAS. All data are reported as least squares means.

Table 2. Composition and nutrient analysis of alternative grains diets

Ingredient	55-125# BW	126-190# BW	191-Mkt
		%	
Barley	37.0	48.5	52.5
Hulless oats	16.0	-.-	-.-
Oats	-.-	10.0	10.0
Buckwheat	-.-	5.0	10.0
Field peas	25.0	25.0	25.0
Expeller SBM 44%	18.5	9.0	-.-
Dicalcium phosphate	1.7	1.1	1.2
Limestone	1.1	.90	.80
Salt	.45	.325	.325
Vit./Min. premix	.25	.20	.18
Total	100.00	100.00	100.00
Calculated analysis:			
ME, kcal/lb	1349	1308	1300
Crude protein, %	20.3	16.4	13.5
Lysine, %	1.10	.85	.66
Calcium, %	.91	.68	.64
Phosphorus, %	.71	.59	.57
Laboratory analysis:			
Crude protein, %	19.50	15.40	13.74
Lysine, %	1.15	.89	.70
Calcium, %	.96	.64	.59
Phosphorus, %	.70	.55	.54
ADF, %	5.87	7.43	7.68
NDF, %	10.94	13.50	15.42

Results and Discussion

On July 3, 2003, a severe wind storm destroyed the cover on one hoop barn. Consequently, data collection for pigs in that barn was terminated. Pig performance data collected from pigs in that barn before the storm remained in the dataset. We observed no significant interactions between treatment and season for any response variable measured in this experiment. Lack of any interactions suggests that pigs responded similarly to the housing and dietary treatments in the summer and winter trials. Consequently, we will present data that has been summarized across both summer and winter trials. Other researchers (Honeyman et al., 2003) reported that efficiency of growth was more negatively influenced by hoop barns in winter than in summer.

Effects on growth performance

We marketed pigs when individual pigs reached about 250 lb of body weight. The variation in pig weight within pen measured by the coefficient of variation (CV) on the day the first pig was marketed was less ($P < .05$) for pigs in the confinement barn compared to HCS pigs (Table 3). This difference occurred even though there was no difference in CV at the start of the experiment. The greater uniformity of pigs in the confinement barn may result from a more constant environment provided to pigs or it may simply be a result of smaller group size in the confinement barn pens (15 head/pen) compared to the hoop barns (80 head/pen).

We marketed pigs over a period of four weeks to maximize the number of pigs that would achieve our target market weight of 250 lb. Performance data is expressed as performance for all pigs from the beginning of the study to the day the first pigs were marketed and performance to the day that the trial was ended. Daily weight gain to first marketing was similar for pigs housed in the hoop barns compared to the confinement barn (Table 3). However, pigs in the hoop barns fed corn-soybean meal diets consumed about 7% more feed ($P < .05$) than pigs in the confinement barn. Efficiency of gain was about 6% worse for pigs in the hoop barn compared to the confinement barn but this difference was not statistically significant. Feeding the alternative grains diet to pigs in the hoop barn reduced daily weight gain ($P < .05$) and required more feed per unit of gain ($P < .01$) compared to pigs fed the corn-soybean meal diet in the hoop barn.

No significant health problems were encountered for pigs assigned to any treatments. Mortality was less than 1.0% for all treatments. A total of 24, 40, and 52 pig-treatment days were recorded for CCS, HCS, and HAG treatments, respectively. A pig-treatment day is any day that a pig required any type of injection or other specialized health care. The proportion of pigs treated in the CCS, HCS, and HAG treatments was 2.85, 5.62, and 7.86%, respectively. These numerical differences were not statistically significant.

Effects on carcass traits

Carcass data was collected by Hormel Foods, Austin, MN on all pigs that achieved the desired market weight within the four-week marketing window. Only 62% of the HAG pigs achieved the desired market weight during the marketing period compared with 81% and 80% for CCS and HCS pigs, respectively (Table 4). The marketing period was dictated by the fastest growing pigs (CCS and HCS) so a relatively low proportion of the slower growing HAG pigs were ready for market at the beginning of the marketing period. If the marketing period was delayed about 10 days for the HAG pigs, a substantially greater proportion of the pigs would have achieved the desired market weight of 250 lb.

Pigs housed in the hoop barns fed the corn-soybean meal diet were fatter than pigs in the confinement barn. This was evident in the significant increase in backfat depth at the 10^{th} and last ribs and by the lower percent carcass lean. Feeding the alternative grains diet to pigs in the hoop barns reduced backfat depth ($P < .10$) and numerically increased percent carcass lean compared to HCS pigs. It is difficult to determine how much of this improvement in carcass leanness is due to the lower energy density of the alternative grains diet and how much can be attributed to the lighter carcasses ($P < .05$) produced by HAG pigs at slaughter.

Table 3. Effect of housing system and diet on growth performance of finishing pigs[a]

Trait	CCS	HCS	HAG	MSE
No. of pens	14	4	4	--
No. of pigs	210	320	318	--
Initial wt., lb[b]	75.6	71.4	71.2	8.80
CV for initial wt., %	10.4	11.8	12.4	3.88
Wt. at first marketing, lb[c,d,e]	233.8	237.4	222.0	12.46
CV for wt. at first marketing, %[b]	7.6	10.9	9.7	3.10
Avg. daily gain to (lb):				
First marketing[e]	1.91	1.94	1.75	.002
End of study	1.76	1.95	1.76	.013
Avg. daily feed intake to (lb):				
First marketing[b]	5.69	6.10	6.13	.080
End of study	5.72	6.22	6.41	.028
Feed:Gain to:				
First marketing[f]	2.97	3.16	3.51	.026
End of study[f]	3.06	3.24	3.73	.059

[a]CCS = confinement barn + corn-soybean meal diets; HCS = hoop barn + corn-soybean meal diets; HAG = hoop barn + alternative grains diets.
[b]CCS different than HCS, ($P < .05$).
[c]Observations decreased to 14, 3, and 3 due to storm. No. of pigs decreased to 210, 240, and 238.
[d]Initial weight used as a covariate.
[e]HCS different than HAG, ($P < .01$).
[f]HCS different than HAG, ($P < .05$).
[g]CCS different than HCS, ($P < .01$).

Twenty loins per treatment were collected from pigs harvested on the same day during the winter trial. Loins were subjected to objective laboratory measures of meat quality (pH, L* value, marbling, drip loss, cooking loss, shear force) and subjective measures of eating quality determined by a trained sensory taste panel of consumers. Pigs reared in confinement produced loins with more marbling ($P < .05$), lower drip loss ($P < .05$), and lower shear force values ($P < .01$) than similarly-fed pigs housed in hoop barns (Table 5). These data suggest that pigs raised in confinement might provide a more favorable eating experience for consumers compared with pigs housed in the hoop barns. Feeding the alternative grains diet in the hoop barn reduced ($P < .05$) pH, marbling, and shear force while increasing ($P < .01$) drip loss and darkness of color. Although there were significant differences in various objective measures of pork quality, these characteristics generally fell within ranges set by the National Pork Board for acceptable quality pork (National Pork Board, 1998).

Table 4. Effect of housing system and diet on carcass traits of finishing pigs[a]

Trait	CCS	HCS	HAG	MSE
No. of pens	14	3	3	--
No. of pigs	171	192	147	--
Market wt., lb	255.2	257.2	252.6	10.37
Hot carcass wt., lb[b]	187.8	189.0	182.7	6.30
Last rib fat depth, in[b,c,e]	.93	1.02	.92	.002
Tenth rib fat depth, in[d]	.99	1.09	.99	.004
Percent lean[f]	55.48	54.42	55.16	.63
Loineye area, sq. in.[c]	6.55	6.17	5.97	.034

[a]CCS = confinement barn + corn-soybean meal diets; HCS = hoop barn + corn-soybean meal diets; HAG = hoop barn + alternative grains diets.
[b]HCS different than HAG, ($P < .05$).
[c]CCS different than HCS, ($P < .01$).
[d]CCS different than HCS, ($P < .05$).
[e]HCS different than HAG, ($P < .10$).
[f]CCS different than HCS, ($P < .01$).

Despite differences in objective measures of pork quality, trained taste panelists could not discern any differences in quality of pork produced from any of the treatments in this experiment. There were not significant differences in tenderness, juiciness, pork flavor, or overall desirability among pork produced from the three treatments. Taste panelists could not detect any presence of off-flavors such as metallic, sour, bitter, rancid, livery, peanutty, burnt, stale, or bloody (data not shown). From these data, it appears that confinement or hoop barn systems as managed in this experiment have no effect on eating quality of pork.

Effects on labor and bedding needs

Labor required to care for pigs in the winter and summer trials is presented in Table 6. The labor and bedding use reported for the summer trial includes data from the one hoop barn that survived the wind storm on July 3rd. Labor requirements were divided into five categories. Health maintenance included treatment of sick or injured pigs. Management of pig comfort included bedding pens in hoop barns, cleaning feeders and waterers, and adjusting and cleaning fans and heaters. Feeding entailed time required to place feed in feeders. The requirement for recording weight of feed delivered to individual feeders necessitated that feeders be filled manually which inflated the labor requirements for feeding in this study relative to commercial conditions where automatic feed delivery systems are employed. Total labor required to care for pigs in the confinement barn was about 14 minutes/pig placed. About 6 minutes of this total labor were used to feed pigs. In the hoop barns, 8.5 minutes were required to care for each pig placed.

Table 5. Effect of housing system and diet on meat quality of finishing pigs raised during winter[a]

Trait	CCS	HCS	HAG	MSE
No. of loins	20	20	20	--
Ultimate pH[b]	5.69	5.66	5.58	.018
Subjective color score[b]	3.56	3.49	3.16	.011
Hunter L* value[b]	54.7	55.2	56.4	3.71
Marbling, %[c,d]	2.88	2.34	1.90	.044
Drip loss, %[b,d]	1.25	1.98	2.28	.715
Cooking loss, %	16.24	17.20	16.89	.189
Shear force, kg[c,e]	3.09	3.50	3.37	.188
Tenderness[f]	5.23	5.53	5.43	.518
Juiciness[f]	4.86	4.60	4.77	.442
Pork flavor[f]	5.01	4.86	4.90	.251
Desirability[f]	4.98	4.98	4.98	.465

[a]CCS = confinement barn + corn-soybean meal diets; HCS = hoop barn + corn-soybean meal diets; HAG = hoop barn + alternative grains diets.
[b]HCS different than HAG, ($P < .01$).
[c]HCS different than HAG, ($P < .05$).
[d]CCS different than HCS, ($P < .05$).
[e]CCS different than HCS, ($P < .01$).
[f]Subjective score determined by a human sensory taste panel.

Total straw bedding required per pig placed ranged from 334 lb for pigs in the winter to 215 lb for pigs during the summer trial. Brumm et al. (1997) estimated that 225-285 lb wheat straw would be required per pig during winter and 140-170 lb during summer. Honeyman et al. (2003) reported 269 lb of bedding were required per pig during winter and 203 lb were needed during summer in Iowa. Bedding use in our experiment was 5% higher than that reported by Honeyman et al. (2003) in summer and 25% higher in winter. The substantially greater bedding use during winter in our experiment might be a reflection of the harsher winters in Minnesota compared with Iowa.

Table 6. Labor (min.) and bedding (lb) required for pigs housed in confinement or hoop barns

	Winter trial[a]		Summer trial[a]	
Trait	Confinement	Hoop	Confinement	Hoop
No. of pigs	120	319	90	159
Total labor for[b]:				
Health maintenance	58	193	23	84
Mgt. of pig comfort	111	510	84	419
Feeding	699	653	577	413
Daily barn checks	560	1033	815	649
Misc.	0	7	0	0
Total labor used	1428	2396	1499	1565
Total labor/pig placed	11.9	7.5	16.7	9.8
Total bedding used	0	106,550	0	34,225
Bedding used/pig placed	0	334	0	215

[a]Winter trial = 12/4/02 to 3/5/03; summer trial = 4/30/03 to 8/27/03.
[b]See text for explanation of activities included in each category.

Summary

Knowledge of immediate benefit to pork producers.
1. Growth rate of pigs housed in hoop barns is similar to pigs housed in confinement barns.
2. Feed intake is 7% higher and efficiency of gain is 6% worse for pigs in hoop compared to confinement barns.
3. Feeding a relatively low energy diet based on small grains slows growth and marginally improves carcass leanness of pigs housed in hoop barns.
4. Neither housing system nor diet composition affected consumer acceptability of pork in this experiment.

Knowledge of future benefit to pork producers.
1. The reduced growth performance of pigs fed diets based on alternative grains suggests that producers need be very attentive to diet costs if this nutritional approach is to be economically viable.
2. Producers may evaluate total amount of labor and partitioning of labor to various activities in each housing system with an aim to improve labor efficiency in their current production system.

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