1972

Sixteenth Annual Swine Day

Animal Science Department
South Dakota State University

Sixteenth Annual

SWINE DAY

November 16, 1972

Department of Animal Science
Agricultural Experiment Station
South Dakota State University
Brookings, S. D. 57006

ACKNOWLEDGMENTS

Appreciation is expressed to the following firms who contributed to the swine research program this year through supplies or research grants.

American Cyanamid Company, Princeton, New Jersey
American Hoechst Corporation, Kansas City, Missouri
Calcium Carbonate Company, Quincy, Illinois
Clinton Corn Processing Company, Clinton, Iowa
Commercial Solvents Corporation, Terre Haute, Indiana
Elanco Products Company, Indianapolis, Indiana
Hoffmann-La Roche Inc., Nutley, New Jersey
Merck and Company, Inc., Rahway, New Jersey
Monsanto Commercial Products Company, St. Louis, Missouri
Chas. Pfizer and Company, Terre Haute, Indiana
Phelps Dodge Refining Corporation, New York, New York
Protein Plus Laboratories, Colfax, Illinois
Trojan Seed Corn Company, Olivia, Minnesota

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South Dakota State University
Brookings, South Dakota

Department of Animal Science
Agricultural Experiment Station

A.S. Series 72-29

Cooked and Raw Soybeans as Supplemental Protein Sources for Growing-Finishing Swine

R. C. Wahlstrom, G. W. Libal, J. F. Fredrikson and R. M. Luther

Research conducted at the Southeast South Dakota Experimental Farm during the winter of 1970-71 showed that properly cooked soybeans were an excellent source of supplemental protein in diets for growing-finishing swine. Raw soybeans are not utilized satisfactorily by the growing pig. However, there is some difference of opinion on the ability of the finishing pig to utilize the protein in raw soybeans.

The objective of the experiment reported herein was to evaluate the use of cooked and raw soybeans in diets for finishing swine.

Experimental Procedure

Seventy-two weanling pigs averaging approximately 44 lb. were divided into nine lots of eight pigs each. Each lot contained four barrows and four gilts.

Three replicate lots received each of the following dietary treatments:

1. Cooked soybean diet
2. Soybean meal diet
3. Soybean meal diet to 130 lb.; raw soybean diet 130 lb. to market weight.

Composition of the diets is shown in table 1. Diets were formulated to contain approximately 16% protein when fed to pigs up to a weight of 130 lb. and 13% protein from 130 lb. to market weight. The cooked soybeans were purchased locally and had been processed with an "on-the-farm cooker". The pigs were housed in a confinement type building. The experiment was conducted during the summer of 1971.

Forty-five pigs were removed from the experiment as they reached a weight of approximately 210 pounds. These pigs were slaughtered and carcass data obtained for carcass length, backfat, loin eye area and ham-loin percent. Because of the variation in weights, all pigs did not reach a 210 lb. weight by the time the experiment was terminated. This accounted for the smaller number of animals represented in the carcass data compared to the growth data.

Results

The growth performance data are summarized in table 2 and the carcass data in table 3.

During the first few weeks of this experiment the pigs fed the cooked soybean diet grew at a very subnormal rate. A sample of these cooked beans along with a sample of raw (uncooked) beans from the same source were submitted

to the South Dakota State University Station Biochemistry Department for determination of urease content. The urease enzyme is present in raw beans but is destroyed by cooking at high temperatures. The urease content of the cooked and raw soybeans was very similar, indicating that the cooked soybeans had not been subjected to a high enough temperature to destroy the urease and they were therefore no better than uncooked or raw beans. A new supply of cooked beans was obtained and incorporated in the diets for pigs in treatment 1 and a marked increase in gain was noted. Gains prior to the change in cooked soybeans averaged 0.70 lb. per day, while the pigs gained 1.71 lb. per day during the remainder of this period on the new source of cooked beans. However, the overall average as indicated in table 2 was 1.06 lb. per day for the growing period.

More feed was required per unit of gain when the pigs were fed the cooked soybean diet. It is assumed that the decreased feed efficiency when fed improperly cooked beans was associated with poor gain. Pigs fed the soybean meal diet had a feed/gain ratio of 2.55 (average) compared to 3.14 for pigs fed the cooked beans.

Feeding raw soybeans as the protein source in diets for pigs from a weight of 130 lb. caused a decrease in gains of 23 percent. Pigs fed the soybean meal diet gained 1.72 lb. daily while those changed to a diet containing raw soybeans gained 1.32 lb. per day. The average daily gain of pigs fed the cooked soybean diet during the finishing period was similar to that of pigs fed the soybean meal diet during this period. It should be pointed out, however, that the experiment was terminated before pigs fed the cooked soybean diet reached as heavy a weight as the pigs on the other treatments. Therefore, the faster gains made by these pigs during the finishing period were obtained over a shorter period of time and do not represent as much of the total gain.

Feed/gain was increased when the raw soybean diet was fed. These pigs required 4.17 lb. of feed per lb. of gain during the finishing period compared to 3.04 and 3.16 lb. for pigs fed cooked soybean or soybean meal diets, respectively.

There were no large differences in carcass characteristics. Carcasses from the pigs fed the cooked soybean diet did have slightly over 0.1 inch more backfat than pigs on the other diets. This trend has also been noted in our previous trials where carcasses from pigs fed cooked beans averaged about 0.1 inch more backfat.

Summary

This experiment indicated very clearly the importance of proper cooking of soybeans if they are to be used in swine diets. Soybeans should be brought to a temperature of at least 225° F, however, a temperature of 250° F as the bean leaves the cooker after 3 to 5 minutes cooking is recommended. Pigs fed improperly cooked soybeans will perform no better than those fed raw soybeans. It would appear that the poor average gains made during the growth period by pigs fed cooked soybeans in this experiment were due to improper cooking.

Older or heavier pigs will utilize raw soybeans better than younger pigs. However, in the experiment reported here, pigs fed raw soybeans after they weighed 130 lb. gained 23% slower and required 32% more feed per lb. of gain than pigs fed soybean meal as their protein source. There was little difference in performance of pigs fed cooked soybeans or soybean meal during the finishing period.

Backfat thickness was increased about 0.1 inch on carcasses from pigs fed cooked soybeans. Other carcass characteristics did not differ between treatments.

Table 1. Composition of Diets (Percent)

	Weaning to 130 lb.		130 lb. to market weight		
Treatment number	1	2 and 3	1	2	3
Ground yellow corn	72.2	76.5	82.7	85.0	82.7
Soybean meal (44%)	--	20.7	--	12.2	--
Cooked soybeans	25.0	--	14.5	--	--
Raw soybeans	--	--	--	--	14.5
Ground limestone	0.55	0.55	0.9	0.9	0.9
Dicalcium phosphate	1.5	1.5	1.15	1.15	1.15
Trace mineral salt (1% zinc)	0.5	0.5	0.5	0.5	0.5
Vitamin-antibiotic[a]	0.25	0.25	0.25	0.25	0.25

[a] Provided per lb. of ration: 1,500 I.U. vitamin A, 150 I.U. vitamin D, 1 mg. riboflavin, 2.5 mg. calcium pantothenate, 7.5 mg. niacin, 50 mg. choline, 5 mcg. vitamin B_{12} and 5 mg. oxytetracycline.

Table 2. Growth Performance of Pigs Fed Cooked or Raw Soybeans

Treatment	Cooked soybeans	Soybean meal	Soybean meal changed to raw soybeans at 130 lb.
No. of pigs[a]	23	24	23
Avg. initial wt., lb.	44.5	44.4	44.5
Avg. final wt., lb.	184.1	207.1	207.9
Avg. daily gain, lb.			
To 130 lb.	1.06	1.64	1.56
After 130 lb.	1.67	1.72	1.32
Avg. for experiment	1.19	1.66	1.42
Avg. feed cons./day, lb.			
To 130 lb.	3.28	4.19	3.96
After 130 lb.	5.19	5.40	4.47
Avg. for experiment	3.53	4.69	4.19
Feed/gain, lb.			
To 130 lb.	3.14	2.56	2.54
After 130 lb.	3.04	3.16	4.17
Avg. for experiment	3.11	2.82	3.12

[a] Three replicates of 8 pigs each per treatment. Two pigs died and data were not included.

Table 3. Carcass Data of Pigs Fed Cooked or Raw Soybeans

Treatment	Cooked soybeans	Soybean meal	Soybean meal changed to raw soybeans at 130 lb.
No. of carcasses	12	15	18
Avg. length, in.	30.5	30.0	31.2
Avg. backfat, in.	1.40	1.29	1.27
Avg. loin eye area, sq. in.	4.0	4.4	4.3
Avg. percent ham and loin	39.07	39.80	39.54

South Dakota State University
Brookings, South Dakota
Department of Animal Science
Agricultural Experiment Station

A.S. Series 72-30

Oats as a Ration for Gestating Sows and Gilts

Richard C. Wahlstrom, George W. Libal and Lawrence R. Dunn

Research conducted the past several years on the nutritional needs of gilts and sows during gestation has resulted in a change from free-choice to limited feeding of brood sows. Limiting feed intake also reduces the total intake of other nutrients. Recent research conducted at Cornell, Illinois and Minnesota using corn as the only source of protein for gestating gilts has shown little effect on litter size or pig weights, but pigs from sows receiving all of their protein from corn gained less from birth to 21 days.

Oats is higher in protein content than corn and often available to South Dakota swine producers. The results of the trials using corn as the only protein source in gestation rations suggested that oat rations should also be investigated. The trial reported here was designed with the objective to evaluate an oat ration supplemented with minerals for gestating gilts and sows.

Experimental Procedure

Fifteen gilts and 17 sows that had been bred for an average of 25 days were randomly assigned from groups of similar age, breeding and servicing sire to two treatments of 16 animals. There were 7 gilts and 9 sows in treatment 1 and 8 gilts and 8 sows in treatment 2. Sows and gilts were kept in separate dirt lots with access to a portable house with a wooden floor.

Diets were fed in individual feeding stalls. The composition of the diets is shown in table 1. The basal diet was composed of corn, alfalfa meal, soybean meal and minerals and was fed at a level of 4.5 lb. per head daily. The oat-mineral diet was fed at 5.25 lb. daily. When fed at these levels, the diets supplied approximately equal daily amounts of protein (280 grams) and metabolizable energy (6030 Kcal). Neither diet was supplemented with vitamins.

On the 110th day of gestation animals were brought into the farrowing house. The same lactation diet was fed to all animals. Pigs were weighed at birth, 7, 14 and 21 days.

Results

A summary of the data obtained in this experiment is shown in table 2. One gilt and one sow on each treatment failed to conceive. Therefore, the results are based on 14 animals fed each diet. Although the oat diet was fed at a higher level to equalize energy intake, both gilts and sows gained less during gestation when fed the oat diet. The sows actually lost an average of 7 lb. the first 57 days they were fed the oat diet and had only a 9 lb. gain for the gestation period from 25 to 110 days.

Production performance was satisfactory and was not affected by the diets fed. Live pigs farrowed per litter were higher for sows fed the basal diet and for gilts fed the oat diet. However, these differences were not significant.

Birth and weaning weights varied with litter size. Both birth and weaning weights decreased as litter size increased.

Sows farrowed more live pigs and heavier pigs than gilts. They also weaned slightly more pigs with heavier weaning weights. However, gilts weaned about 88% of their pigs compared to only 78% for sows.

The results of this experiment would indicate that both gilts and sows could be fed an oat-mineral diet from approximately the 25th day of gestation without affecting production performance. The oat diet would be deficient in certain amino acids, especially lysine. Other research has indicated that the protein level is critical during the first 3 weeks of gestation and also during the last month of gestation. It is also possible that feeding this diet during successive gestation periods could affect production performance. Additional research will be necessary to obtain the information necessary to answer these questions.

Summary

Thirty-one crossbred gilts and sows were assigned to two dietary treatments at approximately the 25th day of gestation. Gilts and sows gained more weight during gestation when fed 4.5 lb. daily of a corn-soybean meal-alfalfa meal-mineral diet than when fed 5.25 lb. of an oat-mineral diet. The diets supplied approximately equal amounts of protein and energy when fed at these levels. Live pigs farrowed, pig birth weight, weaning weight and livability of pigs were not affected by dietary treatment.

Table 1. Percentage Composition of Diets

	Basal	Oats
Ground yellow corn	73.6	--
Ground oats	10.0	97.0
Dehydrated alfalfa meal (17%)	13.5	--
Soybean meal (44%)	--	--
Dicalcium phosphate	2.0	1.8
Limestone	0.4	0.7
Trace mineral salt	0.5	0.5

Table 2. Performance of Sows Fed Oats During Gestation

	Sows		Gilts		Combined	
	Oats	Basal	Oats	Basal	Oats	Basal
Initial wt., lb.	429	428	313	317	371	381
Gestation wt. gain, lb.						
25 to 82 days	-7.3	27.3	41.3	49.0	17.0	36.5
25 to 110 days	9.4	46.1	55.1	70.0	32.3	56.2
Wt. loss farrowing, lb.	57.6	66.0	30.1	21.0	43.9	45.2
Lactation wt. gain, lb.	33.4	27.0	7.6	3.3	18.3	14.1
No. pigs born alive	10.7	11.8	9.6	9.2	10.1	10.6
No. stillborn	0.3	0.4	0	0	0.1	0.2
Avg. birth wt., lb.	3.1	2.9	2.6	2.7	2.9	2.8
No. pigs weaned (21 days)	8.4	9.2	8.6	8.0	8.5	8.5
Percent weaned	78.5	78.0	89.6	87.0	84.2	80.2
Weaning wt., lb.	11.3	9.8	9.9	10.1	10.5	10.0

South Dakota State University
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Department of Animal Science
Agricultural Experiment Station

A.S. Series 72-31

Effect of Flavomycin on Performance of Growing-Finishing Pigs

Richard C. Wahlstrom and George W. Libal

Antibiotics have been used widely in swine rations at low levels to increase rate of gain and improve feed efficiency for the past two decades. The future of antibiotics as feed additives for swine is uncertain following the recent report of the Food and Drug Administration Task Force that recommended antimicrobial agents used in human clinical medicine be prohibited from growth promotion use in animals by December 31, 1973.

Flavomycin is a new antibiotic that is intended for use only in animal nutrition. It is nonabsorbable and therefore does not leave residues in meat. It also has been reported to be effective at levels much lower than those generally used in swine feeding. The objective of this experiment was to study the efficacy of flavomycin in diets for growing-finishing swine when fed at approximately 10% of the levels used for other antibiotics.

Experimental Procedure

Seventy-two crossbred pigs were allotted to three replicates of four treatments on the basis of litter, sex and weight. Each lot of 6 pigs averaged approximately 41 lb. initially and was removed from the experiment at an average lot weight of approximately 200 pounds. Pigs were housed in concrete floored pens bedded with straw and had access to an outside concrete area where self-feeders were located.

The experimental treatments were as follows:

1. No antibiotic
2. Flavomycin 1 mg./kg. (0.9 grams/ton)
3. Flavomycin 2 mg./kg. (1.8 grams/ton)
4. Chlortetracycline 22 mg./kg. (20 grams/ton)

The composition of the basal diet is shown in table 1. The diet was calculated to contain 16% protein until the pigs weighed 125 lb. and 13% protein from 125 to 200 pounds.

Results

Performance data for this experiment are shown in table 2. Growth performance was very good in all treatments during the growing phase from 41 to 125 pounds. All treatments gained about 1.8 lb. per day. Feed efficiency differed significantly ($P < .05$) between treatments during this growing phase. Requiring the least feed/gain (2.47) were pigs fed 1 mg./kg. of flavomycin and the most feed/gain (2.69) was required by pigs fed chlortetracycline. Barrows gained significantly ($P < .025$) faster than gilts up to 125 lb. weights.

Pigs fed 2 mg./kg. of flavomycin or chlortetracycline gained about 0.1 lb. per day faster than the control or pigs fed 1 mg./kg. of flavomycin during the finishing phase. These increases in gains were associated with increased feed consumption as feed efficiency was similar between treatments. The results are somewhat contradictory to earlier reports which indicated the greatest response to antibiotics was during the early growing period. The reason for this difference in response is not clear.

There were no significant differences in daily gains, feed consumption or feed efficiency for the overall experiment. Pigs fed 1 mg./kg. flavomycin, 2 mg./kg. flavomycin or chlortetracycline gained approximately 1, 3 and 5% faster, respectively, than pigs fed the control (no antibiotic) diet.

Summary

Seventy-two weanling pigs were used in an experiment to study the effect of feeding 1 or 2 mg./kg. of flavomycin and 22 mg./kg. of chlortetracycline. All groups of pigs had quite satisfactory growth performance. There was a significant difference in feed efficiency between treatments during the growing phase. Pigs fed the higher level of flavomycin or chlortetracycline grew slightly faster during the finishing period.

Table 1. Composition of Basal Diet (Percent)

	To 125 lb.	125 to 200 lb.
Ground yellow corn	76.2	85.2
Soybean meal (44%)	21.0	12.4
Dicalcium phosphate	1.7	1.3
Ground limestone	0.5	0.5
Trace mineral salt (0.8% zinc)	0.5	0.5
Vitamin premix[a]	0.1	0.1

[a] Provided 1500 I.U. vitamin A, 200 I.U. vitamin D, 125 mg. riboflavin, 5 mg. calcium pantothenate, 10 mg. niacin, 50 mg. choline and 7.5 mcg. vitamin B_{12} per lb. of diet.

Table 2. Performance of Growing-Finishing Pigs Fed Flavomycin or Chlortetracylcine

	Control	Flavomycin 1 mg./kg.	Flavomycin 2 mg./kg.	Chlortetracylcine 22 mg./kg.
No. of pigs[a]	18	18	18	17[b]
Growing phase				
Avg. daily gain, lb.	1.78	1.80	1.82	1.79
Avg. daily feed, lb.	4.64	4.49	4.58	4.91
Feed/gain*	2.58	2.47	2.55	2.69
Finishing phase				
Avg. daily gain, lb.	1.75	1.76	1.89	1.85
Avg. daily feed, lb.	7.17	7.08	7.65	7.75
Feed/gain	4.05	3.96	4.05	4.08
Growing and finishing				
Avg. daily gain, lb.	1.76	1.78	1.85	1.82
Avg. daily feed, lb.	5.78	5.70	5.98	6.17
Feed/gain	3.23	3.15	3.24	3.32

[a] Avg. initial wt., 41 lb.; avg. final wt., 198 lb.
[b] One pig died during finishing phase, data included for growing phase only.
* P <.05.

South Dakota State University
Brookings, South Dakota

Department of Animal Science
Agricultural Experiment Station

A.S. Series 72-32

Effect of Copper Fed at Different Levels and for Different Lengths of Time to Growing-Finishing Pigs

Richard C. Wahlstrom, George W. Libal, Lawrence R. Dunn and Royce J. Emerick

Previous work at the South Dakota station reported in A.S. Series 71-33 has shown that pigs fed 250 parts per million (ppm) copper in the diet have an increased rate of gain with the greatest response occurring during the early growth period. Liver copper stores are elevated by feeding 250 ppm of copper. The experiment reported herein was designed to study the effectiveness of various levels of dietary copper as well as to determine the carry-over effect of copper treatments administered only during an initial 8-week treatment period. The antibiotic tylosin was included as one treatment to aid in evaluating the copper effect.

Experimental Procedure

Ninety-six crossbred pigs averaging about 41 lb. were randomly allotted to three replications of eight treatments on the basis of litter, weight and sex. Each lot consisted of four pigs, three barrows and one gilt, having access to a 6 x 8 foot concrete floored pen with a connecting 8 x 12 foot outside lot where self-feeders and waterers were located.

The eight dietary treatments were as follows:

1. Basal diet (no copper)
2. Basal diet plus 125 ppm copper to market weight
3. Basal diet plus 125 ppm copper for 8 weeks, basal diet to market weight
4. Basal diet plus 187.5 ppm copper to market weight
5. Basal diet plus 187.5 ppm copper for 8 weeks, basal diet to market weight
6. Basal diet plus 250 ppm copper to market weight
7. Basal diet plus 250 ppm copper for 8 weeks, basal diet to market weight
8. Basal diet plus 20 grams of tylosin per ton to market weight

The composition of the basal diet is shown in table 1.

The pigs were removed from their respective treatments at individual weights of approximately 210 lb. after 100 to 110 days on experiment. They were withheld from feed but allowed water for the 24 hours previous to slaughter. Liver samples were obtained at slaughter and frozen for later analysis of copper. Backfat samples were obtained from the shoulder area for determination of iodine number. After a 24-hour chill, carcasses were weighed and measured for length, backfat thickness, loin eye area and percent ham and loin.

Results

A summary of the growth performance and carcass data is presented in table 2. Average daily gains during the first 8-week period were faster when pigs received copper or tylosin in the diet. Pigs fed 250 ppm of copper gained 1.63 lb. per day or 12% faster than the 1.46 lb. per day gain of pigs fed the basal unsupplemented

diet. Pigs fed tylosin or 125 or 187.5 ppm of copper gained 1.54, 1.50 and 1.52 lb. per day, respectively, during this period. Differences in feed consumption during the first 8-week period were statistically significant ($P<.01$). Pigs fed the diets containing copper or tylosin consumed more feed than pigs fed the basal diet. Feed/gain also differed significantly ($P<.05$) during this period. The pigs fed copper were not as efficient in feed conversion as the control pigs.

During the finishing period of this experiment, gains and feed/gain were quite erratic. There was no consistent pattern on the effect of removing copper from the diet after 8 weeks. Gains of pigs fed 125 ppm of copper during the final growth period were essentially identical to those of pigs that had received 125 ppm of copper for the first 8 weeks only (1.67 and 1.68 lb. per day). Pigs fed 187.5 ppm of copper gained 1.86 lb. per day compared to 1.77 for those that received this level only the first 8 weeks. Pigs fed the 250 ppm level of copper gained 1.71 lb. per day during this period, while pigs receiving the high level of copper for 8 weeks gained 1.92 lb. daily during the period that they did not receive copper.

Best overall rates of gain were made by pigs fed 250 ppm of copper for 8 weeks only (1.75 lb. per day) and pigs fed 250 ppm of copper throughout the experiment (1.68 lb. per day). Gains of the other pigs averaged from 1.59 to 1.66 lb. daily. Average daily feed consumption was significantly ($P<.01$) different between treatments ranging from 5.23 lb. per day for pigs fed the basal diet to 6.06 lb. daily for pigs fed 250 ppm of copper for the first 8 weeks.

Carcass length, backfat thickness and iodine number did not differ significantly between treatments. Pigs fed the copper or tylosin diets had heavier livers than pigs fed the unsupplemented diets. This is in contrast to previous data from this station indicating lighter livers in pigs fed dietary copper. Removing the copper from the diet when the pigs weighed approximately 125 lb. resulted in a liver copper level similar to that found in pigs fed the unsupplemented diet. When copper was fed during the entire growth period, liver storage increased with increasing levels of dietary copper.

Summary

Ninety-six crossbred pigs, 72 barrows and 24 gilts, were allotted to eight treatment groups to study the effect of feeding 125, 187.5 and 250 ppm of copper for 8 weeks or for the entire growing-finishing period. Gains were increased at all copper levels for the first 8-week period. For the entire experiment there was no benefit from feeding 125 ppm of copper. Pigs fed 187.5 and 250 ppm gained approximately 3 and 7% faster than pigs fed the basal diet. There were no consistent differences in performance of pigs fed the dietary copper for 8 weeks or the entire experiment except in liver copper storage which was increased with increasing levels of copper fed continuously to slaughter weights. Performance of pigs fed 20 grams of tylosin per ton of feed was similar to that of pigs fed the basal diet.

Table 1. Composition of Basal Diet

Ingredients	Percent
Ground yellow corn	82.8
Soybean meal (49%)	15.0
Ground limestone	0.75
Dicalcium phosphate	0.85
Salt	0.50
Trace mineral mix[a]	0.05
Vitamin mix[b]	0.05

[a] Provided 100 ppm zinc, 50 ppm iron, 27.5 ppm manganese, 5 ppm copper, 0.5 ppm cobalt and 0.75 ppm iodine in diet.

[b] Provided 1136 I.U. vitamin A, 182 I.U. vitamin D, 1.25 mg. riboflavin, 5 mg. pantothenic acid, 10 mg. niacin, 50 mg. choline and 75 mcg. vitamin B_{12} per lb.

Table 2. Effect of Copper on Performance and Carcass Characteristics of Swine

	Basal	125 ppm copper	125 ppm copper withdrawn[a]	187.5 ppm copper	187.5 ppm copper withdrawn[a]	250 ppm copper	250 ppm copper withdrawn[a]	20 grams/ton tylosin
Number of pigs	12	11	12	10	12	12	12	11
Initial weight, lb.	41.3	41.3	41.3	41.1	41.3	41.3	41.2	41.2
8-week summary								
8-week weight, lb.	123.5	126.8	124.4	125.8	126.7	134.4	132.0	127.6
Avg. daily gain, lb.	1.46	1.52	1.48	1.51	1.52	1.65	1.61	1.54
Avg. daily feed, lb.**	3.82	4.40	4.25	3.94	4.35	4.49	4.80	4.18
Feed/gain*	2.61	2.91	2.88	2.61	2.86	2.72	2.98	2.72
8 weeks to final summary								
Final weight, lb.	214.2	213.0	215.6	216.4	219.1	213.4	219.8	216.5
Avg. daily gain, lb.	1.76	1.67	1.68	1.86	1.77	1.71	1.92	1.73
Avg. daily feed, lb.**	6.75	6.44	6.74	7.33	6.87	7.39	7.59	6.82
Feed/gain	3.86	3.89	4.03	3.94	3.86	4.43	3.98	3.95
Overall summary								
Avg. daily gain, lb.	1.60	1.60	1.59	1.66	1.64	1.68	1.75	1.62
Avg. daily feed, lb.**	5.23	5.33	5.48	5.40	5.56	5.81	6.06	5.38
Feed/gain	3.27	3.37	3.47	3.24	3.38	3.50	3.47	3.31
Carcass length, in.	29.8	29.8	29.9	29.8	29.8	29.6	29.8	29.4
Backfat thickness, in.	1.25	1.27	1.22	1.31	1.19	1.24	1.27	1.33
Backfat iodine no.	67.3	66.6	66.3	67.4	68.2	68.5	67.6	64.6
Liver weight, gram	1267	1344	1371	1426	1421	1398	1494	1403
Liver copper (dry-weight basis), ppm	17.9	21.9	18.8	38.0	17.4	77.8	21.0	15.6

[a]Copper fed for 8 weeks only.
*Significant treatment differences (P<.05).
**Significant treatment differences (P<.01).

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A.S. Series 72-33

A Comparison of Opaque-2 and Normal Corn in a Free-Choice Feeding System for Swine

Richard C. Wahlstrom, George W. Libal and Lawrence R. Dunn

Several experiments conducted during the past few years have shown opaque-2 corn to be of higher protein quality than regular or normal corn. The improved quality can be attributed to the higher content of lysine and perhaps tryptophan. Two previous experiments have been conducted at this experiment station which have shown that growing pigs consume less protein supplement on a free-choice basis when opaque-2 corn is the grain rather than normal corn. The experiment reported herein was conducted to obtain further information on feed consumption and performance of growing-finishing pigs fed opaque-2 or normal corn free-choice with two different protein supplements.

Experimental Procedure

Sixty crossbred, female pigs averaging about 41 lb. were allotted into 12 lots on the basis of weight and litter. The pigs were housed in inside, concrete floored pens which were bedded with straw. The pigs had access to outside concrete lots where self-feeders were located during the 1971-72 winter from mid-November to late February.

The composition of the protein-mineral-vitamin-antibiotic supplement is shown in table 1. Supplement A was a combination plant and animal protein supplement while supplement B was composed of soybean meal only as the protein source. Supplement A contained 39.4% protein and 2.62% lysine and supplement B contained 38.1% protein and 2.77% lysine. Both supplements contained approximately 3.35% calcium and 1.9% phosphorus. The opaque-2 corn analyzed 9.0% protein and 0.39% lysine compared to 9.0% protein and 0.26% lysine for the normal corn.

Three lots of pigs were randomly assigned to each of the four treatments as follows:

1. Normal corn and supplement A
2. Opaque-2 corn and supplement A
3. Normal corn and supplement B
4. Opaque-2 corn and supplement B

Results

A summary of the growth and feed data is presented in table 2. There were no significant differences in rate of gain due to treatment although pigs fed normal corn and supplement A gained 0.15 lb. less daily than the other three groups. When supplement A was fed, gains were 1.62 and 1.47 lb. per day for pigs on opaque-2 and normal corn, respectively. However, with supplement B as the protein source, gains were 1.63 and 1.62 for pigs fed opaque-2 and normal corn, respectively.

Significantly less protein supplement was consumed by pigs fed opaque-2 corn. This difference in supplement consumption was noted during both the growing and finishing phases. For the entire feeding period pigs fed opaque-2 corn selected 0.33 lb. less supplement per day than pigs receiving normal corn. There were no differences in consumption of supplements A and B. Overall feed consumption was similar between pigs fed the two different types of corn, as pigs fed opaque-2 corn consumed about 0.3 lb. more corn per day than pigs fed normal corn.

Significantly less feed per gain was required by pigs fed opaque-2 corn during the growing period (2.65 vs. 2.82 lb.) and for the entire trial where pigs fed opaque-2 corn required 2.92 lb. of feed per unit of gain and pigs fed normal corn required 3.05 lb. During the finishing period both groups required 3.31 lb. of feed per lb. of gain. As in previous experiments, feed efficiency was very good for pigs fed free-choice.

Summary

Pigs weighing approximately 41 lb. initially were fed free-choice opaque-2 or normal corn and soybean meal or soybean meal-meat meal-alfalfa meal supplements. Although daily gains were not significantly different, pigs fed the normal corn and the mixed supplement gained about 10% slower than pigs in the other treatments.

Pigs fed opaque-2 or normal corn consumed about the same amount of total feed daily. However, when opaque-2 corn was fed, pigs consumed about 0.33 lb. less supplement and 0.3 lb. more corn than did pigs having access to normal corn and supplement. Therefore, a savings in feed cost was obtained when pigs were fed opaque-2 corn. Pigs fed opaque-2 corn required less feed per gain during the growing period and for the entire experiment.

Table 1. Percentage Composition of Supplements

Ingredients	Supplement A	Supplement B
Soybean meal (44%)	63.1	86.1
Meat meal (50%)	20.0	--
Dehydrated alfalfa meal (17%)	10.0	--
Dicalcium phosphate	3.5	7.5
Ground limestone	0.5	3.5
Trace mineralized salt[a]	2.5	2.5
Vitamin-antibiotic mix[b]	0.4	0.4

[a]Provided in addition to sodium chloride the following elemental levels to the supplement: 200 ppm zinc, 5.5 ppm cobalt, 100 ppm manganese, 12 ppm copper, 82.5 ppm iron, 2.75 ppm iodine.

[b]Contributed per lb. of supplement: 6,800 I.U. vitamin A, 2,000 I.U. vitamin D_2, 20 mcg. vitamin B_{12}, 8 mg. riboflavin, 16 mg. calcium pantothenate, 36 mg. niacin, 40 mg. choline chloride, and 50 mg. chlortetracycline.

Table 2. Results of Feeding Opaque-2 Corn Free-Choice to Growing-Finishing Swine

Corn	Normal	Opaque-2	Normal	Opaque-2
Supplement	A	A	B	B
Number of pigs[a]	15	15	14	14
Avg. initial wt., lb.	40.7	40.8	41.2	40.8
Avg. final wt., lb.	191.6	199.3	199.1	195.4
Avg. daily gain, lb.	1.47	1.62	1.62	1.63
Avg. feed/day, lb.				
Corn	3.61	4.19	3.97	4.00
Supplement**	0.90	0.59	0.94	0.60
Total	4.51	4.78	4.91	4.59
Feed/gain, lb.*	3.07	2.96	3.03	2.89

[a]Three lots of five pigs each.

*Significant difference due to corn ($P<.05$).

**Significant difference due to corn ($P<.01$).

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A.S. Series 72-34

Effect of Dietary Protein Level and Feed Restriction on Growth and Carcass Characteristics of Growing-Finishing Swine

Tim S. Stahly and Richard C. Wahlstrom

Research has shown that pigs fed low dietary protein levels are older at slaughter due to depressed growth rate, require more feed per unit of gain and have decreased carcass leanness and increased intramuscular fat. However, increased age at slaughter due to a restricted energy intake does not adversely affect feed efficiency and has the opposite effect on carcass quality in that carcasses have less fat and more lean. The objectives of this study were to determine the effects of dietary protein level and feed restriction on performance and carcass characteristics.

Experimental Procedure

Sixty crossbred pigs averaging approximately 45 lb. were divided into fifteen lots of four pigs each. Five replicated lots received each of the three dietary treatments. Each lot contained two barrows and two gilts with littermates distributed equally between treatments. Pigs were housed in concrete floored pens bedded with straw and had access to outside concrete feeding areas. Water was provided ad libitum. Pigs were removed for slaughter and subsequent carcass data at weekly intervals at live weights of at least 210 pounds.

The three treatments were as follows:

1. 16-14% protein diets ad libitum
2. 12-10% protein diets ad libitum
3. 16-14% protein diets fed at a restricted level to produce gains equal to pigs in treatment 2.

Compositions of the diets are shown in table 1. Changes in dietary protein were made when pigs weighed approximately 110 pounds.

Results

Growth Performance

A summary of the growth performance data is presented in table 2. Pigs fed 16-14% protein diets ad libitum gained significantly ($P<.05$) faster during all growth periods and more efficiently during the finishing and combined growing-finishing periods than pigs fed the 12-10% protein diets. Feed consumption did not differ significantly between these two groups. Restricted fed pigs required significantly ($P<.05$) less feed per unit of gain during all growth periods than pigs fed the low protein (12-10%) diets. Approximately 16.5% less of the high protein feed was required daily to produce gains equal to those obtained by pigs fed low protein diets ad libitum. No differences in feed/gain ratios existed between pigs fed high protein diets ad libitum or at a restricted level.

Carcass Characteristics

The carcass data are summarized in tables 3 and 4. Dietary protein did not significantly affect dressing percent, carcass length or backfat thickness of pigs fed ad libitum. However, pigs fed high protein diets, either ad libitum or restricted, had significantly larger loin eye areas and improved percentages of ham, loin, shoulder and lean cuts than carcasses from pigs fed the low protein diets.

The 1.17 inch carcass backfat of pigs fed the 16-14% protein diets at a restricted level was significantly less than the 1.31 and 1.38 inch backfat of pigs full-fed the high and low protein diets, respectively. Restricting feed intake also resulted in significantly higher percentages of ham, ham and loin and lean cuts and a lower percentage of belly than carcasses from pigs fed this 16-14% protein diet ad libitum.

Chemical analyses of the loin muscle showed a statistically significant difference in protein, moisture and fat content. Muscle tissue from pigs fed the low protein diets had less moisture and protein and more fat than muscle from pigs fed the higher protein diets either ad libitum or restricted. Percentages of fat were 9.20, 4.66 and 3.62 for pigs fed the low protein, high protein ad libitum and high protein restricted diets, respectively. Increased marbling and juiciness scores were associated with increased intramuscular fat. Flavor, tenderness and shear test values were not significantly affected by dietary protein level or feed intake, although chops from pigs fed the low protein diets tended to be favored. The restriction in feed intake did not significantly affect the chemical composition, consumer acceptability or cooking characteristics of the loin muscle.

Summary

Pigs weighing approximately 45 lb. initially gained significantly faster at all growth stages and were significantly more efficient in feed conversion from 110 to 210 lb. and for the entire growth period when fed ad libitum diets of 16-14% protein compared to pigs fed 12-10% protein diets. Pigs fed the 16-14% protein diets at a restricted level to allow gains equal to pigs fed 12-10% protein diets ad libitum consumed 16.5% less feed and were significantly more efficient than the low protein fed pigs.

Pigs fed the low protein diets had loin eye muscles with less protein and moisture, more fat and higher marbling and juiciness scores than the loin muscle from pigs fed the high protein diets. Loin eye size and percentages of ham, loin, ham and loin, shoulder and lean cuts were all reduced in carcasses from pigs fed low protein diets. Restricted feeding resulted in less carcass backfat, increased percentages of ham, ham and loin and lean cuts and less percent belly than in carcasses from pigs fed either high or low protein diets ad libitum.

Table 1. Composition of Diets (Percent)

Ingredient	% Protein 16	12	14	10
Ground yellow corn	76.41	87.71	81.94	93.44
Soybean meal (44%)	20.83	9.38	15.20	3.63
Dicalcium phosphate	1.71	1.81	2.03	2.13
Ground limestone	0.53	0.55	0.26	0.27
Trace mineralized salt[a]	0.50	0.50	0.50	0.50
Premix[b]	0.08	0.08	0.08	0.08
Calculated analyses, %				
Calcium	0.65	0.65	0.60	0.60
Phosphorus	0.50	0.50	0.55	0.55

[a]Contained sodium chloride, 97%; zinc, 0.8%; cobalt, 0.002%; manganese, 0.4%; copper, 0.048%; iron, 0.33%; iodine, 0.011%.
[b]Provided per lb. of diet: 590 I.U. of vitamin A, 91 I.U. of vitamin D, 5 I.U. of vitamin E, 1.0 mg. of riboflavin, 4.5 mg. of niacin, 5.0 mg. of pantothenic acid, 5.0 mcg. of vitamin B_{12} and 10 mg. of aureomycin.

Table 2. Effect of Protein Level and Feed Restriction on Growth Performance of Growing-Finishing Swine

Protein level, % / Feeding method	16-14 Ad libitum	12-10 Ad libitum	16-14 Restricted
No. of pigs[a]	20	20	20
Avg. initial wt., lb.	44.9	45.0	44.8
Avg. final wt., lb.	213.2	205.4	209.8
Avg. daily gain, lb.			
45-110 lb.	1.55[b]	1.41[c]	1.39[c]
110-210 lb.	1.84[b]	1.42[c]	1.54[c]
45-210 lb.	1.70[b]	1.42[c]	1.46[c]
Avg. daily feed, lb.			
45-110 lb.	4.01[b]	4.12[c]	3.28[c]
110-210 lb.	5.78[b]	5.31[b,c]	4.74[c]
45-210 lb.	5.00[b]	4.85[b]	4.10[c]
Feed/gain			
45-110 lb.	2.62[b,c]	2.95[b]	2.37[c]
110-210 lb.	3.20[b]	4.35[c]	3.32[b]
45-210 lb.	2.98[b]	3.77[c]	2.92[b]

[a]Five replicated lots of four pigs each.
[b,c]Means on the same line without a common superscript are significantly different ($P < .05$).

Table 3. Effects of Dietary Protein and Feed Restriction on Quantitative Carcass Traits

Protein level, % Feeding method	16-14 Ad libitum	12-10 Ad libitum	16-14 Restricted
No. of pigs	19[a]	17[b]	20
Backfat thickness, in.	1.31[d]	1.38[d]	1.17[e]
Carcass length, in.	29.7	30.0	30.4
Longissimus muscle area, sq. in.	4.35[d]	3.51[e]	4.48[d]
Dressing percent	71.83	71.16	70.94
Ham, %[c]	21.18[d]	20.09[e]	22.37[f]
Loin, %	17.52[d]	16.09[e]	18.20[d]
Ham and loin, %	38.71[d]	36.18[e]	40.59[f]
Shoulder, %[c]	17.59[d]	16.98[e]	18.22[d]
Lean cuts, %[c]	56.30[d]	53.16[e]	58.81[f]
Belly, %	12.07[d]	11.99[d]	11.25[e]

[a]One pig died of stress in moving to slaughter.
[b]Three pigs were removed before reaching slaughter weight.
[c]Bone in - packing house trim.
[d,e,f]Means on the same line without a common superscript were significantly different ($P < .05$).

Table 4. Effects of Protein Level and Feed Restriction on Qualitative Carcass Traits

Protein level, % Feeding method	16-14 Ad libitum	12-10 Ad libitum	16-14 Restricted
No. of pigs	19	17	20
Longissimus muscle, fresh			
Moisture, %	72.25[g]	70.47[h]	72.95[g]
Protein, %	21.90[g]	19.38[h]	21.60[g]
Ether extract, %	4.66[g]	9.20[h]	3.62[g]
Marbling score[a]	2.55[g]	3.60[h]	2.35[g]
Color and firmness score[b]	2.90	2.90	2.85
Longissimus muscle, cooked			
Shear value, kg.[c]	7.06	6.57	7.02
Tenderness score[d]	3.67	3.13	3.95
Flavor score[e]	3.49	3.34	3.47
Juiciness score[f]	4.16[g]	3.09[h]	4.55[g]
Cooking loss, %	22.21	22.10	23.53
Drip loss, %	8.79	8.99	8.88
Volatile gas loss, %	13.42	13.11	14.65

[a]Based on 1 to 5 scale, 1 = trace to 5 = abundant.
[b]Based on 1 to 5 scale, 1 = pale, soft and watery to 5 = dark and firm.
[c]Kilograms of force to shear a core 2.54 cm. in diameter.
[d]Based on a 1 to 8 scale, 1 = extremely tender to 8 = extremely tough.
[e]Based on a 1 to 8 scale, 1 = extremely desirable to 8 = extremely undesirable.
[f]Based on a 1 to 8 scale, 1 = extremely juicy to 8 = extremely dry.
[g,h]Means on the same line without a common superscript were significantly different ($P < .01$).

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A.S. Series 72-35

An Evaluation of the Use of Dexamethasone for Inducing Parturition in the Sow

T. D. Rich, G. W. Libal, L. R. Dunn and R. C. Wahlstrom

Synchronizing all farrowings to a certain day or days of the week should allow closer attention to sows farrowing as well as sufficient time to disinfect facilities between farrowings. These procedures could result in the loss of fewer pigs at or near birth.

Dexamethasone is a corticosteroid which has been demonstrated to possess abortive inducing capabilities in cows and ewes. This substance, in precise dose levels, will induce parturition within approximately 40 to 48 hours after injection in pregnant cows and ewes near term. Its capabilities have not been evaluated in the pregnant sow.

The objective of this study was to evaluate the use of dexamethasone for inducing and controlling the time of parturition in the sow.

Experimental Procedure

Forty-nine crossbred gilts and sows with known breeding dates were stratified according to age across a 2 x 3 factorial arrangement of treatments. Experimental treatments consisted of two different days of receiving an injection (day 110 or 112 of pregnancy) and three levels of dexamethasone (0, 10 or 20 mg.). The experimental design and number of sows per treatment are presented in table 1.

The 0 mg. dexamethasone treatment group received an injection of sterile saline, while the 10 and 20 mg. groups received dexamethasone in sterile saline solution. All injections were given intramuscularly.

Results and Discussion

The intervals from injection to birth of the first pig are presented in table 2. There were no significant differences ($P > .10$) between levels of dexamethasone within days of injection. Based on these data, it is concluded that 10 or 20 mg. of dexamethasone will not induce parturition in the pregnant sow. These data are in contrast with reports of 20 mg. dexamethasone inducing parturition in cows and ewes.

There also were no significant differences ($P > .10$) between treatments for interval between birth of first and last pig (table 3) or percent pigs born alive of total pigs born (table 4).

Summary

The use of dexamethasone for controlling the time of parturition in sows was evaluated on 49 head of crossbred sows. Intramuscular injections of 0, 10 or 20 mg. of dexamethasone failed to induce parturition in sows 110 to 112 days pregnant.

Table 1. Experimental Design and Number of Sows Per Treatment

Day of pregnancy when injected	Level of dexamethasone, mg.		
	0	10	20
		No. of sows	
110	10	5	10
112	11	4	9

Table 2. Influence of Dexamethasone on the Interval from Injection to Birth of the First Pig (Hours)

Day of injection	Level of dexamethasone, mg.		
	0	10	20
110	90.5±9.4[a]	103±11.2	89.9±14.4
112	46.5±8.5	67±11.6	56.3± 9.8

[a] Mean ± standard error.

Table 3. Influence of Dexamethasone on the Intervals from Birth of the First to Last Pig (Hours)

Day of injection	Level of dexamethasone, mg.		
	0	10	20
110	2.9±0.4	5.4±1.8	3.2±0.8
112	2.7±0.5	3.2±0.7	2.7±0.5

Table 4. Influence of Dexamethasone on Percent Pigs Born Alive of Total Pigs Born

Day of injection	Level of dexamethasone, mg.		
	0	10	20
110	91.1%	93.6	98.5
112	98.2	89.6	98.1

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A.S. Series 72-36

Effect of Zinc Bacitracin on Performance of Growing-Finishing Pigs

Richard C. Wahlstrom and George W. Libal

The recent FDA (Food and Drug Administration) Task Force report on the use of antibiotics in animal feeds recommended that all antimicrobial agents used in human clinical medicine that fail to meet guidelines established by the Task Force in regard to safety be prohibited from use in animal feeds by December 31, 1973. It is not the purpose of this report to question the conclusions and recommendations of the Task Force. It has, however, necessitated that additional research be conducted to justify the efficacy and safety of antibiotics in swine feeds.

One antibiotic that is not used orally or as an injectable antibiotic in human medicine is zinc bacitracin. The experiment reported herein was conducted to evaluate the effectiveness of zinc bacitracin, to determine the effective dose range in growing-finishing pigs and to compare it with an antibiotic (tylosin) that has been used successfully as a swine feed additive.

Experimental Procedure

One hundred twenty crossbred pigs averaging 38 lb. were assigned to 24 lots of five pigs (three barrows and two gilts) from within groups based on weight, litter and sex. Groups of five pigs were randomly assigned to each of six treatments within four replicates. The pigs were housed in portable wood frame houses with concrete floors and a connecting 6 x 12 ft. concrete outside pen where feeders and waterers were located.

The compositions of the diets fed are shown in table 1. Diets were changed in level of protein from 16 to 13% when the pigs averaged about 110 pounds. The experiment was terminated when each pen averaged approximately 210 pounds.

Antibiotic treatments were as follows:

1. None
2. 10 grams of zinc bacitracin per ton
3. 20 grams of zinc bacitracin per ton
4. 40 grams of zinc bacitracin per ton
5. 80 grams of zinc bacitracin per ton
6. 20 grams of tylosin per ton

Results

Average daily gain, daily feed and feed per gain data are summarized in table 2.

Pigs fed antibiotics gained approximately 3 to 7% faster than the control pigs during the period from 38 to 112 pounds. These differences were not statistically significant. However, there were significant differences in feed efficiency

during this early growth period. Requiring the most feed per lb. of gain were pigs fed the control diet which did not contain any antibiotic. Performance of pigs fed the various levels of zinc bacitracin was similar, indicating that 10 grams of zinc bacitracin per ton of feed was as effective as higher levels.

During the finishing phase, 112 to 211 lb., gains and feed per lb. of gain were similar except for pigs fed tylosin. These pigs required about 25 lb. less feed per hundredweight of gain than the average of the other treatment groups. Combining the data over the entire feeding period showed only very small, nonsignificant differences in daily gains among treatments. Feed efficiency was also similar between control and zinc bacitracin-fed pigs but was improved about 7% when tylosin was fed. Daily feed consumption was also less when pigs were fed tylosin with other lots consuming similar amounts of feed daily.

There were significant differences in performance of replicate lots. Barrows gained significantly faster than gilts during all three periods.

Summary

The results of this experiment indicated no difference in performance of pigs fed 10, 20, 40 or 80 grams of zinc bacitracin per ton of diet. Pigs fed each of the antibiotic levels grew slightly faster and more efficiently than pigs not receiving antibiotic during the early growth period, 38 to 112 pounds. There were no advantages of feeding the antibiotic during the finishing period.

Pigs fed 20 grams of tylosin per ton of diet grew similarly to those pigs fed zinc bacitracin but were more efficient during the finishing and overall periods.

Table 1. Composition of Basal Diets (Percent)

	To 110 lb.	110 to 210 lb.
Ground yellow corn	76.9	84.0
Soybean meal (44%)	20.2	12.1
Dicalcium phosphate	1.7	1.7
Ground limestone	0.5	0.5
Trace mineral salt (0.8% zinc)	0.5	0.5
Premix[a]	0.2	0.2

[a]Provided 1500 I.U. vitamin A, 150 I.U. vitamin D, 1.25 mg. riboflavin, 5 mg. pantothenic acid, 10 mg. niacin, 50 mg. choline and 7.5 mcg. vitamin B_{12} per lb. of diet.

Table 2. Performance of Growing-Finishing Pigs Fed Tylosin and Various Levels of Zinc Bacitracin

Antibiotic	None	Zinc bacitracin				Tylosin
Level, grams/ton	0	10	20	40	80	20
No. of pigs[a]	19	19	19	20	20	19
Avg. initial wt., lb.	38.0	38.0	38.5	38.3	38.4	38.4
Avg. final wt., lb.	211.0	211.7	211.8	211.9	211.0	211.9
Avg. daily gain, lb.						
38 to 112 lb.	1.53	1.59	1.61	1.63	1.57	1.63
112 to 211 lb.	1.73	1.69	1.72	1.78	1.76	1.73
38 to 211 lb.	1.64	1.65	1.68	1.71	1.69	1.69
Avg. daily feed, lb.						
38 to 112 lb.	4.23	4.18	4.25	4.36	4.18	4.05
112 to 211 lb.	6.40	6.55	6.59	6.70	6.57	6.01
38 to 211 lb.	5.41	5.50	5.53	5.66	5.47	5.15
Avg. feed/lb. gain, lb.						
38 to 112 lb.*	2.74	2.59	2.63	2.67	2.64	2.53
112 to 211 lb.	3.70	3.85	3.73	3.75	3.69	3.49
38 to 211 lb.	3.29	3.31	3.24	3.29	3.21	3.06

[a]Four replicated lots of 5 pigs (3 barrows and 2 gilts) per treatment. Four pigs died or were removed from the experiment.
*Significant treatment difference ($P<.05$).

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A.S. Series 72-37

Starter Diets for Weaned Pigs

George W. Libal and Richard C. Wahlstrom

The swine producer who operates a farrow-to-finish operation and the feeder pig producer who sells his pigs at 40 or 15 lb. are both interested in getting weaned pigs off to a quick start. Lack of palatability and low feed consumption are two problems associated with young pigs. Additions of ingredients to make the feed more acceptable to the pig add cost to an already expensive diet. Another problem often encountered is edema disease. High protein diets have often been listed as a predisposing cause of this disease. Work at this station (A.S. Series 70-33) has shown little benefit from complex starter diets over simple corn-soybean meal diets. In the simple starter diet, the high level of protein is the main contribution to the cost of the diet. It seems logical that the addition of limiting amino acids which constitute protein may allow for a reduction in the level of protein required for maximum pig performance. The trials reported herein were designed to test this hypothesis and to observe if differences in edema disease occurred on diets differing in protein content.

Experimental Procedure

Two trials were conducted to study the effects of protein level, lysine content and feed ingredients upon feed consumption, feed efficiency and gain of weaned pigs. In both trials the pigs were housed in inside, concrete floored pens. Supplemental heat was provided by space heaters to maintain at least a 50^{o} F. temperature at all times. The pigs were weaned and allowed about a week to adjust to dry feed before allotment to treatments.

Trial 1

The first trial was conducted during the winter utilizing 54 crossbred pigs with an initial weight of approximately 17 pounds. The pigs were randomly allotted to three replications of three experimental diets on the basis of genetic background, weight and sex. The three experimental diets were:

1. 18% protein (corn-soybean meal + 30% rolled oats)
2. 18% protein (corn-soybean meal)
3. 15% protein + 0.20% lysine (corn-soybean meal)

Trial 2

The second trial was conducted in the spring utilizing 84 crossbred pigs with an intiial weight of approximately 16 pounds. The pigs were allotted seven to a pen by the same criteria as in trial 1. Four experimental diets were used in this trial as follows:

1. 18% protein (corn-soybean meal + 30% rolled oats)
2. 18% protein (corn-soybean meal)
3. 15% protein + 0.20% lysine (corn-soybean meal)
4. 15% protein (corn-soybean meal)

In both trials, pig weights and feed consumption were obtained weekly. The length of both trials was five weeks (35 days).

Table 1 shows the experimental diets used in trials 1 and 2 and their calculated protein and lysine content. Diets 2 and 3 differed in protein but were equal in lysine and diets 3 and 4 were equal in protein but differed in lysine content.

Results

Trial 1

The results of trial 1 are shown in table 2. At the end of the five week experimental period, pigs in the three lots averaged 50, 52 and 54 pounds. The gain was considered acceptable in that pigs gained about 1 lb. per day from the initiation of the trial. No significant differences in average daily gain, feed consumption or feed per pound of gain were observed. This would indicate that under these conditions the 15% protein diet with additional lysine was as adequate for this stage of growth as either 18% protein diet. Two pigs fed the 15% protein diet died and one pig that was fed the 18% protein corn-soy-rolled oats diet died. Autopsy revealed cause of death was edema disease.

Trial 2

The results of trial 2 are shown in table 3. At the end of the five week period, lots averaged about 40 to 45 lb. and had gained from 0.71 lb. per day on the 15% protein diet to 0.83 lb. per day on the 18% protein corn-soybean meal diet. These gains were not statistically different because of the variation in gain of pigs within treatment groups. Feed consumption was equal between treatments but feed per lb. of gain was statistically ($P < .025$) different. Pigs receiving the 15% protein diet were least efficient and pigs receiving the 18% protein corn-soybean meal diet were most efficient. These results would indicate that the 15% protein diet was probably inadequate for efficient feed conversion by pigs at this stage of growth. However, when lysine content of the 15% protein diet equaled that of the 18% protein diet, improvement in feed efficiency was observed.

Summary

Weaned pigs fed diets containing 18% protein and 15% protein plus additional lysine to equal the lysine in the 18% protein ration performed similarly. However, when no additional lysine was added to the 15% protein diet, a poorer feed efficiency was obtained. The addition of 30% rolled oats and 5% sugar to the 18% protein diet was not beneficial. In these trials no additional edema disease was observed with high protein diets.

Table 1. Experimental Diets (Percent)[a]

Ingredients	Diets 1	2	3	4
Ground yellow corn	42.95	73.85	80.55	80.75
Rolled oats	30.00	--	--	--
Soybean meal (49%)	19.00	23.00	16.00	16.00
Sugar	5.00	--	--	--
Dicalcium phosphate	1.70	1.80	1.90	1.90
Ground limestone	0.50	0.50	0.50	0.50
Trace mineralized salt (1% zinc)	0.50	0.50	0.50	0.50
Vitamin-antibiotic premix[b]	0.35	0.35	0.35	0.35
L-lysine monohydrochloride	--	--	0.20	--
	100.00	100.00	100.00	100.00
Calculated protein content, %	18.00	18.00	15.00	15.00
Calculated lysine content, %	0.80	0.89	0.89	0.69

[a]Diets 1 through 3 were used in trial 1 and diets 1 through 4 were used in trial 2.

[b]Provided per lb. of diet: 2000 I.U. vitamin A, 237 I.U. vitamin D, 1.25 mg. of riboflavin, 5 mg. pantothenic acid, 10 mg. niacin, 50 mg. choline, 7.5 mcg. vitamin B_{12}, 50 mg. chlortetracycline, 25 mg. penicillin and 50 mg. sulfamethazine.

Table 2. Growth Performance of Pigs in Trial 1

	Diets 1	2	3
	18% protein Corn-soybean meal 30% rolled oats	18% protein Corn-soybean meal	15% protein Corn-soybean meal + 0.20% lysine
Number of pigs[a]	19	21	18
Avg. initial weight, lb.	17.2	17.4	17.3
Avg. final weight, lb.	54.0	50.0	52.0
Avg. daily gain, lb.	1.07	0.95	1.01
Avg. daily feed, lb.	2.41	2.05	2.32
Feed per lb. of gain, lb.	2.29	2.21	2.34

[a]Three replicates of seven pigs per treatment. One pig died on the 18% rolled oats diet and two died on the 15% protein with added lysine diet and one pig was removed from each of these two treatments because of very slow growth. The diagnosis of cause of death of the three pigs was edema disease.

Table 3. Growth Performance of Pigs in Trial 2

	Diets			
	1	2	3	4
	18% protein Corn-SBM 30% rolled oats	18% protein Corn-SBM	15% protein Corn-SBM + 0.20% lysine	15% protein Corn-SBM
Number of pigs[a]	21	21	20	20
Avg. initial weight, lb.	15.7	15.7	15.8	15.7
Avg. final weight, lb.	43.0	44.9	42.2	40.4
Avg. daily gain, lb.	0.78	0.83	0.75	0.71
Avg. daily feed, lb.	1.84	1.82	1.80	1.81
Feed per lb. of gain, lb.[b]	2.36	2.19	2.40	2.51

[a]Three replicates of seven pigs per treatment. One pig removed from the 15% protein corn-soybean meal plus lysine diet and one from the 15% protein corn-soybean meal diet because of slow unrepresentative gains.

[b]A statistically significant difference in feed per lb. of gain was observed due to treatment ($P<.025$) and due to replication ($P<.05$).

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A.S. Series 72-38

Opaque-2 Corn in Pig Starter Diets

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Opaque-2 or "high lysine corn" has been shown to be an effective dietary ingredient for growing-finishing swine, allowing a reduction in the total protein needed in the diet and thus reducing the cost of the diet. The study reported herein was designed to evaluate opaque-2 corn in pig starter diets fed to pigs after weaning when amino acid needs of the pig are greatest.

Experimental Procedure

Eighty-four crossbred pigs averaging approximately 16 lb. were allotted to two replications of six treatments. The pigs were weaned at approximately four weeks of age and placed on test after a week's adjustment period. Each pen contained three barrows and four gilts. The length of the trial was five weeks (45 days). The pigs were housed in concrete floored pens.

The six experimental diets utilized were:

1. 14% normal corn-soy diet + 0.27% lysine
2. 18% normal corn-soy diet
3. 14% normal corn-soy diet + 0.41% lysine
4. 18% normal corn-soy diet + 0.14% lysine
5. 14% opaque-2 corn-soy diet + 0.26% lysine
6. 18% opaque-2 corn-soy diet

The composition and calculated nutrient content of the experimental diets are shown in table 1. Diets 1, 3 and 5 were equal in protein percent (14%) and diets 2, 4 and 6 each contained 18% protein. Diets 1 and 2 were equal in lysine percent (0.89%) but different from diets 3, 4, 5 and 6 which contained 1.03% lysine. Diets 3 and 4, respectively, differed from diets 5 and 6, respectively, only in proportion of lysine from natural and synthetic sources. Diets 3 and 4 contained normal corn (0.25% lysine), whereas diets 5 and 6 contained opaque-2 corn (0.45% lysine).

Results and Discussion

The growth pattern observed over the 5-week experimental period for the average of all pigs on all treatments is shown in figure 1. As is seen in most cases when pigs are weaned at an early age, the figure illustrates the delay of growth during the first week. Since the pigs received approximately a 1-week adjustment period before the start of the trial, it can be assumed that in this case the delay in growth was for nearly 2 weeks after weaning. After the initial delay, growth rate increased to as much as 8.5 lb. during a 1-week interval as shown in figure 2. Figure 3 shows the average feed consumed per day during weekly intervals. Feed consumption was 0.87 lb. per day the first week, increasing in a linear fashion to 3.16 lb. per day during the fifth week of the trial. These increases in feed consumption corresponded with increased

weekly gains until the fifth week, illustrating that the limiting factor for growth rate in the early weaned pig is the pig's desire and ability to consume more feed. Pigs weaned at 7 to 8 weeks of age that are more used to dry feed from a creep feeder or the sow's feeder often do not exhibit as marked a period of delay. However, in spite of this advantage for later weaned pigs, in most cases there is an economic advantage to early weaning pigs. The number of days for a pig to reach market weight was equal under either management system and early weaning of pigs allowed early breeding of the sow to maximize the number of litters she can produce over a given period of time.

Summary

Eighty-four crossbred pigs weighing approximately 16 lb. were used to study the effect of feeding normal corn and opaque-2 corn as well as supplemental lysine in starter diets containing 14 or 18% protein and 0.89 and 1.03% lysine. The results of the 5-week trial showed final weights of from 44 to 49 lb. and no significant differences in average daily gain, feed consumption or feed efficiency due to either protein or lysine levels.

Table 1. Composition of Experimental Diets and Calculated Nutrient Content

Ingredients	Diets					
	1	2	3	4	5	6
Normal corn	83.4	73.6	83.4	73.6	--	--
Opaque-2 corn	--	--	--	--	83.4	73.6
Soybean meal (49%)	13.3	23.3	13.3	23.3	13.3	23.3
Dicalcium phosphate	2.0	1.8	2.0	1.8	2.0	1.8
Limestone	0.5	0.5	0.5	0.5	0.5	0.5
Trace mineral salt (1% zinc)	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin-antibiotic premix[a]	0.3	0.3	0.3	0.3	0.3	0.3
L-lysine	0.54	--	0.82	0.28	0.52	--
Calculated protein, %	14.00	18.00	14.00	18.00	14.00	18.00
Calculated lysine, %	0.89	0.89	1.03	1.03	1.03	1.03

[a]Provided per pound of diet: 1.25 mg. riboflavin, 5 mg. pantothenic acid, 10 mg. niacin, 50 mg. choline, 7.5 mcg. vitamin B_{12}, 274 I.U. vitamin D, 2,300 I.U. vitamin A, 50 mg. chlortetracycline, 25 mg. penicillin and 50 mg. sulfamethazine.

Table 2. Growth and Feed Data

	Diets					
	1	2	3	4	5	6
Number of pigs[a]	13	14	13	14	14	14
Initial weight, lb.	16.1	15.8	16.0	15.9	15.5	16.0
Final weight, lb.	43.6	45.8	45.5	49.2	45.6	47.0
Avg. daily gain, lb.	0.78	0.85	0.85	0.95	0.86	0.88
Feed consumption, lb.	2.09	1.99	2.10	2.18	2.26	2.19
Feed per lb. gain, lb.	2.67	2.33	2.48	2.29	2.64	2.47

[a]One pig was removed from diet 1 and one from diet 3 because of unrepresentative growth rates.

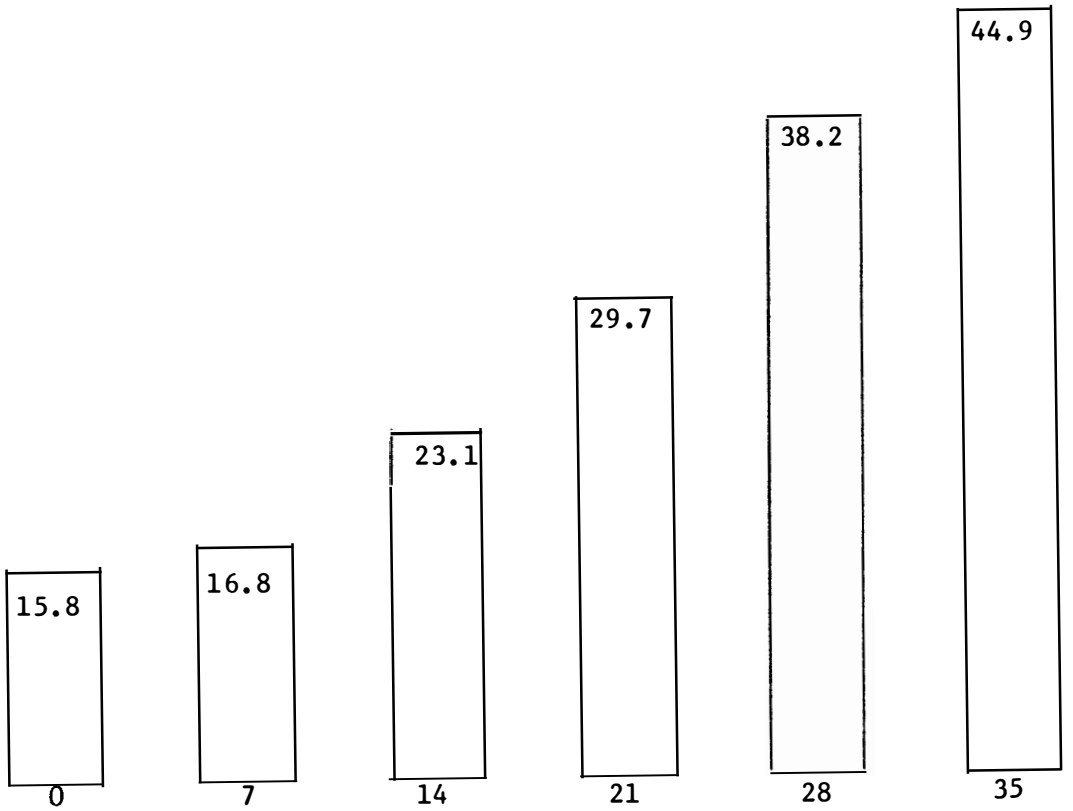

Figure 1. Avg. pig weight, lb.

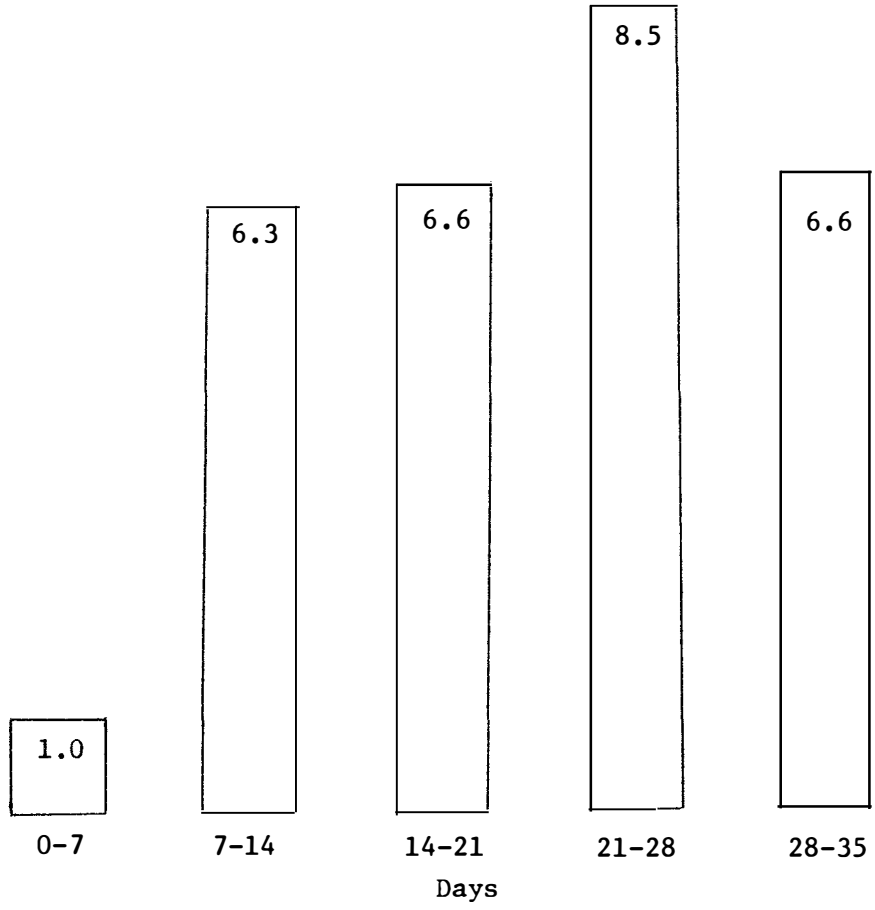

Figure 2. Avg. weekly gain, lb.

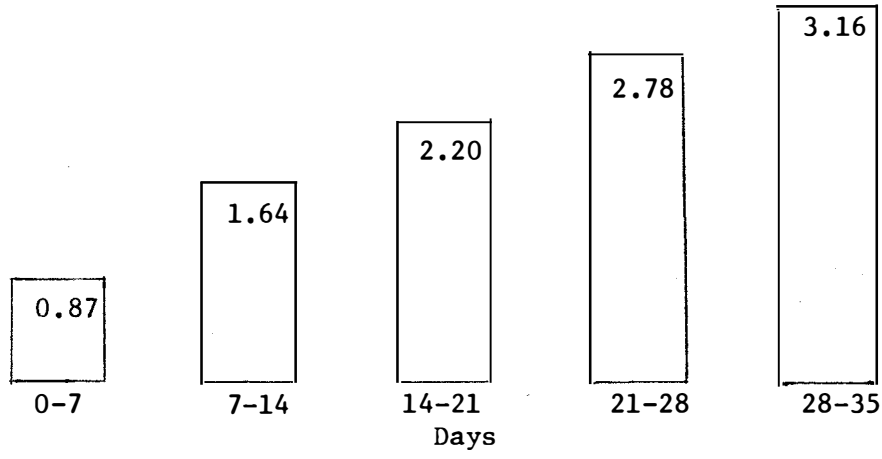

Figure 3. Avg. feed/day, lb.

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A.S. Series 72-39

Effect of Cooked Corn in Diets of Growing-Finishing Swine

Richard C. Wahlstrom, George W. Libal and Richard M. Luther

A considerable amount of research has been conducted during the past few years on the effects of various methods of processing grain on performance of finishing cattle. One of the methods that has been reported to improve performance of finishing cattle is cooking corn. This method of processing grains is now possible by use of the "on-the-farm cookers" that have been developed for cooking soybeans.

Little information is known concerning the effects of cooking corn on the growth performance of growing-finishing pigs. Therefore, the objective of the present study was to evaluate the performance of pigs fed cooked or regular corn in free-choice and complete mixed ration feeding systems.

Experimental Procedure

Forty-eight crossbred pigs averaging about 60 lb. were allotted to three replications of four treatments on the basis of litter, weight and sex. The pigs were housed in a confinement type house with slotted floors.

The four treatments were as follows:

1. Cooked corn, complete mixed diet
2. Regular corn, complete mixed diet
3. Cooked corn, free-choice diet
4. Regular corn, free-choice diet

The composition of the protein-mineral-vitamin-antibiotic supplement used in this experiment is shown in table 1. The complete mixed diets were formulated by mixing 77.5 lb. of the respective type of corn and 22.5 lb. of supplement and fed until the pigs averaged 115 lb. From 115 lb. to market weight the proportion of corn and supplement in the diets was 87 and 13 lb. The diets formulated in this way contained 15.9% protein when fed to 115 lb. and 12.1% protein after pigs weighed 115 lb. Pigs fed free-choice were allowed corn and supplement in separate compartments of the self-feeder.

The corn was cooked in a "on-the-farm cooker" to a temperature of about 250° F. Moisture content was 9.14 and 11.29% for the cooked and regular corn, respectively.

Twenty-six pigs were slaughtered at the termination of the experiment and carcass data were obtained for length, backfat, loin eye area and ham-loin percent.

Results

A summary of the results of this experiment is presented in table 2. The data have been combined by type of corn and method of feeding. Cooking the corn did not affect rate of gain during either the growing or finishing

periods. However, pigs fed cooked corn consumed less total feed and were more efficient in that they required less feed per unit of gain. Although these differences existed during both the growing and finishing periods, they were significant only during the growing period from 60 to 115 lb. in weight. For the entire trial, pigs fed cooked corn required 6% less feed per lb. of gain than pigs fed regular corn. The improvement in feed efficiency due to cooked corn is slightly over 4% when adjusted for the difference in moisture content of the corn.

Faster gains were obtained when pigs were fed complete mixed diets than when they were self-fed free-choice. These differences were statistically significant during the finishing (115 to 205 lb.) period and for the entire experiment. Pigs fed free-choice gained at a similar rate during both growing and finishing periods. The feed consumption of the free-choice fed pigs was considerably less than those fed complete diets during the finishing period. However, feed efficiency was similar with the two feeding systems. These results are not in agreement with other research where we have noted no significant differences due to method of feeding.

There were no significant differences in any of the carcass data obtained for either type of corn or feeding method.

Summary

Forty-eight crossbred pigs were used to study the effect of cooking corn and complete mixed or free-choice feeding systems. In this experiment, cooking corn did not affect rate of gain but did decrease feed consumption and improve feed efficiency. Pigs fed complete mixed diets gained about 11% faster than those fed free-choice. There was no difference in feed efficiency between the two feeding systems. Quality of carcasses was not affected by either corn or feeding method.

Table 1. Composition of Supplement

Ingredients	Percent
Soybean meal (44%)	63.1
Meat meal (50%)	20.0
Dehydrated alfalfa meal (17%)	10.0
Dicalcium phosphate	3.0
Ground limestone	1.0
Trace mineral salt (1% zinc)	2.5
Vitamin-antibiotic premix[a]	0.4

[a] Provided per lb. of supplement: 6,800 I.U. vitamin A, 1,000 I.U. vitamin D, 6 mg. riboflavin, 24 mg. calcium pantothenate, 48 mg. niacin, 240 mg. choline, 36 mcg. vitamin B_{12} and 45 mg. oxytetracycline.

Table 2. Effect of Cooking Corn on Performance of Pigs Fed Free-choice or Complete Mixed Diets

	Corn		Feeding Method	
	Cooked	Regular	Complete	Regular
No. of pigs	24	24	24	24
Avg. initial wt., lb.	59.7	59.9	59.5	60.0
Avg. final wt., lb.	208.1	207.2	210.7	204.6
60 to 115 lb.	1.71	1.70	1.75	1.66
115 to 205 lb.	1.81	1.78	1.92[a]	1.67[a]
60 to 205 lb.	1.77	1.75	1.85[a]	1.67[a]
Avg. daily feed, lb.				
60 to 115 lb.	3.93[b]	4.25[b]	4.11	4.07
115 to 205 lb.	5.63	5.80	6.06	5.37
60 to 205 lb.	4.98	5.20	5.31	4.87
Avg. feed per lb. gain, lb.				
60 to 115 lb.	2.31[b]	2.51[b]	2.35	2.47
115 to 205 lb.	3.12	3.30	3.19	3.23
60 to 205 lb.	2.81	3.00	2.88	2.93
Carcass data				
No. of pigs	13	13	17	9
Length, in.	30.25	30.30	30.25	30.30
Backfat, in.	1.16	1.09	1.15	1.10
Loin eye area, sq. in.	4.32	4.67	4.65	4.33
Ham-loin, %	42.96	42.56	42.99	42.53

[a] Significant difference due to feeding method ($P < .05$).
[b] Significant difference due to corn ($P < .05$).