Nutritional Management for Efficient Swine Production

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INTRODUCTION

Today's health-conscious consumer challenges the swine industry to produce lean pork. The swine producer, the meat packer and the swine-related industries are faced with the task of producing and preparing an acceptable and economical product for the consumer while maintaining a profit.

Nutrition research with swine at North Dakota State University has been geared toward contributing information to the swine industry for improved efficiency of production. Efficiency of lean growth and lactation are the primary objectives of the swine nutrition research projects being conducted. This report summarizes some of the recent results and progress of various swine research projects.

RACTOPAMINE FOR FINISHING SWINE

Ractopamine is a new feed additive that is currently being tested to determine its effectiveness as a lean growth promoter for swine. Ractopamine belongs to a class of compounds called beta-adrenergic agonists which apparently repartition nutrients toward more lean tissue growth and less fat deposition. Ractopamine was developed by the Eli Lilly Co., Elanco Division and is currently under the scrutiny of the Food and Drug Administration.

A dose-titration study was conducted involving finishing swine raised from approximately 140 to 235 pounds and fed pelleted barley diets containing 0, 2.5, 5, 10, 20 and 30 ppm ractopamine. Each diet was fed to four pens of six pigs per pen. Growth rate, feed intake, feed efficiency and carcass lean and fat composition were determined.

Results of the effects of ractopamine on growth efficiency and carcass composition are presented in Table 1. Average daily gain was not affected by ractopamine, but there was a linear decline in average daily feed intake as dietary concentrations of ractopamine were increased. Feed efficiency improved in a quadratic fashion as dietary ractopamine was increased. Optimum feed efficiency was obtained at the 5 ppm ractopamine concentration. Tenth-rib backfat depth and carcass fat were reduced and tenth-rib loineye area and carcass lean were improved as dietary ractopamine increased ($P<.01$).

When or if ractopamine will be approved by FDA is not known at this time. The favorable response of swine to ractopamine suggests that the feed additive may offer an opportunity for swine producers to improve feed efficiency and lean production of pork.

PHASED FEEDING SCHEME FOR DEVELOPING GILTS

Animals undergoing compensatory growth exhibit greater body weight gain, improved feed efficiency, enhanced feed intake capacity, and changes in body tissue composition. Few experiments have attempted to determine how the body and various tissues function when the animal is in a state of compensatory growth. Previous research at this station has determined that dairy heifers reared under a phased feeding scheme of restricted, followed by compensatory growth had improved efficiency of growth and subsequent milk production (3). A better understanding of the mechanisms of compensatory growth may lead to the development of economical feeding strategies designed to take advantage of the improved growth efficiency associated with compensatory growth.

The objectives of this project were to determine if a phased feeding scheme would improve the overall efficiency of growth and lactation in gilts and to gain a better understanding of tissue and metabolic responses to compensatory growth. Only preliminary results of the growing and finishing phases of the experiment are presented in this report.

Eighty crossbred gilts averaging 46 pounds were subjected to either a conventional (C) or phased (P) feeding scheme designed to cause restricted (RG) followed by compensatory (CG) growth in a "stairstep" fashion during the growing (three weeks RG; three weeks CG) and finishing (five weeks RG; five weeks CG) phases of production. The RG and CG diets were formulated to provide 70 percent and 115 percent of the protein and metabolizable energy content of the conventional diets, respectively. All gilts were offered feed and water free choice. There were four pens per feeding scheme and 10 gilts initially assigned per pen. One pig per pen was slaughtered at each diet change for mammary, heart, liver, kidney, lung, and muscle tissue analysis. Blood samples were collected from four designated gilts/pen, one day before each diet change.

GROWING PHASE

Results of the performance and blood serum responses to the phased-feeding program are presented in Table 2. Dur-

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Table 1. Effects of Ractopamine on Growth Efficiency and Carcass Composition of Finishing Swine.

	Dietary Ractopamine, ppm					
Criterion	0	2.5	5	10	20	30
Gain, lbs/d	1.84	1.84	1.90	1.89	1.91	1.82
Feed Intake, lbs/d*	6.85	6.56	6.51	6.50	6.53	6.35
Feed to gain ratio**	3.73	3.57	3.42	3.45	3.44	3.50
10th-rib loineye area, sq. in***	5.64	5.51	5.68	5.93	6.00	6.19
10th-rib backfat depth, in.***	.95	.98	.95	.89	.87	.78
Carcass lean, %***	51.50	—	54.90	—	56.80	—
Carcass fat, %***	29.20	—	26.20	—	24.10	—

* Linear treatment effect (P< .10).
** Quadratic treatment effect (P< .10).
*** Linear treatment effect (P< .01).

Table 2. Performance and Blood Metabolites of Phase-fed Gilts

Time on Test (wks)	Growing Phase			Finishing Phase			Overall
	0-3	3-6	0-6	6-11	11-16	6-16	0-16
Diet[a]				Average daily gain, lbs			
C	1.09	1.27*	1.18+	1.63+	2.05+	1.84	1.59*
RG	1.01	—	—	1.48+	—	—	—
CG	—	1.70*	—	—	2.50+	—	—
P	—	—	1.35+	—	—	1.98	1.75*
				Average daily feed intake, lbs			
C	3.18	3.48	3.32	5.25*	6.89	6.00*	4.85+
RG	3.32	—	—	5.92*	—	—	—
CG	—	3.88	—	—	6.95	—	—
P	—	—	3.59	—	—	6.40*	5.19+
				Feed to grain ratio			
C	2.99	2.74*	2.84	3.23*	3.37+	3.27	3.04
RG	3.31	—	—	4.03*	—	—	—
CG	—	2.29*	—	—	2.80+	—	—
P	—	—	2.65	—	—	3.24	2.97
				Serum Urea-nitrogen, mg/dl			
C	16.45*	16.66*		14.30*	15.24		
RG	13.10*	—		9.92*	—		
CG	—	14.71*		—	15.76		
				Serum Glucose, mg/dl			
C	96.72*	87.44		98.75	90.18*		
RG	89.14*	—		96.00	—		
CG	—	84.66		—	98.63*		
				Serum Triglycerides, mg/dl			
C	63.04	66.84*		57.72+	37.87*		
RG	55.77	—		66.62+	—		
CG	—	78.79*		—	56.17*		
				Serum Protein, g/dl			
C	6.73	7.18		6.89	6.66		
RG	6.46	—		6.78	—		
CG	—	7.31		—	7.02		

[a] C = Control, RG = restricted-growth, CG = compensatory-growth, P = phase-fed gilts (RG-CG). Avg. initial and final wt. of the C and P gilts were 45.8, 46.4 and 225.5, 243.5 lbs, respectively.

* Means differ (P< .05); + = (P< .10).

ing the growing phase no differences in gain, feed intake and feed efficiency were detected between gilts fed the restricted-growth diet (RG) compared to the control diet (C). The restricted-growth diet reduced serum urea-nitrogen and glucose compared to the control diet. This response was expected since the gilts fed the RG diet consumed a lower amount of dietary protein and energy.

However, when fed the compensatory-growth diet (CG) gilts gained faster and were more efficient than the controls. Compensatory diets reduced serum urea-nitrogen and increased serum triglycerides. The reduced serum urea-nitrogen may reflect better utilization of the ingested dietary protein, since the protein intake was also higher for the CG gilts compared to controls. The higher serum triglycerides were anticipated because of the higher intake and level of fat in the CG diet. During the entire six-week growing period the phased-fed (P) gilts gained faster than the controls and tended to consume more feed and be more efficient.

FINISHING PHASE

Gilts fed the restricted-growth diet gained slower, consumed more feed and were less efficient than controls during the finishing phase. Restricted-growth diets reduced serum urea-nitrogen and increased serum triglycerides in finishing gilts (Table 2), but had no effect on serum glucose or protein. The reduced serum urea-nitrogen is likely a reflection of the lower intake of protein. The increase in triglycerides suggests an increase in the mobilization of body fat stores. The lack of change in serum glucose further suggest that body fat was being mobilized to meet the energy maintenance needs of the body (by maintaining glucose levels).

The compensatory-growth diet improved growth rate and feed efficiency of finishing gilts but did not influence feed intake (Table 2). An increase in serum glucose and triglycerides was detected for gilts fed the compensatory-growth diet, but no effect was observed in serum urea-nitrogen or protein. The increase in serum glucose and triglycerides most likely reflects a higher intake of dietary energy. During the finishing phase, the phase-fed gilts consumed more feed, gained slightly faster (nonsignificant) and were just as efficient as the controls. Over the entire growing-finishing period (Table 2), phased-fed gilts gained faster, consumed more feed, were equally efficient and weighed an average of 18 pounds heavier at the end of the experiment than conventionally-fed gilts.

The regulation of feed intake was expected to result in a "compensatory growth effect" as observed in our previous studies with dairy heifers (3) and rats (4). These effects included an improved efficiency of growth and nutrient utilization as well as changes in key metabolites. The overall response of the phase-fed gilts suggests that the main effect of restricted growth was a sparing effect on protein at the expense of body fat stores, while the compensatory growth effect was primarily related to increased nutrient intake.

At this writing the results of the effects of the phased feeding program on reproduction and mammary tissue development are incomplete. A second experiment has been initiated with similar objectives and experimental design with the exception that restricted growth will be regulated by limit-feeding of the control diet, instead of free choice intake of a low energy-low protein diet.

COMPUTER MODELING OF SWINE GROWTH

Feed represents approximately 60 percent of the cost of swine production. Efficiency of feed conversion markedly influences the financial success of a swine enterprise. Fixed costs of confinement systems have also increased and further emphasize the need for efficient, rapid growth of swine.

Advances in computer technology have enabled researchers to develop swine growth models to predict the cost and efficiency of various dietary inputs on swine production. A comprehensive growth model (6) encompassing nutrition, environment and economics has been developed at North Dakota State University in cooperation with researchers at other universities and the North Central Computer Institute at Madison, Wisconsin. The objective of the research reported here was to compare the model's predictions of swine growth responses to actual swine growth responses under measured environmental conditions.

Crossbed barrows or gilts averaging 106 pounds were fed corn-soybean meal based diets formulated to contain either 13, 14, 15 or 16 percent crude protein for 57 days. Six pigs were assigned per pen and two pens were assigned per treatment per sex group. Pig weights and feed consumption was recorded biweekly. Air temperature and humidity within the facility were recorded at hourly intervals throughout the 57 day period.

Average weekly temperature and humidity data, nutrient composition of diets, building dimensions, ventilation capabilities, insulation values, pig density per pen and sex of the animals were put into the computer model as determinants of growth, feed intake and feed efficiency. Predicted responses were compared (paired comparisons of difference between actual and predicted means using a T-test) to the actual performance on a biweekly basis.

Performance responses to dietary protein and the predicted responses are presented in Table 3. In general the model slightly underestimated the rate of gain and feed consumption of barrows and gilts fed the various dietary protein levels. Feed efficiency (gain to feed ratio) was similar between the actual and predicted responses.

The predicted responses to dietary protein for gain, feed intake and feed efficiency for barrows and gilts were reasonably comparable to the actual responses. For practical use, the model could be used to predict the potential economic value of feeding various protein levels if the pigs were to be fed in a thermoneutral environment. More data are needed on how the model would predict responses of pigs in temperatures outside the thermoneutral range. Also, more research is needed to determine the effects of disease on growth and feed efficiency.

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Table 3. Actual Versus Predicted Responses of Barrows and Gilts Fed Varying Levels of Dietary Protein.

	Protein Level, %				Protein Level, %			
Criterion	16	15	14	13	16	15	14	13
	Barrows				Gilts			
Gain, lbs/d	2.07	2.00	2.11	1.98	1.94	1.85	1.98	1.74
(Predicted)	1.92	1.94	1.92	1.83	1.87	1.87	1.81	1.70
Feed, lbs/d	7.31	7.09	7.36	6.74	5.97	5.53	6.23	5.75
(Predicted)	6.56	6.59	6.48	6.39	5.95	5.93	5.86	5.77
G/F ratio	.28	.28	.29	.29	.33	.33	.32	.30
(Predicted)	.29	.29	.30	.29	.31	.32	.31	.29

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