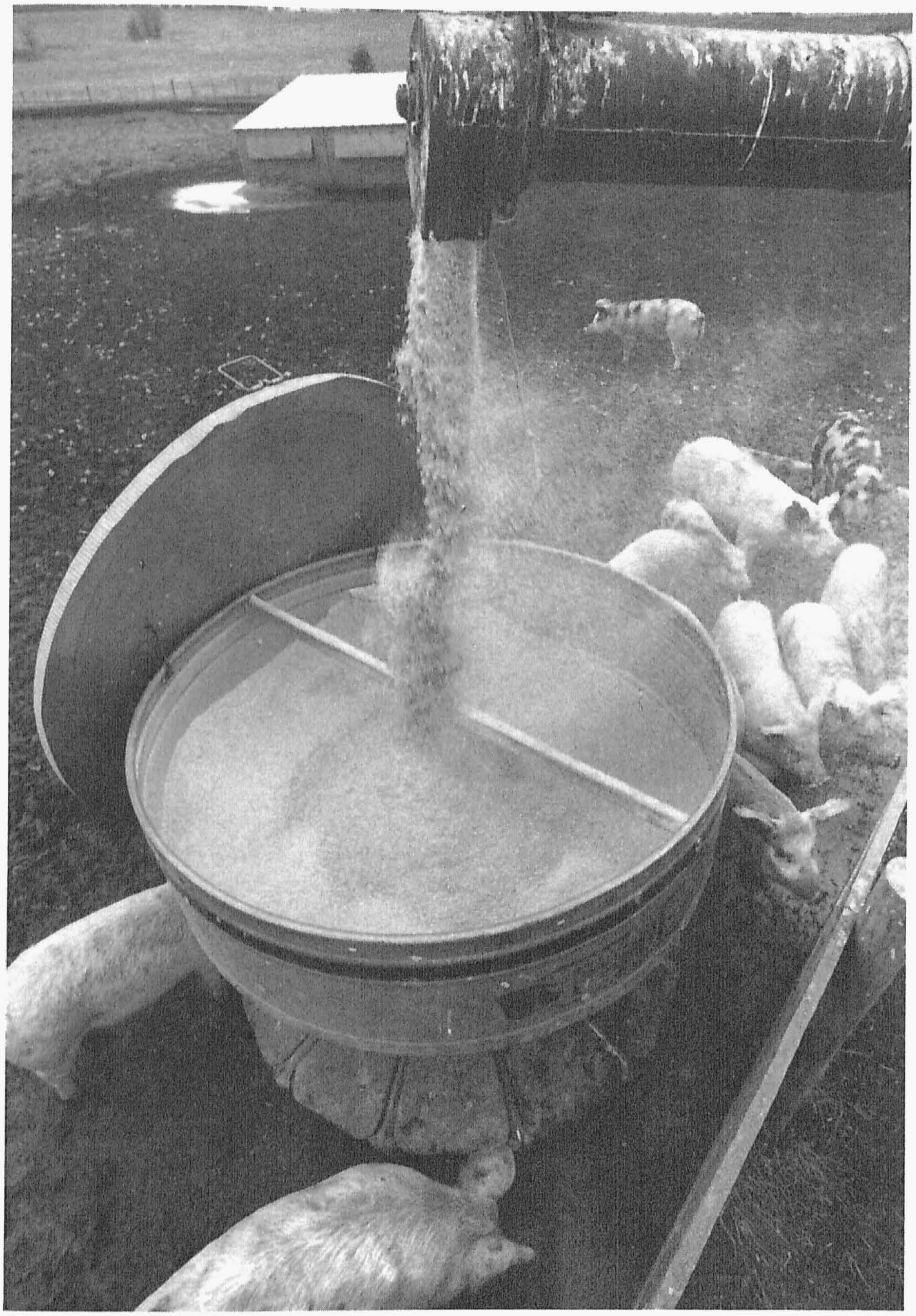
1992

Swine Day Report



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College of Agriculture

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The decade of the 1990's will continue to bring changes to the swine industry. New biotechnology products that enhance lean tissue growth and help control disease will dramatically influence pork production in the '90's. Producers must keep informed of new opportunities to make their operations more efficient and competitive.

The goal of our swine research program is to provide information that will aid Missouri producers in improving productivity or reducing costs. This 1992 Swine Research Report is one of the many efforts of the Department of Animal Sciences, University of Missouri, to assist Missouri swine producers. We have attempted to briefly inform you of what we have done, what we have found and how you may use these results in your operation. We welcome your suggestions on how we can do a better job in communicating our research results.

The swine industry in Missouri is a significant contributor to the state's economy. Our swine group at MU is dedicated to serving this very economically important Missouri swine industry by providing effective teaching, research and extension programs.

Listed within this report are those directly supporting our swine program this past year. We greatly appreciate this support.

Sincerely,

Gary L. Allee

Gary L. Allee
Unit Leader
Animal Sciences

GLA/ell

ACKNOWLEDGEMENT

Through the Mr. Frederick B. Miller Trust, the Department of Animal Sciences in the College of Agriculture is able to enrich the program of research, scholarships and development of livestock.

This publication of research topics concluded or in progress and/or lectures focus on current technology of interest of the Pork Producers in the industry. Presentation of research results will continue on an annual basis.

Participants from off-campus and from other facilities assemble with resident staff from the University of Missouri Animal Science faculty to review, discuss and update technology related to industry opportunities and problem evaluation. This new knowledge base complements existing technology and provides Missouri producers the competitive advantage or opportunity to improve resource utilization for maximum production efficiency and profitability.

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EFFECTS OF DIETARY LEVELS OF RACTOPAMINE AND CRUDE PROTEIN ON THE PERFORMANCE AND CARCASS CHARACTERISTICS OF FINISHING HOGS

G. W. Jesse[1], C. A. Martin[2] and J. A. Miyat[3]

SUMMARY

One hundred and eight crossbred barrows and gilts were used during a finishing trial to compare the effects of three different levels of Ractopamine (0, 5 and 10 ppm) and three diets that differed in level and/or quality of crude protein (16% CP/.88% lysine, corn-soy; 13.5% CP/.67% lysine, complex; and 14.6% CP/.74% lysine, complex) on performance and carcass characteristics. Growth rate was not significantly affected by treatment; however, dietary crude protein produced significant differences in feed intake (FI) and Ractopamine affected ($P<.05$) feed conversion (F/G). Ractopamine-fed pigs produced carcasses that were heavier, leaner and higher-grading.

INTRODUCTION

During the summer of 1990 a finishing trial was initiated at the University of Missouri Southwest Center, located at Mt. Vernon, to determine the effects of feeding a repartitioning agent (Ractopamine) in combination with various levels and quality of dietary crude protein on swine performance and carcass desirability.

PROCEDURES

One hundred and eight barrows and gilts (54 of each sex) averaging 161.4 lbs. were used for this study which began on September 19, 1990. The experimental design was a randomized complete block with treatments arranged as a 3 x 3 factorial and replicated three times as shown in table 1. Independent variables included three dietary levels of Ractopamine (0, 5 and 10 ppm) and three finishing diets (16.6% CP/.88% lysine, corn-soy; 13.5% CP/.67% lysine, complex; and a 14.6% CP/.74% lysine, complex).

The pigs for this study were selected from a group of 144 crossbred barrows and gilts that were utilized in a previous seven-week feeder pig management study, which terminated on August 29. This group of 144 pigs represented 72 head of multiowner pigs

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[1]University of Missouri

[2]MFA Incorporated

[3]Lilly Research Laboratories

(three sources) purchased from the Alton Sales Company of Alton, MO and 72 head of one owner pigs obtained from the MFA Research Farm at Marshall, MO. Both groups of 72 contained an equal number of barrows and gilts.

TABLE 1. EXPERIMENTAL DESIGN

Treatment				
No.	Diet[a]	Ractopamine,ppm	No. Pens	No. Pigs[b]
1	16.6% Corn-soy	0	3	12
2	16.6% Corn-soy	5	3	12
3	16.6% Corn-soy	10	3	12
4	13.5% Complex	0	3	12
5	13.5% Complex	5	3	12
6	13.5% Complex	10	3	12
7	14.6% Complex	0	3	12
8	14.6% Complex	5	3	12
9	14.6% Complex	10	3	12

[a]Dietary lysine levels were .88, .67 and .74% for the 16.6% CP corn-soy and the 13.5 and 14.6% CP complex diets, respectively.
[b]All pens were balanced by sex (barrows and gilts) and source (Alton and MFA).

Pigs were blocked by weight and randomly allocated within source (Alton vs MFA) and sex to dietary treatment on August 29, which was the ending date for the previously-mentioned feeder pig management study. Each pen contained one barrow and one gilt from each source (Alton and MFA). Dietary treatments were randomly assigned to pen within a block of nine pens. Likewise, each block was randomly assigned to barn location (west end vs middle vs east end).

Immediately prior to penning, each pig was scored for feet and leg soundness by four individuals (Jesse, Martin, Miyat and Bates) using the following system:

1 = sound
2 = borderline or questionable on soundness
3 = unsound

The test facility was an open-front barn with 30 pens that were 5' x 15' with 5' x 10' of the total pen area under roof. The floor and pen dividers were solid concrete and the back (north) wall had hinged doors that could be opened to allow for natural ventilation. Each pen was equipped with one nipple waterer and a one-hole Smidley self-feeder. A thermostatically-controlled overhead sprinkler system was available for cooling the pigs when the temperature exceeded 80 degrees F.

During the 21-day transition period (August 29 to September 19), all pigs were fed a 15% CP corn-soybean meal diet. The intent of this treatment was to remove any carry over effects of the feeder pig management study which compared various feed grade antibiotics during a seven week period. All pigs were weighed on test on September 19 and provided their respective test diet for the duration of the study.

All diets (meal form) were formulated by MFA Incorporated and prepared at their mill at Mexico, MO. The complex protein diets were formulated to investigate the use of alternative protein sources in addition to soybean meal. Ractopamine was supplied by Lilly Research Labs as a 2% premix with 1/2 lb of Ractopamine premix providing 5 ppm. Each diet was prepared as one batch and delivered to Mt. Vernon prior to the beginning of the test.

Final pig weights and pen feed consumption were obtained on day 30 (October 19) for replicate 1 and on day 44 (November 2) for replicates 2 and 3. The original intent was to feed the pigs to an average slaughter weight of 235 lbs. Average final weights at the test facility were 244.0, 236.8 and 243.0 lbs for replicates 1, 2 and 3, respectively with all 108 head completing the study.

After the pigs were weighed off test each pig was given an off-test soundness score; however, for each of the two weigh-off dates, only three of the four evaluators were able to be present. Pens of four pigs were anonymously presented to the evaluators by a fourth person to avoid any possible bias in the evaluation procedure. At this time pigs were also individually tattooed for later identification of the carcass.

All hogs were transported to the Monfort slaughter plant at St. Joseph, MO on Monday following their preceding Friday off-test date. Standard quantitative carcass data obtained included hot carcass weight and backfat thickness at the 10th and last rib. In addition, data routinely collected by Monfort Packing Company obtained for each carcass included backfat and loineye area resistance, backfat and loineye area depth (estimated electronically), percent lean and a house grade.

The data were compared by analysis of variance with means separated by Least Significant Difference protected via a significant F. Pen means were considered the experimental unit.

RESULTS AND DISCUSSION

As depicted in table 2, diet had a significant effect on feed intake (FI) whereas Ractopamine produced a significant treatment difference in feed efficiency (F/G), carcass weight, percentage lean and grade. There were no significant diet x Ractopamine interactions ($P>.05$).

Table 3 portrays feedlot performance means (ADG, FI and F/G) for all nine treatments as well as the main effects of dietary crude protein (16.6% CP/.88% lysine, corn-soy vs 13.5% CP/.67% lysine, complex vs 14.6% CP/.74% lysine, complex) and level of dietary Ractopamine (0 vs 5 vs 10 ppm). Average daily gain ranged from 2.33 lbs for those pigs fed 16.6% CP corn-soy with 10 ppm of

Ractopamine to 1.85 lbs for the 14.6% CP complex diet without Ractopamine. Raw means seem to indicate a trend toward greater gains for pigs fed Ractopamine and/or the corn-soy diet; however, it should be noted that analysis of variance revealed that treatment differences were not significant (P>.05).

TABLE 2. F-Statistic

	Dependent Variable							
Source[a]	ADG	FI	F/G	Carwt	Length	BF	%Lean	Grade
Diet	.34	.01	.21	.97	.16	.53	.10	.60
Ractopamine	.13	.61	.003	.02	.78	.38	.03	.01
Diet x Ract.	.41	.13	.68	.08	.58	.26	.14	.84

[a]Degrees of freedom were 2, 2 and 4 for diet, Ractopamine and Ractopamine x diet, respectively.

Pigs fed Ractopamine were more efficient converters of feed to gain than the control (0 ppm) pigs as noted in table 3. The 0 ppm pigs had an F/G value of 3.5 compared to 3.11 and 3.13 for the 5 and 10 ppm Ractopamine fed pigs. No other statistical differences were noted for feed efficiency.

TABLE 3. AVERAGE DAILY GAIN, FEED EFFICIENCY AND FEED INTAKE[a]

	Diet			
Ractopamine ppm	Corn-soy 16.6% CP	Complex 13.5% CP	Complex 14.6% CP	Average
		ADG		
0	2.01	1.92	1.85	1.93
5	2.08	2.19	2.02	2.10
10	2.33	1.96	2.11	2.13
Avg.	2.14	2.02	1.99	
		F/G		
0	3.50	3.67	3.34	3.50[b]
5	3.12	3.12	3.09	3.11[c]
10	3.14	3.17	3.08	3.13[c]
Avg.	3.26	3.32	3.17	
		FI		
0	1100	1087	961	1049
5	1012	1068	964	1015
10	1148	973	992	1038
Avg.	1087[d]	1043[de]	972[e]	

[a]Feed intake (FI) is expressed on a pen basis for the entire test period.
[b,c]Means in a column not having a superscript in common are different (P<.05).
[d,e]Means in a row not having a superscript in common are different (P<.05).

Feed intake was affected by dietary crude protein as noted in table 2. Those pigs fed the corn-soy diet consumed more feed than the 14.6% CP complex fed pigs. Consumption of the 13.5% CP complex diet was intermediate to the other two diets. Although diet x Ractopamine interactions were not significant, it does appear that higher levels of Ractopamine caused a linear decrease in FI of the 13.5% CP complex diet. To the contrary, there was a tendency for the 16% CP corn-soy and the 14.6% CP complex diets to be consumed in greater amounts as the level of Ractopamine increased.

As shown in table 4, Ractopamine had a significant effect on carcass weight, percentage carcass lean and carcass grade. Although dietary crude protein and diet x Ractopamine comparisons were not significant, there was tendency for diet and diet x Ractopamine to affect carcass lean and grade (P>.10 and P>.14, respectively). Actual means for carcass weight, length, last rib backfat, percent lean and grade are shown in table 4. Ractopamine-fed pigs produced heavier carcasses that were leaner and had a more desirable grade as compared to the control (0 ppm Ractopamine) pigs. The cause of the lack of an effect of level of Ractopamine on backfat thickness is not apparent.

No differences were observed in subjective feet and leg soundness scores. Average off-test scores were: 1.32, 1.36 and 1.32 for the 16.6% CP corn-soy, 13.5% CP complex and 14.6% CP complex diets, respectively and 1.25, 1.37 and 1.38 for 0, 5 and 10 ppm of Ractopamine, respectively.

TABLE 4. CARCASS TRAITS

Ractopamine ppm	Diet: Corn-soy 16.6% CP	Complex 13.5% CP	Complex 14.6% CP	Average
Carcass Weight, lbs				
0	176.1	180.5	168.8	175.1[a]
5	181.7	188.1	178.8	182.9[ab]
10	187.6	179.3	197.8	188.2[b]
Avg.	181.8	182.7	181.8	
Carcass Length, in.				
0	31.2	31.2	30.6	31.0
5	31.1	31.3	30.7	31.0
10	31.3	30.9	31.1	31.1
Avg.	31.2	31.1	30.8	
Last Rib Backfat, in.				
0	1.24	1.34	1.18	1.25
5	1.26	1.32	1.29	1.29
10	1.27	1.19	1.24	1.23
Avg.	1.26	1.28	1.23	
Carcass Lean, %				
0	48.8	47.0	46.2	47.3[c]
5	48.6	49.0	50.1	49.3[cd]
10	52.6	47.2	50.7	50.2[d]
Avg.	50.0	47.7	49.0	
Carcass Grade				
0	63.0	63.2	63.2	63.1[e]
5	63.6	64.0	64.0	63.8[f]
10	63.9	63.9	64.5	64.1[f]
Avg.	63.5	63.7	63.8	

[a,b]Means within a column not having a superscript in common are different (P<.05).

EFFECT OF SINGLE SOURCE VERSUS MULTIOWNER, COMMINGLED FEEDER PIGS AND RECEIVING DIET ANTIBIOTIC ON SUBSEQUENT HEALTH AND PERFORMANCE

G. W. Jesse[1], E. D. Usewicz[2] and C. A. Martin[3]

SUMMARY

During a seven-week study, 144 feeder pigs representing one-owner versus multiowner sources were used to determine the effectiveness of providing CSP or TYLAN/Sulfa in a 28-day receiving diet followed by either no antibiotic or TYLAN at 40 g per ton for an additional 21 days on health and performance. Average daily gain and feed efficiency significantly favored ($P<.05$) the multiowner pigs which were purchased through a commercial feeder pig barn. Growth rate during the 28-day receiving period favored the TYLAN/Sulfa group as compared to the CSP group (1.43 vs 1.30 lbs, respectively); however, feed efficiency was not different. ADG for the 49-day study was highest for those pigs provided TYLAN/Sulfa followed by TYLAN (1.55 lbs) and poorest for the CSP group that received TYLAN during the last three weeks (1.37 lbs).

INTRODUCTION

Two topics which continue to be of interest to feeder pig finishers include receiving diets and single source versus multiowner, commingled pigs. In an effort to address both of these concerns simultaneously, a seven-week feeder pig management study was conducted which included the following objectives:

To compare the health and performance of single source feeder pigs that are transported directly from farm of origin to the feeder pig finisher's farm (FTF) versus multiowner feeder pigs that are purchased from a commercial feeder pig market and commingled prior to transport to the feeder pig finisher's facility (FMF).

To compare the health and performance of feeder pigs fed a corn-soy diet with CSP or TYLAN/Sulfa for the first 28 days followed by TYLAN or no antibiotic for the remaining 21 days of a 49-day trial.

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[1]University of Missouri

[2]Elanco Animal Health Company

[3]MFA Incorporated

PROCEDURES

One hundred and forty-four feeder pigs with an average weight of 48.6 lbs were used to compare two sources of pigs (single source or farm to farm, FTF vs multiowner or farm to market to farm, FMF), two antibiotic treatments during the first 28 days (CSP vs TYLAN/Sulfa) and two different treatments during the last 21 days (no antibiotic vs TYLAN) of a 49-day trial. Details on the experimental design are included in table 1.

TABLE 1. EXPERIMENTAL DESIGN

Treatment			
	Diet		
Source of pigs[a]	d 0-28[b]	d 28-49[c]	No. of pigs[d]
FMF	CSP	Control	18
		TYLAN	18
	TYLAN/Sulfa	Control	18
		TYLAN	18
FTF	CSP	Control	18
		TYLAN	18
	TYLAN/Sulfa	Control	18
		TYLAN	18

[a]FMF pigs were purchased through the Alton Sales Company of Alton, MO and represented four different farms of origin. The FTF pigs were one owner pigs from the MFA farm at Marshall, MO.

[b]CSP provided 100 g of chlortetracycline, 100 g of sulfamethazine and 50 g of penicillin per ton. The TYLAN/Sulfa provided 100 g of tylosin and 100 g of sulfamethazine per ton.

[c]Included 40 g per ton of tylosin.

[d]Represents six pigs (3 barrows and 3 gilts) per pen; hence, six replicates of the four treatments (FMF-CSP, FMF-TYLAN/Sulfa, FTF-CSP, FTF-TYLAN/Sulfa) compared during the first 28 days and three replicates of the eight treatments (FMF-CSP-Control, FMF-CSP-TYLAN, etcetera) compared during the last 21 days of the study.

The pigs for this study represented 72 one-owner pigs from the MFA Research Farm at Marshall, Missouri and 72 multiowner pigs purchased through the Alton Sales Company at Alton, Missouri. The MFA pigs will hereafter be referred to as the FTF pigs and the Alton pigs the FMF pigs. These acronyms (FTF and FMF) refer to the pigs' travel from farm of origin to the finisher's facility (FTF) and farm of origin to a feeder pig market before delivery to the finisher's facility (FMF).

On Monday evening, July 9, 1990 Mr. Mike Dethrow (owner of the Alton Sales Co.) selected 36 barrows and 36 gilts for this study from four different consignments (most pigs came from three farms) shortly after their arrival at the barn. These pigs were kept in separate pens according to owner until their shipment the following evening. During the pigs' stay at the market they were not provided feed or water. On Tuesday, afternoon the pigs were eartagged, given an ivermectin injection and individually weighed. At this particular time, pigs were randomly assigned, within source and sex, to receiving treatment (CSP vs TYLAN/Sulfa) with the treatment being designated by one of two colors of ear tags.

On Tuesday evening (July 10) the pigs were transported by truck to the University of Missouri Southwest Center at Mount Vernon arriving at the test facility at approximately 6 a.m. on Wednesday, July 11. Upon arrival at the test facility all pigs were weighed and assigned to pen and replicate at random, within sex, to their previously determined receiving treatment. Each pen contained six head (3 barrows and 3 gilts).

Procedures and time schedule for the seventy-two FTF pigs (36 barrows and 36 gilts) located at the MFA Research Farm at Marshall were nearly identical to those previously described for the FMF pigs of Alton. After unloading, the FTF and FMF pigs were kept in separate areas to prevent nose-to-nose contact prior to placement in their respective test pens.

The test facility was an open-front barn with thirty 5' x 15' pens. The floor and the pen dividers are solid concrete and the back wall can be opened to allow for natural ventilation. Each pen is equipped with a one-hole Smidley feeder and a nipple waterer.

The basal receiving diet was a 15% crude protein corn-soybean meal diet in meal form. As shown by the experimental design (table 1), during the first four weeks half of the pigs were fed a diet that included CSP and the other half TYLAN/Sulfa. On day 28, half of each of the antibiotic-fed groups were switched to the basal 15% crude protein diet without an antibiotic and the other half received the basal diet with 40 g of TYLAN for the duration of the seven-week study.

Pig weights and feed consumption by pen were determined on day 14, 28 and 49. The data were compared by analysis of variance as a randomized complete block with pen being the experimental unit. Treatment means were separated using Fisher's Least Significant Difference.

RESULTS AND DISCUSSION

Average daily gain by source (FMF vs FTF), diet during the first 28 days (CSP vs TYLAN/Sulfa; Diet1), diet during the last 21 days (Control vs TYLAN; Diet2) and the interaction of diet for the first 28 days with the last 21 days (Diet1 x Diet2) is shown in table 2. Generally speaking, health of the pigs was excellent. Two pigs failed to complete the study; one FTF-CSP pig was removed from test on day 28 due to scouring and poor performance and one FMF-CSP pig was removed on day 33 because of a rectal prolapse. Growth rate for the multiowner FMF pigs was significantly greater ($P<.05$) than the single source FTF pigs during last three weeks and for the entire 49-day study (1.68 vs 1.50 lbs and 1.51 vs 1.42 lbs, respectively).

During the second 14-day period and for the entire 28-day receiving period the TYLAN/Sulfa-fed pigs outgained ($P<.05$) those provided CSP; however, during the last three weeks and for the 49-day study performance was essentially the same. However, one should keep in mind that dietary treatments for these pigs actually changed on day 28.

Average daily gain by diet during the last 21-day period (indicated as Diet2) and for the entire 49-day study was not different for the two treatments which were 'no antibiotic' versus 'TYLAN'.

As shown in table 2, there was a significant diet by diet (Diet1 x Diet2) interaction for the overall 49-day study. Those pigs switched from CSP to TYLAN were slower growing ($P<.05$) than pigs started on TYLAN/Sulfa and then switched to TYLAN (1.37 vs 1.55 lbs; $P<.05$). On the other hand, the initial antibiotic (CSP or TYLAN/Sulfa) did not seem to affect subsequent performance when the pigs were switched to a control diet during the last 21 days. One can speculate that switching pigs from one antibiotic to another greatly different antibiotic may be detrimental to subsequent performance. A future study which would include an additional treatment of switching TYLAN/Sulfa pigs to CSP seems warranted in order to further investigate this aspect.

TABLE 2. AVERAGE DAILY GAIN BY SOURCE AND DIET

Treatment	Days d 0-14	d 14-28	d 0-28	d 28-49	d 0-49
Source					
FMF	1.16	1.60	1.38	1.68[a]	1.51[a]
FTF	1.09	1.62	1.36	1.50[b]	1.42[b]
Diet1 (d 0-28)					
CSP	1.08	1.52[a]	1.30[a]		
T/S	1.17	1.70[b]	1.43[b]		
Diet2 (d 28-49)					
C				1.56	1.47
T				1.62	1.46
Diet1 x Diet2					
CSP x C	1.15	1.61	1.38	1.62	1.48[a]
CSP x T	1.01	1.42	1.22	1.57	1.37[b]
T/S x C	1.13	1.68	1.40	1.51	1.45[ab]
T/S x T	1.21	1.72	1.46	1.67	1.55[a]

[ab]Means in a column by source, diet1, diet2 or diet1 x diet2 having a different superscript are different ($P<.05$).

Although no significant ADG differences occurred for source x diet1 x diet2, means for these eight treatments are provided in table 3. Numerically speaking, the fastest and the slowest gaining for the first 28 days and the overall 49-day trial were the FMF-T/S-TYLAN and the FTF-CSP-TYLAN treatment groups, respectively.

TABLE 3. AVERAGE DAILY GAIN FOR SOURCE X DIET1 X DIET 2, LBS.

Treatment			Days				
			d 0-14	d 14-28	d 0-28	d 28-49	d 0-49
FMF	CSP	Control	1.10	1.55	1.33	1.76	1.51
FMF	CSP	TYLAN	1.11	1.40	1.25	1.63	1.41
FMF	T/S	Control	1.13	1.71	1.42	1.53	1.47
FMF	T/S	TYLAN	1.29	1.73	1.51	1.80	1.63
FTF	CSP	Control	1.21	1.67	1.44	1.47	1.45
FTF	CSP	TYLAN	.92	1.45	1.19	1.52	1.33
FTF	T/S	Control	1.12	1.65	1.39	1.49	1.43
FTF	T/S	TYLAN	1.12	1.71	1.41	1.55	1.47

Means were not different (P>.05).

As shown in table 4, feed efficiency values for the most part, were not significantly affected by treatment; however, F/G values did favor (P<.05) the FMF pigs for three of the five comparisons (d 0-28, d 28-49 and d 0-49). This significant difference for the first 28 days is somewhat surprising since ADG by source was not different; however, during the last three weeks and for the entire 49-day study the FMF pigs were faster gaining, therefore one could expect this relationship of ADG to F/G. No significant interactions were observed and therefore feed efficiency means for all eight treatments will not be shown.

TABLE 4. FEED EFFICIENCY (F/G) BY SOURCE AND DIET

Treatment	Days				
	d 0-14	d 14-28	d 0-28	d 28-49	d 0-49
Source					
FMF	2.16	2.19	2.17^{a}	2.79^{a}	2.48^{a}
FTF	2.45	2.35	2.35^{b}	2.96^{b}	2.62^{b}
Diet1 (d 0-28)					
CSP	2.42	2.25	2.28		
T/S	2.19	2.29	2.25		
Diet2 (d 28-49)					
C				2.92	2.57
T				2.83	2.54
Diet1 x Diet2					
CSP x C	2.20	2.21	2.21	2.86	2.55
CSP x T	2.64	2.29	2.34	2.79	2.56
T/S x C	2.11	2.38	2.27	2.98	2.58
T/S x T	2.26	2.21	2.22	2.87	2.52

[ab]Means by source, diet1 or diet2 or diet1 x diet2 having a different superscript are different ($P<.05$).

EFFECTS OF PRODUCTION SYSTEM AND SLAUGHTER WEIGHT ON GROWTH RATE, CARCASS COMPOSITION AND TENDERNESS OF PORK

E. J. ESAH[1], G. W. Jesse[1], H. B. Hedrick[2] and H. Heymann[2]

SUMMARY

Sixty-five crossbred barrows were used in two trials to determine the effect of production system and slaughter weight on growth rate, pork tenderness and quantitative and qualitative carcass characteristics. Pigs raised in confinement were significantly faster gaining ($P<.05$) and fatter ($P<.05$) than those finished in outside (dirt) lots. No differences were found in pork tenderness due to system of production.

INTRODUCTION

Although, historically all pork has been assumed to be tender due to the relative young age at which pigs are slaughtered, Hendrix et al. (1963) reported that toughness was a major reason for unacceptability of pork. Anderson and Parrish (1972) advocated that as more and more pigs are raised in confinement rather than pasture, efforts should be directed to determine if system of production has any effect on palatability of muscle. It is quite evident from a search of the literature that pork tenderness has received much less attention than tenderness of beef; hence, we decided this area should be examined. The objectives of this study were to determine: 1) the effect of system of production (Confinement vs Non-confinement) and slaughter weight (220 vs 240 vs 260 lbs) on the tenderness of pork, 2) to determine the effect of system of production and slaughter weight on carcass composition and 3) to determine the effect of system of production on growth rate.

PROCEDURES

Sixty-five university-raised, crossbred barrows of Landrace, Yorkshire and Duroc descent were used for this study to compare six treatments as shown in table 1. All pigs were farrowed at the Swine Research Complex (SRC) which is a total confinement facility and weaned at four weeks. The pigs then spent five weeks in the SRC grower facility. However, after this, the trial 1 and 2 pigs were handled differently. Trial 1 littermate pairs were randomly assigned to either the Confinement or Non-confinement treatment at nine weeks of age compared to assignment

[1]Animal Sciences Department

[2]Food Science & Nutrition Department

to treatment at 11 weeks for the trial 2 pigs. The Non-confinement pigs were transported from the SRC to the Pasture Facility (PF) immediately following assignment to treatment. At this time, these pigs were placed in a modified open-front barn for the next three weeks. At approximately 12 and 14 weeks of age the trial 1 and 2 pigs, respectively were placed in an outside (dirt) lot and given access to an open-front shelter.

Our original intent was to have equal representation across slaughter weight groups; however, due to difference in growth rate and the logistics of scheduling slaughter, we ended up with unequal numbers by weight group as shown in table 1.

TABLE 1. EXPERIMENTAL DESIGN[a]

Treatment		No. of pigs[b]	
System of production	Slaughter wt, lb	Trial 1	Trial 2
Confinement	220	3	4
	240	5	4
	260	8	8
Non-confinement	220	11	5
	240	4	5
	260	2	5

[a]Trial 1 (Winter Trial) was initiated in November and completed in March, 1991. Trial 2 (Summer Trial) represented the period of June to October, 1991.

[b]Trial 1 included 16 littermate pairs plus one extra pig. Trial 2 used 16 littermate pairs; however, one poor performing pig was removed from test before completing the study.

All pigs were fed a 16% CP corn-soybean meal diet (G diet; meal form) throughout the test period. During the first six weeks the diet included banminth and mecadox; however, no additives were fed for the remainder of the study.

Dependent variables obtained include: ADG and quantitative and qualitative carcass measurements of weight, length, backfat thickness, loin muscle (eye) area and quality grade. A sensory panel evaluation of a loin chop was conducted of all carcasses of trial 1 and in addition, Warner-Bratzler shear (Instron) values were determined on the longissimus muscle for both trials. The chops were cooked by oven broiling and cooking loss was determined. One half of each carcass was ground and subsampled for subsequent chemical (proximate) analysis.

RESULTS AND DISCUSSION

As shown in table 2, growth rate differed significantly between the two production systems. Average daily gain for the Confinement (SRC) fed pigs was .15 lb/day more ($P<.05$) than the

Non-confinement (PF) pigs. Likewise, days to 230 lbs favored the SRC reared pigs (6.3 and 8.9 days for trials 1 and 2, respectively). Growth rate during the summer trial was lower than during the winter trial.

TABLE 2. FEEDLOT PERFORMANCE

	Trial 1		Trial 2	
Variable	SRC	PF	SRC	PF
Initial wt, lb	53.9	55.8	76.3	76.9
Ending wt., lb	237.6	219.5	237.7	234.0
ADG, lb	1.79[a]	1.65[b]	1.66[a]	1.52[b]
Days to 230 lb	161.6[a]	167.9[b]	172.2[a]	181.1[b]

[a,b]Means within a row by trial not having a superscript in common are different (P<.05).

As shown in table 3, several treatment differences were noted in quantitative carcass traits; however, qualitative traits were not significantly affected by treatment. Pigs raised in confinement (SRC) produced heavier, fatter carcasses (P<.05) with these differences being greater during the winter trial. Although not significant, there was a trend for the older, outside fed (PF) pigs to have larger loin eyes.

TABLE 3. QUANTITATIVE AND QUALITATIVE CARCASS CHARACTERISTICS

	Trial 1		Trial 2	
Variable	SRC	PF	SRC	PF
Quantitative traits				
Cold car. wt.,lb	173.1[f]	167.9[g]	173.9	170.4
Length, in.	30.4[f]	31.3[g]	31.9	31.7
LEA[a], sq. in.	4.5	5.0	4.6	4.9
BF[b], in.	1.5[f]	1.2[g]	1.3[f]	1.2[g]
Leaf fat, lb	4.8[f]	3.9[g]	4.1	3.6
Dressing percent	74.8[f]	73.0[g]	74.9[f]	72.7[g]
Qualitative traits				
Muscling score[c]	4.97	4.72	5.17	4.73
Marbling score[d]	2.24	2.31	2.08	2.13
Color score[d]	2.89	2.80	2.46	2.60
Firmness score[e]	2.11	2.08	2.04	2.00

[a]Adjusted to a 230 lb basis.

[b]Represents an average of three measurements (1st rib, last rib and last lumbar) adjusted to a 230 lb basis.

[c]Subjective scores were 1-9 with 9 being the heaviest muscled.

[d]Subjective scores were 1-5 with 5 being the most marbling or color.

[e]Subjective scores were 1-3 with 3 being the firmest.

[f,g]Means in a row by trial not having a common superscript are different (P<.05).

Sensory analysis (palatability traits) and instron values are shown in table 4. There were no significant differences in tenderness, juiciness, chewiness, flavor, shear force or cooking loss values.

TABLE 4. SENSORY ANALYSIS AND INSTRON VALUES

	Trial 1		Trial 2	
Variable	SRC	PF	SRC	PF
Tenderness[a]	5.43	4.88		
Juiciness[a]	4.28	3.88		
Flavor[a]	5.00	4.91		
Chewiness	22.47	22.97		
Instron value[b] (kg)	3.99	4.16	4.29	4.36
Cooking loss (%)	23.37	21.53	26.75	26.66

[a] Subjective scores were 1-9 with 9 being the most tender, most flavor and most juicy.
[b] Instron (Shear Force) value is an average force (kg) required to shear a 1.20 cm core of cooked chop. It is a mechanical compression test to cross check tenderness.

As shown in table 5, pigs raised in total confinement were fatter (P<.05) than those finished in outside lots during both trials with the Winter trial (Trial 1) pigs being fatter than those finished during the summer.

TABLE 5. PROXIMATE ANALYSIS OF THE CARCASS

	Trial 1		Trial 2	
Variable	SRC	PF	SRC	PF
Protein (%)	14.24	14.69	14.40[a]	15.31[b]
Fat (%)	41.66[a]	36.30[b]	38.38[a]	33.40[b]
Moisture (%)	41.73[a]	46.49[b]	44.49[a]	47.77[b]
Ash (%)	2.78	2.82	2.62	2.87

[a,b]Means within a row by trial not having a superscript in common are different (P<.05).

CONCLUSIONS

These results indicate that pigs of similar genetic makeup finished in total confinement will be fatter than outside fed pigs. Hence, in order to produce a carcass similar in composition one may need to market confinement fed pigs at a lighter weight.

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Effect of sex and lysine level on performance of market hogs.[a]

S.L. Tilton, R.O. Bates, J.C. Rea and S. Woods.

Summary

Research was conducted to evaluate the effect of feeding two different lysine levels to barrows and gilts penned by sex from 130 pounds to market weight. Rations were formulated to contain .65% and .82% lysine, and were fed ad libitum. Results of this study indicate that it is beneficial to feed the higher lysine diet to gilts between 130 and 180 pounds. However, it was not beneficial to feed the .82 % lysine ration to barrows from 130 pounds to market weight. Feeding the high lysine ration to gilts also tended to reduce last rib fat thickness. The results obtained here and in prior research suggest that it is beneficial to pen market hogs by sex so that gilts can receive a higher lysine diet than barrows, at least from 130 to 180 pounds.

Introduction

It is common knowledge that gilts and barrows differ in growth rate, feed efficiency and carcass composition. There is a general trend for gilts to be leaner and heavier muscled than barrows. This higher percentage of body protein suggests that gilts have a higher protein requirement than barrows to obtain maximum efficiency of gain (Shurson and Miller, 1983). However, there are also environmental and genetic factors that can effect the response to increased dietary protein.

Research was therefore designed to evaluate growth and production traits in a study using two different lysine levels and feeding animals by sex.

Materials and Methods

Two replicates of 200 pigs each, with average initial body weight of 131 pounds were used in a 2 X 2 factorial to evaluate the effect of sex, barrow or gilt, and lysine content of diet, .65% or .82%. Pigs were reared in confinement with free choice access to nipple waterers and ad libitum feed intake. Pigs were weighed initially at an average weight of 130 pounds, at approximately 180 pounds and again at an average weight of 230 pounds. Feed intake was measured by recording feed added to the feeders and weighing feed remaining at 180 and 230 pounds. Upon completion of the study, all pigs had last rib fat thickness measured via ultrasound.

Lysine content of the diets was altered by changing the ratio of corn to soybean meal, with rations being formulated to

[a] We wish to thank Ham Hill Farms, Marshall, MO for their cooperation with this study.

contain .65% and .82% lysine (Table 1). Actual analyses of these diets were similar to what was expected with diets containing 12.1% and 14.88% crude protein.

Average daily gain (ADG) and average daily feed intake (ADFI) were recorded, and the feed to gain ratio was calculated and analyzed for differences due to sex and protein level. No interactions (P>.05) were found between replications so data were pooled.

Results and Conclusion

Average daily feed intake was greater (P<.05) for barrows than gilts (see Table 2). However, gilts were more efficient (P<.05) at utilizing feed consumed compared to barrows.

Gilts fed the high lysine diet had higher average daily gains than gilts on the low lysine ration between 130 and 180 pounds (P<.05; see Table 2), and did not differ from barrows fed the high lysine diet during this period. However, the higher lysine level did not affect the performance of gilts between 180 and 230 pounds. No differences in average daily gain were seen between high lysine and low lysine rations when fed to barrows between 130 and 180 pounds; however, barrows fed the low lysine ration between 180 and 230 pounds gained better than those fed the high lysine diet. Gilts fed the high lysine diet tended to be leaner (P=.10) than gilts fed the low lysine diet, although both groups of gilts were leaner than barrows (P<.01).

The results obtained form this study show that it is beneficial to feed a higher protein diet to gilts than barrows, from 130 pounds and 180 pounds body weight. This difference may be even further modified by feeding genetically leaner gilts and possibly even barrows, as they may be able to more efficiently utilize the higher protein level in the diet.

Literature Cited

Shurson, G.C. and E.R. Miller. 1983. Growth performance and carcass characteristics of barrows and gilts on different dietary protein levels. Michigan State University Swine Research Report AS-SW-8309 p. 35.

Table 1. Formulation of high and low lysine rations.

Ingredient	High Lysine	Low Lysine
Corn	81.6 %	88.6 %
Soybean meal	15.5 %	9.0 %
Dical	1.2 %	.8 %
Calcium	.9 %	.8 %
Vitamin/trace mineral	.4 %	.4 %
Salt	.25%	.25%
Lysine	.15%	.15%
Total	100.0 %	100.0 %
Crude Protein, %	14.88 %	12.08 %
Lysine, %	.82 %	.65 %
Calcium, %	.69 %	.79 %
Phosphorus, %	.59 %	.55 %

Table 2. Performance of barrows or gilts on high or low lysine levels.

	Barrows		Gilts					
Percent Lysine	.65	.82	.65	.82	S.E.	Sex	Lysine	S X L
ADG1, lb/day	1.795	1.724	1.641[b]	1.786[a]	0.032	--	--	.05
ADG2, lb/day	1.505[a]	1.427[b]	1.507	1.478	0.035	--	--	.05
ADG, lb/day	1.630[a]	1.562[b]	1.569	1.613	0.024	--	.05	.05
ADFI, lb/day	6.319	6.166[a]	6.003	5.842[b]	0.085	.05	.05	.05
FE	3.961	3.880[a]	3.780	3.667[b]	0.060	.05	.05	.05
LRF, in.	0.964	0.950	0.835[a]	0.765[b]	0.160	.01	--	.10

[a,b] LSMEANS with different superscripts differ by value in S X L column.

EXTRUDED WHOLE SOYBEANS vs SOYBEAN MEAL IN FINISHING SWINE RATIONS

John C. Rea, Ron O. Bates and Scott Woods[a]
State Swine Specialists

SUMMARY

Two hundred growing-finishing pigs were allotted by sex and protein source to a trial to compare performance from 83 to 220 pounds. Pigs were fed corn-soybean meal rations or corn - extruded whole bean rations. Overall gains of pigs were similar on either the soybean meal or the extruded bean rations, however, during finishing, pigs on extruded beans had slightly faster gains than those on soybean meal rations. Pigs on the extruded bean rations ate less feed and had significantly improved conversion of feed to pork compared to the finishign phase those on soybean meal rations.

Barrows had significantly faster gains than gilts but were less efficient in converting feed to gain.

METHODS AND PROCEDURES

In the summer of 1991 a field trial was conducted at the Ham Hill hog farm at Marshall, Missouri to compare performance of market hogs fed grower and finisher rations using either 48 percent soybean meal or whole extruded soybeans as the primary protein supplement source.

Two-hundred market hogs (100 barrows and 100 gilts) were started at approximately 83 pounds and fed to 220 pounds average ending weights. Pigs were housed in a complete slatted floor, pit confinement buildings. Pigs were penned by sex with 10 pigs per pen in 8 x 10 foot pens. Animals were allotted to rations shown in tables 1 and 2. Grower rations were fed until pigs weighed 131 pounds. Pigs were on finishing rations from 131 to 220 pounds.

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[a]Area Livestock Specialist, Higginsville

Table 1. Grower Rations

Corn-Soy Ingredient	Lbs	Corn-Whole Beans Ingredient	Lbs
		Extruded	
SBM (48%)	425	Beans	500
Dical	33	Dical	33
L.S.	17	L.S.	17
Premix	6.5	Premix	6.5
Vit. mix	6.5	Vit. mix	4.5
Lysine	--	Lysine	3.0
Salt	5	Salt	5.0
Filler	4	Filler	4.0
Corn	1505	Corn	1427
Total	2000	Total	2000
Nutrient Analysis			
Protein, %	16.06		17.51
Lysine, %	1.026		.990
Calcium, %	.98		.88
Phosphorus, %	.75		.75

Table 2. Finisher Rations

Corn-Soy Ingredient	Lbs	Corn-Whole Beans Ingredient	Lbs
		Extruded	
SBM (48%)	250	Beans	300
Dical	22.5	Dical	22.5
L.S.	17.5	L.S.	17.5
Premix	4.5	Premix	4.5
Vit. mix	3.5	Vit. mix	3.5
Lysine	3.0	Lysine	4.25
Salt	5.0	Salt	5.0
Filler	4.0	Filler	4.0
Corn	1693	Corn	1641.75
Total	2000	Total	2000
Nutrient Analysis			
Protein, %	13.48		14.41
Lysine, %	.804		.851
Calcium, %	.99		.90
Phosphorus, %	.56		.64

RESULTS

Performance data are shown in tables 3 thru 9. Overall pigs on soybean meal and extruded beans had similar daily gains (table 5). During the finishing phase (131-220 pounds) however pigs on extruded bean rations had slightly higher gains ($P<.10$) than those pigs on meal rations (table 4). Feed efficiency of pigs fed extruded bean rations was better than those fed soybean meal during both the grower and finisher stages ($P<.01$). Feed intake of pigs on extruded bean rations was significantly less than pigs on soybean meal rations ($P<.01$).

Barrows in this trial gained faster, ate more feed per day but were less efficient in feed utilization than were gilts ($P<.01$).

During the grower phase barrows on extruded bean rations had the most efficient feed conversion however during the finisher phase and overall gilts had the best conversion of feed to pork.

Table 3. Pig Performance (83-131 pounds) on SBOM or Extruded Bean Rations

Trait	SBOM	Extruded
ADG, lbs	1.52	1.49
Feed/day, lbs	4.36^{a}	3.99^{b}
Feed/gain, lbs	2.90^{a}	2.66^{b}

^{a,b}Means with different superscript are different ($P<.01$).

Table 4. Pig Performance (131-220 pounds) on SBOM or Extruded Bean Rations

Trait	SBOM	Extruded
ADG, lbs	1.58^{a}	1.64^{b}
Feed/day, lbs	5.49^{c}	5.26^{d}
Feed/gain, lbs	3.61^{c}	3.47^{d}

^{a,b} = ($P<.10$). ^{c,d} = ($P<.01$).

Table 5. Pig Performance (83-220 pounds) on SBOM or Extruded Bean Rations

Trait	SBOM	Extruded
ADG< lbs	1.56	1.59
Feed/day, lbs	5.07[a]	4.79[b]
Feed/gain, lbs	3.34[a]	3.16[b]

[a,b]Means with different superscripts are different ($P<.01$).

Table 6. Pig Performance by Sex (83-220) Pounds

Trait	Barrows	Gilts
ADG, lbs	1.62[a]	1.53[b]
Feed/day, lbs	5.01[a]	4.86[b]
Feed/gain, lbs	3.30[a]	3.20[b]

[a,b]Means with different superscripts are different ($P<.05$).

Table 7. Pig Performance by Sex as Affected by Protein Source (83-131 pounds)

	Barrows		Gilts	
Trait	SBOM	Extruded	SBOM	Extruded
ADG, lbs	1.53	1.53	1.51	1.46
Feed/day, lbs	4.43[a]	3.93[b]	4.28[a]	4.05[b]
Feed/gain, lbs	2.95[a]	2.62[b]	2.85[a]	2.69[b]

[a,b]Means with different superscripts are different ($P<.05$).

Table 8. Pig Performance by Sex as Affected by Protein Source (131-220 pounds)[a]

	Barrows		Gilts	
Trait	SBOM	Extruded	SBOM	Extruded
ADG, lbs	1.64	1.67	1.52	1.61
Feed/day, lbs	5.64	5.32	5.34	5.18
Feed/gain, lbs	3.74	3.51	3.48	3.42

[a]The treatment by diet interaction was not important ($P<.10$).

Table 9. Pig Performance by Sex as Affected by Protein Source (83-220 pounds)

	Barrows		Gilts	
Trait	SBOM	Extruded	SBOM	Extruded
ADG, lbs	1.60	1.63	1.51	1.54
Feed/day, lbs	5.20[a]	4.02[b]	5.95	4.77[b]
Feed/gain, lbs	3.44[a]	3.18[b]	3.25	3.14[b]

[a,b]Means with different superscripts are different (P<.05)

Yeast Culture Supplementation of Sow Diets[a]

Juan C. Reyes and Trygve L. Veum

Summary

Ninety-four crossbred sows and gilts were used to determine the effect of yeast culture on apparent nutrient digestibilities and sow reproductive performance from day 60 of gestation through day 28 of lactation. Yeast culture was added at 0, .5, 1.0 or 2.0% of the diet. Sows were fed 4.73 lb per day of a 13% CP corn-soybean diet containing 25.0% alfalfa meal during gestation. During lactation a 14% corn-soybean diet containing 12.5% alfalfa meal was fed to appetite. Yeast culture treatment had no effect (P>.05) on litter performance. Apparent nutrient digestibilities were not affected (P>.05) by yeast culture during gestation or lactation.

Introduction

Yeast culture, a fungal product, has been reported to increase dry matter, fiber and protein digestion by ruminants (Wiedmeier et al., 1987). Yearling horses had higher nitrogen retention when yeast culture was added to the diet (Glade and Biesick, 1986). Yeast culture tended to improve feed efficiency of young pigs (Bowman and Veum, 1973; Veum et al., 1988) and the performance and phosphorus utilization in heavy pigs (Chapple, 1981).

This experiment was conducted to determine the effect of yeast culture on the apparent nutrient digestibilities of gestation and lactation diets and on sow reproductive performance from day 60 of gestation to day 28 of lactation.

Methods and Materials

A total of 94 crossbred sows and gilts were allotted to one of four treatment groups on day 60 of gestation. Four treatment groups were made by adding yeast culture (Diamond V. Mills, Inc., Cedar Rapids, IA) at 0, .5, 1.0 or 2.0% of the diet. Sows were fed 4.73 lb per day of a 13% crude protein corn-soybean meal diet containing 25.0% alfalfa meal in individual stalls during gestation (Table 1). A 14% crude protein corn-soybean meal diet containing 12.5% alfalfa meal was fed to appetite during lactation. Chromic oxide was added to the diets at .05% as an indigestible marker, and fecal samples were collected from days 90 to 97 of gestation and 20 to 27 of lactation. Diets and feces were analyzed for dry mater, chromium, nitrogen, crude fat, neutral detergent fiber, acid detergent fiber, ash and gross energy. Data for six farrowing groups was pooled and analyzed statistically; testing for treatment, farrowing group, and treatment x farrowing group. Treatments were also tested for linear, quadratic and cubic effects.

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[a]Diamond V. Mills, Inc., Cedar Rapids, IA is acknowledged for supporting this research and supplying the yeast culture.

Results

Yeast culture did not (P>.05) affect sow weight gain during gestation (Table 2), and did not (P>.05) improve the digestibilities of dry matter, energy, protein, fat, acid detergent fiber, or neutral detergent fiber during gestation or lactation (Table 3). All nutrient digestibilities were higher (P<.01) during lactation compared to gestation. Control sows (no yeast culture) lost more weight (P<.05) per day during lactation than sows fed 1.0 or 2.0% yeast culture (Table 2). There was a linear (P<.05) reduction in weight loss with increasing concentration of yeast culture. However, this greater weight loss for the control sows may be explained at least in part by the fact that the control group produced heavier litters (not statistically) at 21 days and consumed slightly less feed during lactation than sows fed 1.0 or 2.0% yeast culture. The greater milk production required to produce heavier litters would explain the greater weight loss of the control group during lactation. Yeast culture treatment did not (P>.05) affect litter performance to 21 days of age (Table 2).

Conclusion

Yeast culture did not improve litter performance or nutrient digestibilities of sows during gestation or lactation.

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TABLE 1. Composition of Basal Diets

Ingredient (%)	Gestation Diet (control)	Lactation Diet (control)
Corn	61.54	67.91
Alfalfa meal (dehydrated)	25.00	12.50
Soybean meal, 44%	5.02	10.80
Lard	3.00	3.00
Wheat middlings[a]	2.00	2.00
Monosodium phosphate	1.54	.53
Dicalcium phosphate	.90	1.86
Trace mineral premix[b]	.50	.50
Vitamin premix[b]	.50	.50
Salt	.40	.40
TOTAL	100.00	100.00

Calculated nutrient composition (analyzed values in parentheses):

Nutrient	Gestation	Lactation
Digestible energy, Mcal/lb	1.36	1.50
Crude protein, %	13.0	14.0
NDF, %	19.0 (25.3)	14.0 (21.6)
ADF, %	11.1 (11.7)	7.5 (8.7)
Lysine, %	.54	.62
Calcium, %	.83	.88
Phosphorus, %	.74	.79

[a]Yeast culture replaced wheat middlings at .05%, 1.0% and 2.0% for gestation and lactation feed formulations.
[b]Exceeded NRC (1988) requirements.

TABLE 2. Sow and Litter Performance

Variable	Control	Yeast Culture .5%	Yeast Culture 1.0%	Yeast Culture 2.0%
Sow weight, lb.				
Day 60 of gestation	461	460	461	468
Day 107 of gestation	514	511	519	520
Day 1 of lactation	478	474	482	493
Day 28 of lactation	445	459	464	466
Daily weight loss from day 1 to 28 of lactation, lb[a]	-1.30[b]	-.81[bc]	-.62[c]	-.55[c]
Lactation daily feed intake, lb.	12.8	12.3	13.4	13.2
Interval between weaning and estrus, days	5.4	5.5	5.4	5.1
Number of pigs born alive	9.8	10.0	11.3	9.7
Litter weight at birth, lb	35.6	33.2	40.0	33.9
Litter size on day 21	8.7	8.5	8.8	8.1
Litter weight on day 21, lb	119.5	109.8	109.6	112.9

[a]Linear effect ($P<.05$)
[b,c]($P<.05$)

TABLE 3. Digestibility of Nutrients in Sow Diets Containing Difference Concentrations of Yeast Culture[a]

	Treatment			
		Yeast Culture		
Variable	Control	.5%	1.0%	2.0%
		Gestation, %		
Dry matter	73.98	73.62	74.48	75.13
Energy	74.13	73.83	74.59	75.19
Nitrogen	69.45	68.34	69.25	70.51
Fat	74.69	76.35	77.11	74.80
ADF	35.27	34.20	36.29	37.91
NDF	54.89	55.33	56.52	56.76
		Lactation, %		
Dry matter	78.03	78.13	79.14	78.82
Energy	78.03	77.38	78.94	78.58
Nitrogen	72.22	71.64	72.84	73.28
Fat	76.13	76.52	78.87	78.15
ADF	43.83	43.62	44.78	43.02
NDF	61.42	61.75	62.73	62.07

[a]Higher ($P<.01$) mean digestibility values during lactation compared to gestation. No yeast culture effect ($P>.05$).

1991 MISSOURI SWINE FEED SURVEY[1]

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SUMMARY

Forty-three hog farmers across Missouri cooperated in a study to evaluate ration quality of swine feeds. Nutrient analysis were made of 118 complete swine feeds for protein, lysine, phosphorus and calcium. Eighty-one grain samples were analyzed for protein content and presence of mycotoxins.

The analysis of complete feeds showed a wide range in nutrient content compared to either producers formulation or NRC nutrient recommendations. About 20 percent of these rations would be expected to result in reduced performance or unnecessarily high feed costs.

Protein analysis of grain also showed a wide range upon analysis and averaged below common book values for protein in corn. Twenty percent of grain samples had detectable levels of mycotoxins, but most were not sufficient to adversely affect performance of pigs.

INTRODUCTION

Surveys conducted through the mid-west during the 80's indicate that a large amount of the swine feeds being fed are manufactured on farms. Concerns about quality feeds and good mixing procedures vary from year to year. Low hog prices often stimulate a closer look at the job we are doing in this area how it effects feed quality and overall profits. Such things as drug contamination also bring to producers attention the possibility of poor mixing procedures causing excess drug and residue problems.

In the early 80's a feed sampling survey was conducted in Missouri. Two-hundred sixteen hog feed samples were analyzed for protein, calcium and phosphorus. In addition, at that time, 80 samples of feed ingredients were analyzed for sulfa residue. Results indicated many of the swine rations being fed in Missouri did not contain proper nutrient levels of protein, calcium and phosphorus. At that time also 16 percent of the samples contained sulfa residue in amounts sufficiently high to cause residue in hogs at a violative rate.

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[1]Supported by grants from the Missouri Pork Producers Association and Commercial Agriculture Funding.

Table 1 shows the feed analysis of feed samples taken at that time on finishing rations.

Table 1. FINISHING FEED SAMPLE ANALYSIS
MU 1982

Analysis	No.	Avg. %	Range %	NRC %
Crude protein	62	14.6	11.4 - 20.4	13.0
Calcium	62	.71	.2 - 1.2	.5
Phosphorus	62	.52	.4 - .8	.4

Sixty-two finishing rations were analyzed. Protein averaged 14.6 percent, calcium .71 percent, and phosphorus .52 percent. The range in protein was wide going from 11.4 to 20.4 percent. There was a total of six samples that were under 12 percent or over 16 percent protein. The lower values would probably limit performance and those over 16 percent on a finishing ration would unnecessarily add to the total feed cost. The range on calcium was .2 to 1.2 per-cent, however, there were only a few samples that were out of the normal range for calcium. Phosphorus ranged from .4 to .8 percent so all were well within the normal limits.

OBJECTIVES AND PROCEDURES

A research proposal was funded in 1991 by the Missouri Pork Producers Association and the Univerity of Missouri Commercial Agriculture Extension program.

The main objective was to obtain a cross section of Missouri swine producers finishing swine rations and analyze specific nutrients to provide information on nutritional adequacies of rations and the relation between nutrients actually present and what was formulated. Other objectives were to look at possible differences in protein and mycotoxin levels in old crop and new crop grains used in these rations.

Extension Area Livestock Specialists obtained feed and grain samples from forty-three Missouri swine producers. Each producer was asked to provide samples from three consecutive finishing ration batches and two grain samples, one harvested in 1990 and one in 1991.

Finishing feed samples were analyzed for protein, calcium, phosphorus and lysine. Grain was analyzed for protein and the presence of mycotoxins. A total of 118 useable rations and 81 grain samples were analyzed and summarized in the following tables.

RESULTS AND DISCUSSION

Table 2 shows the results of protein analysis of the finishing rations and the average percent protein producers formulated for in this survey.

TABLE 2. PROTEIN PERCENT IN FINISHING RATIONS
MU 1991

	# Samples	Finishing Rations Avg Protein, %	Range - Protein, %
Formulation	116	14.51	12.0 - 18.0
Analysis	118	14.18	10.0 - 18.94

Producers formulated these rations to average 14.51 percent protein. Actual analysis was very close to this with 118 samples averaging 14.18 percent protein. A major concern however is the range in protein from a low of 10.0 to a high of 18.94 percent protein. There also was considerable variation in protein content of consecutive samples from individual producer's rations formulated to be identical. Five percent of total samples were under 12 percent protein which could reduce performance of pigs and 11.87 percent were over 16 percent protein. One would expect both of these sets of rations could be improved resulting in greater net profits to hog producers.

TABLE 3. PROTEIN ANALYSIS BREAKDOWN
Finishing Rations - MU 1991

Protein Analyzed, %	# Sample	Percent
Under 12	7	5.93
12 to 14	50	42.37
14 to 16	47	39.83
16 to 18+	14	11.87
Total	118	100.00

Tables 4, 5 and 6 show the average lysine, phosphorus and calcium content of the 118 complete feed samples. Averages compared to NRC requirements are satisfactory but as was found with the protein analysis the range of these nutrients indicate a problem for some producers. One has to assume major errors in adding ingredients, poor mixing techniques or errors in sampling to explain some of the extreme results. Producers finding deficiencies shown in these nutrients are encouraged to do additional testing and to evaluate feed formulation and mixing procedures.

TABLE 4. LYSINE - FINISHING RATIONS
MU 1991

# Samples	Avg Lysine, %	Range, %
118	.717	.397 - 1.709

TABLE 5. PHOSPHORUS - FINISHING RATIONS
MU 1991

# Samples	Avg Phosphorus, %	Range, %
118	.60	0.7 - 1.18

TABLE 6. CALCIUM - FINISHING RATIONS
MU 1991

# Samples	Avg Calcium, %	Range, %
118	.75	.31 - 2.59

Protein analysis of grains are shown in table 7. Corn samples had an average protein content of 8.48 percent. Old crop corn (1990) averaged 8.39 percent and new crop corn averaged 8.60 percent protein. These results may explain in some cases low protein found in protein analysis of complete rations if one assumes an average book value of corn protein as 8.9 percent when formulating rations. As shown in table 8, over 20 percent of the corn samples had less than 8 percent protein. The nine milo samples also had a wide range in analyzed protein.

TABLE 7. PROTEIN ANALYSIS OF GRAINS
MU 1991

Grain	# Samples	Avg Protein, %	Range, %
Corn (1990)	34	8.39	7.42 - 10.58
Corn (1991)	30	8.60	7.37 - 9.53
Milo	9	9.26	7.47 - 12.33
Wheat	5	12.31	11.21 - 13.22
Oats	3	11.28	10.28 - 12.47
	81		

TABLE 8. VARIATION IN CRUDE PROTEIN CONTENT OF CORN
MU 1991

Crude Protein, % Range	# Samples	% Samples
7.00 - 7.49	2	3.13
7.50 - 7.99	12	18.75
8.00 - 8.49	24	37.50
8.50 - 8.99	11	17.19
9.00 - 9.49	10	15.62
9.50+	5	7.81
	64	100.00

In the mycotoxin screen survey 17 samples had detectable levels. These are shown in table 9. Over half of the small grain samples had detectable levels and 15 percent of the corn samples. Most of these did not contain high enough levels of mycotoxins to be a significant problem for producers.

TABLE 9. POSITIVE SAMPLES FOR MYCOTOXIN & FUMONISINS
MU 1991

Grain	Harvested	Mycotoxin	Level
Corn	1990	Vomitoxin	.5 ppm
Milo	1991	Vomitoxin	.5 ppm
Wheat	1991	Vomitoxin	7.5 ppm
Wheat	1991	Vomitoxin	6.6 ppm
Oats	1991	Vomitoxin	15.7 ppm
Wheat	1991	Vomitoxin	5.0 ppm
Oats	1991	Vomitoxin	5.0 ppm
Corn	1990	Fumonisin	1.0 ppm
Mix	1990	Vomitoxin	2.5 ppm
Corn	1990	Aflatoxin B-1	1000 ppb
Corn	1990	Vomitoxin	1.0 ppm
		Fumonisin	1.0 ppm
Corn	1991	Aflatoxin	150-200 ppb
		Vomitoxin	1.0 ppm
Corn	(retest)	Aflatoxin B-1	20 ppb
		Fumonisin	1.0 ppm
Corn	1991	Aflatoxin B-1	100 ppb
Corn	1991	Fumonisin	1.0 ppm
Corn	1991	Aflatoxin	50 ppb
Corn		Fumonisin	1-10 ppm

Effect of Heat Stress and Energy Intake from Days 3 to 30 Postmating on Embryo Survival.

Chung-Wen Liao and T. L. Veum

Summary

Bred gilts were used to investigate the effect of heat stress and dietary energy on embryo survival. On day 3 post mating, gilts were assigned to the thermoneutral or the hot stress chambers, and to 5400 kcal or 8100 kcal of ME intake per gilt daily in a 2 x 2 factorial arrangement of the treatments. On day 30 postmating, the gilts were slaughtered and the reproductive tracts collected. There were no interactions (P>.05) between dietary energy and temperature for the criteria measured, thus main effects are reported. Gilts fed the high energy diet had a higher number of live embryos (P<.06) which increased the percentage of embryo survival (P<.02). Gilts housed in the hot chamber had fewer (P<.05) embryos than gilts housed in the thermoneutral chamber.

Introduction

Approximately 40% of the potential piglets are lost during gestation (Robertson et al., 1951; Perry and Rolands, 1962). Most embryo loss occurs during the first week after mating and during the preimplantation period of 10 to 18 days postmating (Perry and Rolands, 1962; Stone, 1987). The main factors contributing to prenatal loss include nutritional manipulation before and after mating (Bazer et al., 1968; Friend et al., 1981) and high environmental temperatures (Edwards et al., 1968; Omtvedt et al., 1971). The negative effect of high ambient temperature on embryo survival has been well established. However, the effect of energy intake on embryo survival from day 0 to 30 of gestation has not been consistent. The interactive effect of high temperature and dietary energy on the growth and reproductive performance of the gilts is still controversial. The objective of this experiment was to determine the effect of heat stress and dietary energy during the first 30 days of pregnancy on embryo survival and reproductive performance of the gilts.

Materials and Methods

A total of 72 gilts were used in three trials, 24 gilts per trial. Gilts were brought to the environmental chambers on day 3 postmating and allotted to one of four groups. Treatments consisted of two dietary energy levels (5400 and 8100 kcal ME daily per gilt) and two environmental temperatures in a 2 x 2 factorial arrangement. Diets were formulated to equalize daily nutrient intake for each gilt except for ME intake (Table 1). Daily feed intake was 3.52 or 4.29 lb per day for gilts fed the low or high energy diets, respectively. The temperature in the hot chamber was cyclic. The temperature gradually increased from 76°F at 0800 to

93°F at 1400. Temperature remained at 93°F from 1400 to 1600, and then gradually lowered to 76°F at 2000, where it remained until 0800. The thermoneutral room temperature was kept constant at 74°F. Gilts were hand-fed once a day at 0800. Water was supplied ad libitum. Rectal temperatures were taken twice daily. Gilts were weighed every week. At day 30±2 postmating, gilts were slaughtered and whole reproductive tracts were recovered. Number of corpora lutea and live embryos, and embryo length and weight were determined. Backfat thickness of the gilts was measured at the first rib, last rib and last lumbar vertebrae. Data were analyzed as a completely random design with a factorial arrangement of the treatments.

Results

There was no interaction (P>.05) between dietary energy and temperature for any criteria measured in this experiment. Thus, main effects of dietary energy and temperature are presented in Table 2 for number of corpora lutea and live embryos, embryo survival, embryo length and weight and gilt performance criteria. Gilts housed in the hot chamber had fewer (P<.05) embryos than gilts housed in the thermoneutral chamber. Gilts fed the high energy diet had a larger number of embryos (P<.06), which resulted in a higher percentage of embryos that survived to day 30. Gilts fed the high energy diet had a greater (P<.001) backfat thickness and daily gain than gilts fed the low energy diet (Table 2).

Conclusions

This experiment confirms the detrimental effects of heat stress on embryo survival in early gestation. However, high energy intake increased embryo survival. The high energy intake also increased average daily gain and backfat thickness of the gilts. These results indicate that appropriate measures should be used to reduce the effects of heat stress in early gestation. Drip cooling, snout cooling and fans may be practical approaches to reduce heat stress in confinement situations. A high energy diet may also improve embryo survival.

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TABLE 1. Diet Composition

Ingredients	Low energy diet	High energy diet
Ground yellow corn, %	59.1	48.5
Soybean meal 44%, %	30.1	24.7
Lard, %	5.1	22.24
Dicalcium phosphate, %	3.2	2.63
Sodium monophosphate, %	0.4	0.23
Salt, pulverized, %	0.5	0.4
Vitamin premix[a], %	1.0	0.8
Mineral premix[b], %	0.6	0.5
Calculated values:		
Crude protein, %	18.27	14.99
Metabolizable energy, kcal/lb	1540	2000
Calcium, %	1.14	1.07
Phosphorus, %	1.04	0.85
Lysine, %	1.02	0.84

[a]Vitamin premix provides per kg of low energy diet: 11,000 USP vitamin A acetate, 1100 USP vitamin D_3, 66.0 IU vitamin E as dl-α-tocopheryl, 13.2 mg vitamin K as menadione sodium bisulfite complex, 11.0 mg riboflavin, 55.0 mg d-pantothenic acid as calcium pantothenate, 66.0 mg niacin, 0.77 mg vitamin B_{12}, 1540 mg choline chloride, 4.4 mg folic acid, and 0.44 mg biotin.

[b]Trace mineral mix provided per kg of low energy diet: 150 mg Zn as zinc oxide, 150 mg Fe as ferrous sulfate, 30 mg Mn as manganese sulfate, 18 mg Cu as cupric oxide, 0.6 mg I as calcium iodate and 0.12 mg Se as sodium selenite.

TABLE 2. Main effects of dietary energy and temperature on embryo survival, length and weight and performance of the gilts.

Criteria	Energy Main Effects		Temperature Main Effects	
	Low energy	High energy	Thermo-neutral	Hot temperature
Corpora lutea, number	13.6	13.6	14.1	13.1
Live embryos, number	8.58[a]	10.30[b]	10.36[c]	8.52[d]
Embryo survival (%)	67.4[e]	80.6[f]	76.0	72.0
Embryo length (cm)	3.95	3.94	3.88	4.01
Embryo weight (g)	3.19	3.24	3.06	3.37
Average daily gain (lb/day)	0.95[g]	1.67[h]	1.30	1.32
Average backfat thickness (inch)	1.49[i]	1.72[j]	1.60	1.61
Dressing percentage (%)	75.1	75.0	74.6	75.5

a,b: Energy effect (P<.06) on number of embryos
c,d: Temperature effect (P<.05) on number of embryos
e,f: Energy effect (P<.02) on percent of embryo survival
g,h: Energy effect (P<.03) on average daily gain
i,j: Energy effect (P<.001) on backfat thickness

INFLUENCE OF A HIGH DIURNAL TEMPERATURE ON PERFORMANCE, BLOOD PARAMETERS AND CARCASS COMPOSITION OF DIFFERENT WEIGHT PIGS

J. Lopez, G. W. Jesse and B. A. Becker

SUMMARY

One hundred ninety-six barrows were used in two 42-d trials to determine the effect of environmental temperature on performance of the growing-finishing pig. The independent variables included diurnal temperatures of 64 to 72^o F (TN) versus 73 to 95 ^{o}F (HD) and average initial weights of 150.4, 109.2, 74.5 and 46.7 lb. Overall, the HD pigs grew 6.0% slower and consumed 8.6% less feed than the TN pigs. No differences in F/G were found. In addition, no significant interactions of weight group by temperature were noted. Pigs raised in the HD environment were 7.5% leaner than the TN pigs. However, hogs raised in the HD had higher blood pH levels indicative of alkalosis. In conclusion, this investigation indicates that management programs to diminish the effects of heat stress for finishing swine are important.

INTRODUCTION

Development of mathematical models which accurately predict swine growth and feed consumption is a necessary step toward evaluating trade-offs in swine producing systems (Christianson et al., 1982). Periods of hot temperatures induce performance penalties, thereby increasing time to market. Under such conditions, it would be extremely helpful if a producer could accurately predict the response of a growing-finishing pig to a variety of dietary or environmental regimens, then select for the regimen that optimizes economic returns (Crenshaw et al., 1986).

The objectives of this research were to determine the effects of a hot environment on average daily gain (ADG), feed intake (FI) and feed efficiency (F/G) of different weight pigs and to evaluate the effects of heat stress on selected blood gases and carcass characteristics.

Materials and Methods

Two trials representing a total of 96 pigs were conducted during the summer and fall of 1991. The experimental design was a 4 X 2 factorial with weight groups of 150.4 (A), 109.2 (B), 74.5(C) and 46.7 lbs (D) and environmental temperatures of 64 to 72 ^{o}F (thermoneutral; TN) and 72 to 95^{o}F (hot,diurnal; HD). Humidity averaged 55% for both the TN and HD temperatures.

The pigs were housed in two environmentally controlled chambers with twelve 4'X 4' pens in each chamber. Each pen had one watering cup and a one-hole self-feeder. Corn-soybean meal diets, without antibiotics were fed. Pigs weighing less than 125 lb were fed a 16% crude protein diet while those pigs with pen average weights over 125 lb were fed a 14% crude protein diet. Individual pig weights and FI and F/G on a pen basis were determined on a weekly basis. At the end of the study, the heaviest group (A) was slaughtered for carcass measurements. Each trial consisted of a 14-d acclimation period and a 42-d test period.

Results and Discussion

Pigs in the HD room grew 6.0% slower ($P<.05$) than those in the TN environment (1.66 vs 1.76 lb). Average daily gain was 1.76, 1.75, 1.73 and 1.57 lb for the heaviest to the lightest weight group, respectively. Average daily gains by temperature and weight group are shown in table 1. Temperature by weight group interactions were not significant ($P>.05$).

The HD pigs ate 8.6% less feed ($P<.05$) per day than TN pigs (5.10 vs 5.60 lb). As expected, the heavier pigs ate more feed per day than the lighter pigs (6.1 vs 5.7 vs 5.1 vs 4.3 lb for groups A, B, C and D, respectively); however, temperature by weight group interactions were not different ($P>.05$).

Even though high temperatures reduced gain and feed intake, F/G was not different ($P>.05$) by temperature. Feed efficiency for the 42 day study was 3.25 vs 3.28 for the TN and HD pigs, respectively. As expected feed efficiency did become worse ($P<.05$) as pigs became heavier (2.80, 3.00, 3.47 and 3.80 for the lightest to heaviest groups, respectively).

Pigs in the HD room had 7.5% less backfat ($P<.05$; 1.32 vs 1.42 in.) when adjusted to a 230 lb basis. Apparently, the decrease in feed intake reduced the amount of energy available for fat deposition. Differences were not significant ($P>.05$) for loineye area, carcass length, 10th rib fat or dressing percent.

Average blood pH was higher ($P<.05$) for the HD pigs compared to the TN pigs (7.34 vs 7.25). Likewise, pH was higher ($P<.05$) for each of the HD weight groups compared to the TN (7.40, 7.39, 7.33 and 7.25 vs 7.27, 7.28, 7.24 and 7.22 for groups A, B, C and D of the HD vs TN pigs, respectively). As pigs become heavier, heat stress becomes more severe. This change in blood pH affects the oxygen carrying capacity of the blood and hence metabolism is affected. The lower ($P<.05$) partial pressure of carbon dioxide (60.21 vs 63.62 mmHg) for the HD pigs resulted in the high blood pH. Temperature had no effect ($P>.05$) on partial pressure of oxygen, base excess or total carbon dioxide.

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TABLE 1. AVERAGE DAILY GAIN BY ENVIRONMENTAL TEMPERATURE AND WEIGHT GROUP, LBS

Weight Group[a]	Int.wt[b]	End.wt	Temperature[a] TN	HD	Avg
A	175.1	249.6	1.83	1.70	1.76[e]
B	135.4	209.6	1.81	1.70	1.75[e]
C	100.2	173.2	1.76	1.69	1.73[e]
D	68.2	134.7	1.60	1.55	1.57[f]
Avg			1.76[c]	1.66[d]	

[a] Differences by temperature and weight group were not significant (P>.05).

[b] These initial weights represent weights taken after a 14 d acclimation.

[c,d] Means within a row not having a superscript in common are different (P<.05).

[e,f] Means within a column not having a superscript in common are different (P<.05).

EFFECTS OF DIETARY ELECTROLYTE BALANCE AND SUPPLEMENTAL FAT ON GROWTH RATE AND BLOOD PARAMETERS OF FINISHING SWINE DURING PERIODS OF HIGH AMBIENT TEMPERATURES

J. Lopez, G. Jesse, D. Ledoux, A. Garcia and T. L. Veum

SUMMARY

During the summer of 1991, 120 finishing hogs were used in a seven week study to determine if supplemental fat or electrolytes or a combination of supplemental fat and electrolytes could enhance performance during periods of heat stress. A corn soy diet with 5% added fat produced the fastest and most efficient gains. Pigs fed an electrolyte supplemented diet were more efficient converters of feed to gain; however ADG was not different from the control diet. Likewise, performance of those pigs fed the fat and electrolyte supplemented diet was not different from the fat supplemented diet. Selected blood parameters measured were not affected by diet.

Introduction

High summer time temperatures cause a noticeable reduction in feed intake and growth rate in finishing swine. In addition, an increase in respiration rate due to heat stress can disturb blood normality and as a result affect metabolism.

Several investigators have shown that the addition of fat to swine finishing diets during the summer results in an improvement in growth rate and feed conversion which is primarily attributed to a decrease in dietary heat increment.

Some researchers advocate that a diet with an electrolyte balance (EB) of 114 meq/lb may enhance pig performance under high environmental temperatures because of the increase in blood buffering capacity. Electrolyte balance (EB) refers to milliequivalents of sodium (Na) plus potassium (K) minus chloride (CL) per pound of diet. Most finishing diets contain EB levels of approximately 68 meq/lb.

The objectives of this experiment were to determine the effects of dietary electrolyte balance (EB) and supplemental fat on selected blood parameters and the performance of finishing swine under summer time environmental conditions.

Experimental Procedures

During the summer of 1991, one hundred and twenty crossbred barrows and gilts (60 of each sex), with an average initial weight of 155 lbs, were used in a seven-week study to compare four dietary treatments. These treatments included: 1) a control diet with an electrolyte balance (EB) of approximately 68 meq/lb (Control), 2) a diet with an EB of 114 meq/lb (HEB), 3) a diet with 5% supplemental fat and an EB of approximately 68 meq/lb (FAT) and 4) a diet with 5% supplemental fat and an EB of 114 meq/lb (FHEB). Hence, the experimental design was a 2 x 4 factorial arrangement of treatments with the independent variables being sex (barrows vs gilts) and diet (Control vs HEB vs FAT vs FHEB). Pigs were randomly assigned to diet within sex and penned in groups of three which resulted in five pens of barrows and five pens of gilts per dietary treatment.

All diets (meal form) were formulated to meet or exceed NRC (1988) requirements plus maintain a similar calorie to protein ratio. As shown in table 1, choice white grease, $NaHCO_3$, choline chloride and potassium chloride were the ingredients added to the Control diet to create the FAT, HEB and FHEB diets.

The test facility was the University of Missouri's Swine Research Complex (SRC) finishing barn which is totally-enclosed and includes a negative pressure ventilation system. The floor is totally slotted with waste being removed by an under-the-floor flush. Each pen contained a nipple waterer and a one-hole Smidley feeder. Temperature was recorded continuously by use of a hygro-thermograph.

All pigs were weighed weekly and feed intake recorded on a pen basis. Blood samples were obtained from approximately half of the pigs (eight randomly selected barrows and eight randomly selected gilts per diet) on week 2 (P1), 5 (P2) and 7 (P3) for blood pH and gases and electrolyte (Na, K and Cl) analysis. Blood pH and gases were analyzed within one hour of collection. Plasma was frozen for later determination of electrolyte content.

Results and Discussion

As noted in table 1, the diets were somewhat lower in electrolyte balance (EB) than intended; however, the difference between the average EB of the Control and FAT diets versus the HEB and FHEB diets was an acceptable 32 meq/lb. Average weekly high and low temperatures during the 49-day study are shown in figure 1.

Growth rate (ADG), feed intake (FI) and feed efficiency (F/G) by diet are shown in table 2. Pigs fed the diet with 5% supplemental fat (FAT) consumed less feed and gained significantly faster (P=.03) and more efficiently (P=.0001) than the Control pigs. However, ADG of the FAT pigs was not different from the HEB and FHEB treatment groups. Feed intake and ADG of pigs fed the high electrolyte balance (HEB) diet were not different from the Control diet; however, feed efficiency (F/G) favored the HEB diet. Performance of pigs fed the HEB and FHEB diets very similar.

Blood pH did not differ by diet (P=.53); however, it did increase (P<.0001) with subsequent bleedings (P1 = 7.26 vs P2 = 7.31 vs P3 = 7.33). This may have occurred as a result of an increase in body weight resulting in a greater susceptibility to heat stress.

The amount of blood bicarbonate (HCO_3) and partial pressure of carbon dioxide (PCO_2) were highest (P<.05) during periods two and three (P1 = 26.8, P2 = 32.3, P3 = 33.3 and P1 = 59.3, P2 = 64.9 and P3 = 64.3 mmol/l for the HCO_3 and PCO_2, respectively). Generally, high PCO^2 levels will cause blood pH to decrease, however this did not occur. An increase in sodium and potassium levels will also cause the blood pH to increase. Plasma sodium levels were found to be higher (P<.05) during period three (P1=.32, P2=.32 and P.34, %), however, only to be offset by a reduction (P<.05) in the amount of plasma potassium levels (P1=.025, P2=.022 and P3=.022, %).

Conclusions

The addition of 5% supplemental fat to a corn soy finishing diet resulted in a significant improvement in growth rate and feed efficiency under summer time conditions. Adding electrolytes to a corn soy diet improved feed conversion; however, growth rate and feed intake were not different from the non-supplemented control diet. Likewise, the addition of electrolytes to a fat supplemented diet did not improve swine performance.

TABLE 1. COMPOSITION OF EXPERIMENTAL FINISHING DIETS

Item	Diets, % Control	FAT	HEB	FHEB
Ground Corn	86.08	77.50	84.42	76.10
Soybean Meal (44%)	12.00	15.44	12.30	15.70
Choice White Grease	.00	5.00	.00	5.00
Ground Limestone	.81	.60	.60	.60
Dicalcium Phosphate	.44	.85	1.01	1.02
Salt	.15	.24	.33	.34
$NaHCO_3$	.15	.00	.61	.61
Choline Chloride	.13	.13	.13	.13
Potassium Chloride	.00	.00	.36	.27
Trace Min. Mix[a]	.12	.12	.12	.12
Vitamin premix[b]	.10	.10	.10	.10
Chemical Analysis, %				
Sodium	.16	.17	.36	.30
Potassium	.45	.50	.49	.60
Chloride	.14	.19	.25	.25
Actual Electrolyte Balance (meq/lb)	65.88	67.53	96.22	101.13
Calculated Electrolyte Balance (meq/lb)	68.20	68.20	114.00	114.00
Calculated Analysis, %				
Crude Protein	13.00	13.90	13.00	13.90
Lysine	.61	.69	.61	.69
ME, cal/lb	1513.38	1607.56	1491.97	1589.47
Calorie:Protein	116.38	115.64	114.76	114.35

[a] Swine Trace Mineral premix MU-91

[b] Swine Vitamin Premix MU-91

TABLE 2. EFFECT OF DIET ON AVERAGE DAILY GAIN (ADG), FEED INTAKE (FI) AND FEED EFFICIENCY (F/G) OF FINISHING HOGS UNDER SUMMER TIME TEMPERATURES

Item,	DIETS CONTROL	HEB	FAT	FHEB	SE[a]
ADG,	1.60[b]	1.63[bc]	1.71[c]	1.70[bc]	.03
FI,	7.20[b]	6.62[bc]	6.14[c]	6.65[bc]	.21
F/G,	4.40[b]	4.00[c]	3.59[d]	3.80[cd]	.11

[a] SE= standard error.

[b,c,d] Means within a row not having a superscript in common are different (P<.05).

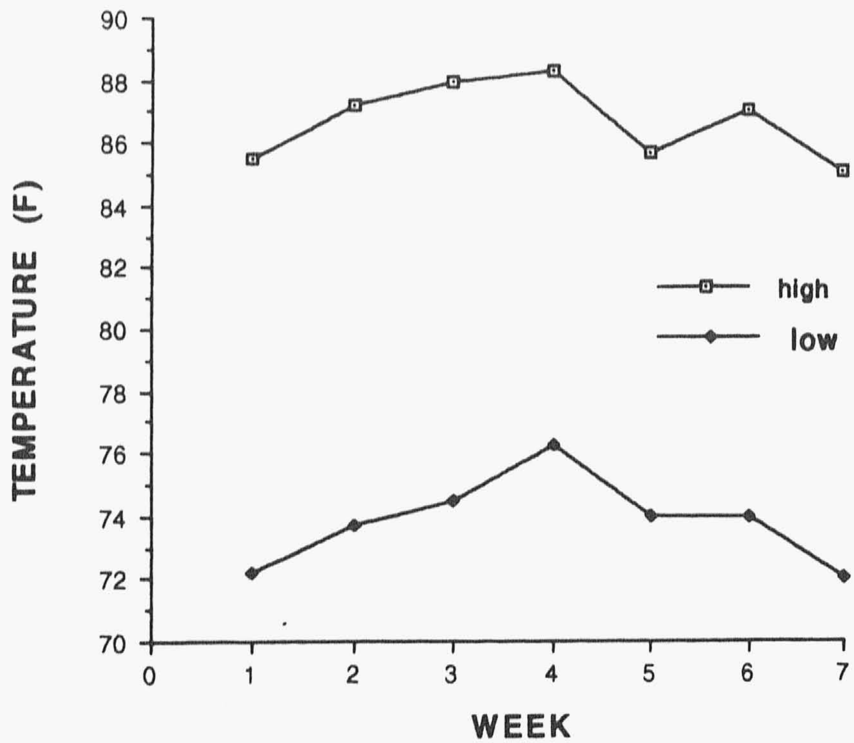

FIGURE 1. AVERAGE WEEKLY HIGH AND LOW TEMPERATURES DURING THE EXPERIMENT.

EVALUATION OF THE MATURATION OF THE PORCINE IMMUNE SYSTEM IN THE PIGLET FROM 1 TO 30 DAYS OF AGE

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SUMMARY

A study was conducted to evaluate the maturation of the porcine immune system in the piglet from 1 to 30 days of age. Piglets were sacrificed on 1, 18-19 and 27-30 days of age. Lymphocytes isolated from the blood, thymus and spleen were phenotyped. Numbers of cell types were determined. Cell function was evaluated by mitogen analysis. Our results indicate that the porcine immune system is not functionally mature at birth and maturation appears to be associated with overall growth.

INTRODUCTION

Swine mortality and low vigor and thriftiness during the neonatal period are reported to range from 8 to 30%. The immaturity of the porcine humoral immune system has been recognized and immunoglobulins from the dam's colostrum must be absorbed by the piglet in order to provide early protection. Information about the status of the other aspects of the porcine immune system during this period is incomplete. Our interest in the study reported here was to examine the maturation of the porcine immune system in the neonatal piglet. Our future interest is to examine how environmental stress may affect the development of the immune system of the neonate and to determine if stress is associated with mortality and low thriftiness during this period.

PROCEDURES

Nineteen crossbred (Landrace x Yorkshire x Duroc) male piglets were used in this experiment. Piglets were sacrificed according to Animal Care and Use Committee approval on days 1 (n=6), 18-19 (n=6) and 27-30 (n=7) of age. Body weights were taken immediately. Twenty ml of blood were sampled from the heart. Thymus glands and spleens were removed and weighed and prepared for processing. Adrenal glands were removed, weighed, then frozen for later analysis.

Leukocytes and red blood cell counts from the peripheral blood were determined using a Coulter Counter (Model ZBI, Coulter Electronics). The percentages of lymphocytes and neutrophils were estimated from differential cell counts. These percentages were then used to calculate the number of lymphocytes and neutrophils as a proportion of the total leukocytes.

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Peripheral blood lymphocytes were isolated using histopaque (Sigma Chemical Co.) at a density of 1.077 ug/ml. Lymphocytes were collected, resuspended and washed several times in culture media [Hepes-buffered RPMI 1640 supplemented with 0.5 mM l-glutamine, penicillin-G potassium (100 units/ml) and gentamycin (50 ug/ml)]. Erythrocytes were lysed with a Tris-NH_4Cl lysis buffer. Lymphocyte viability was evaluated by Trypan Blue exclusion. Lymphocytes from the spleen and thymus were gently massaged out of the respective organs and filtered through a 40-mesh screen. The lymphocytes from these organs were isolated and processed in the same manner as lymphocytes from the blood.

To assess immune function, mitogenic assays were performed on the various preparations. Isolated lymphocytes from each organ were adjusted to a final concentration of 2 x 10^6 cells/ml in culture media. Fifty ul of cell suspension was pipetted in triplicate into 96-well microplates. Fifty ul of mitogen of either phytohemagglutinin (PHA, 7.5 ug/ml, Sigma Co.), concanavalin A (Con A, 10 ug/ml, Pharmacia), pokeweed mitogen (PWM, diluted 1:150, Gibco Co.) or medium alone (control) were added to each well along with 20 ul fetal calf serum. Cultures were incubated at 37° C and 5.0% CO_2 environment for 72 h. After 72 h, 1 uCi of tritiated thymidine (ICN Biochemicals) dissolved in culture media was added to the cultures and cells were again incubated for 16 h. Cells were harvested onto glass fiber filter paper and radioactivity was counted by liquid scintillation. Data were expressed as a stimulation index whereby thymidine uptake (in cpm) of stimulated cells by respective mitogen was divided by the control counts.

To examine lymphocyte cell surface antigen expression, isolated cells were adjusted to a concentration of 1 x 10^6 cells/ml. Cells were incubated with 100 ul of the monoclonal antibodies for 45-60 min at 4° C. Cells were then incubated for 45-60 min with 100 ul of fluorescein isothiocynate-labeled goat anti-mouse IgG antibody. Cells were washed in PBS and fixed in .2% paraformaldehyde in PBS. Flow cell cytometry analysis was conducted on a EPICS 753 flow cytometer. Data are represented as percent of cells expressing the respective cell surface antigens.

RESULTS AND DISCUSSION

Table 1 lists the body and organ weights of the piglets on days 1, 18-19 and 27-30. These weights were within expected ranges.

Peripheral blood cell types and the changes in numbers as the piglets grew are shown in Table 2. Leukocyte and lymphocyte numbers increased over time. As a percentage of cells, neutrophils decreased as the piglets grew; however, since total leukocyte numbers were increasing, the estimated numbers of neutrophils did not change. Increases in red blood cells were slight, with significant changes occurring between 18-19 and 27-30 days. These numbers suggest that there are sufficient cell types of the hemapoetic system to sustain normal growth and health status as the piglet grows.

Having determined adequate cell types and numbers, we conducted mitogenic assays to determine if the lymphocytes isolated from the blood and various immune organs would proliferate when exposed to various mitogens. The data are presented in Table 3. No detectable proliferation was found on day 1 for lymphocytes from the blood or any of the organs. In the blood, significant changes were not detectable until days 27-30. For the lymphocytes from the spleen, slight responses were found on days 18-19 and 27-30. Responses of lymphocytes isolated from the thymus increased the greatest on day 27-30. These data suggest that the baby piglet would have limited functional activity during the first several weeks and would be most susceptible to infection during the first week of life.

Lymphocyte populations can be distinguished by differences in cell surface antigen expression. In this study monclonal antibodies recognizing cell surface molecules such as CD_2, found on all T-cells; CD_8, found on cytotoxic T cells; and MSA_3, which recognizes MHC class II molecules were used. No expression of these molecules was detected on day 1 on lymphocytes from the peripheral blood, spleen or thymus (Table 4). Expression varied with age and organ on days 18-19 and 27-30, with the greatest being found on lymphocytes from the thymus, the organ in which maturation of the T lymphocytes occurs. The results from these determinations and those from the blastogenic assays suggest that the porçine immune system is not functionally mature during the early neonatal period and that maturation appears to occur synergistically with overall growth.

Table 1. Changes in body and organ weights (least square means ± SEM) from piglets of day 1 to 30 of age

Organ	Day 1	Day 18-19	Day 27-30	Effect P =
Body wt (lb)	3.5 ± .5	13.9 ± 2.0	19.2 ± .7	.0001
Thymus wt (oz)	.07 ± .01	.42 ± .09	.86 ± .07	.0001
Spleen wt (oz)	.07 ± .02	.46 ± .09	.79 ± .13	.0001
Adrenal wt (oz)	.01 ± .003	.03 ± .003	.04 ± .003	.0001

Table 2. Changes in numbers of peripheral blood cell types (least square means ± SEM) of the growing piglet

Cell type	Day 1	Day 18-19	Day 27-30	Effect P =
Leukocytes ($X10^3/mm^3$)	6.0 ± 1.9	8.7 ± 2.5	12.3 ± 5.0	.08
Lymphocytes (/100 cells)	69.5 ± 4.8	81.3 ± 6.2	84.8 ± 6.1	.0006
($X10^3/mm^3$)	(4.2)	(7.1)	(10.5)	
Neutrophils (/100 cells)	30.5 ± 4.8	18.6 ± 4.8	15.1 ± 6.1	.0006
($X10^3/mm^3$)	(1.8)	(1.6)	(1.8)	
Red blood cells ($X10^6/mm^3$)	5.1 ± .3	5.4 ± .3	6.2 ± .3	.0270

Table 3. Stimulation index (mitogen/control) for blastogenic responses to several mitogens by lymphocytes from various organs

Organ	PHA[a]	CONA[b]	PWM[c]
<u>Peripheral blood</u>			
Day 1	ND[d]	ND	ND
18-19	1.85 ± 8.63	7.69 ± 6.55	2.45 ± 2.13
27-30	28.73 ± 7.88	15.08 ± 5.98	18.10 ± 1.95
<u>Spleen</u>			
Day 1	ND	ND	ND
18-19	5.20 ± 8.63	11.47 ± 6.55	3.49 ± 2.13
27-30	2.35 ± 9.50	12.43 ± 7.21	2.71 ± 2.35
<u>Thymus</u>			
Day 1	ND	ND	ND
18-19	2.46 ± 7.56	4.00 ± 5.74	2.21 ± 1.87
27-30	9.11 ± 9.50	17.50 ± 7.21	7.54 ± 2.35
<u>Effect (P =)</u>			
Age	.3436	.3583	.0007
Organ	.4004	.9071	.0208
Age x organ	.4310	.7673	.0118

[a]PHA = phytohemagglutinin
[b]CONA = concanavalin A
[c]PWM = pokeweed mitogen
[d]ND = nondetectable

Table 4. Percentage of leukocytes expressing cluster of differentiation (CD) antigens CD_2, CD_8 and MHC Class II molecules

	CD_2	CD_8	MHC Class II molecules
	(%)	(%)	(%)
<u>Peripheral blood</u>			
Day 1	ND[a]	ND	
18-19	59.64 ± 3.78	51.04 ±3.05	31.79 ± 27.7
27-30	34.82 ± 3.93	29.26 ± 3.12	18.63 ± 8.7
<u>Spleen</u>			
Day 1	ND	ND	ND
18-19	67.53 ± 3.78	29.46 ± 3.05	49.55 ± 37.18
27-30	58.18 ± 4.06	27.95 ± 3.27	15.32 ± 4.75
<u>Thymus</u>			
Day 1	ND	ND	ND
18-19	90.44 ± 3.78	64.26 ± 3.05	36.65 ± 39.9
27-30	81.33 ± 4.06	61.80 ± 3.27	2.24 ± 4.00
<u>Effect (P =)</u>			
Age	.0003	.0037	.0001
Organ	.0001	.0001	.0052
Age x organ	.1026	.0075	.0125

[a]ND = nondetectable

FISH OIL IN POULTRY AND SWINE DIETS: A BRIEF REVIEW OF THE EVIDENCE FOR EFFECTS ON THE IMMUNE SYSTEM

K.L. Fritsche

SUMMARY

Infectious diseases cause serious economic losses to the swine and poultry industries every year. Evidence suggests that current nutrient requirements do not optimize immune responses nor disease resistance. Recent data indicate that dietary polyunsaturated fatty acids (PUFA) from the omega-3 (n-3) family may beneficially influence immune cell function and disease resistance through the modulation of eicosanoid production. New findings on the immunological impact of feeding fish oil to pigs and chickens are presented. The possibility that some of the beneficial effects of fish meal may be coming from endogenous n-3 PUFA is discussed briefly. More research is necessary to gain a better understanding of the influence of n-3 PUFA, whether from fish oil or fish meal, on the immune system of chickens and pigs.

BACKGROUND

Apart from their role in supplying calories, dietary fats are necessary for providing the essential fatty acids (EFA), particularly, linoleic acid (18:2n-6). Under most practical conditions grain-based diets for swine and poultry provide levels of linoleic acid more than adequate for growth and reproduction (i.e., ~1-2%). Evidence for the essentiality of alpha-linolenic acid [LNA (18:3n-3)] in swine and poultry is equivocal. The importance of EFA in poultry diets was the subject of a recent review (1). In the last year, some rather remarkable, and as yet unsubstantiated, claims were made for supplementing swine diets with LNA (2). At the heart of these claims is the recognition that omega-3 (n-3) fatty acids, like LNA, can influence the production of eicosanoids (e.g., prostaglandins, leukotrienes, and 5-HETE).

Eicosanoids are the oxygenated metabolites of 20-carbon fatty acids, particularly arachidonic acid (AA). Prostaglandins (PG) are the most studied of the eicosanoids, but there are many others, including thromboxanes and leukotrienes (LT) just to name a few. These arachidonic acid metabolites function as second messengers, linking extracellular signals with intracellular events. They play important regulatory roles in a wide variety of biological systems, including renal, endocrine, neural, immune, and cardiovascular. Excessive production of eicosanoids is associated with a number of pathological disease states, such as cancer, sepsis, asthma, and autoimmunity.

OVERVIEW OF RECENT RESEARCH IN THIS AREA

Recently, much attention has been focused on the potential health benefits associated with an increased consumption of the n-3 PUFA, because of their ability to reduce eicosanoid production. The scientific community has given little attention to the possible beneficial effects of n-3 rich oils, such as flax and fish oils, in domestic animal production. Compared to humans and laboratory animals, little is known about the production of these immuno-modulatory and pro-inflammatory compounds in chickens or pigs. Since the production of eicosanoids is related to the availability of precursor fatty acids, particularly arachidonic acid, documenting the impact of diet on this parameter is important. We have shown that by providing sows with fish oil during the last week of gestation and throughout lactation, sufficient n-3 PUFA are transferred through the milk to modify the fatty acid composition of piglet immune tissues, including splenocytes, alveolar macrophages (AM), and thymocytes (3). Furthermore, these immune cells from piglets suckling fish oil-fed sows produce less pro-inflammatory and immuno-inhibitory prostaglandin E_2 (PGE_2) compared with piglets from lard-fed sows (4). We have recently finished a study with broiler chickens which demonstrated that n-3 PUFA from fish oil reduced immune cell eicosanoid synthesis (unpublished observations). Others have shown that eicosanoid production in chickens was similarly reduced by feeding diets enriched with LNA (5).

Our laboratory has hypothesized that dietary n-3 PUFA could enhance immune responses and disease resistance in swine and poultry by reducing eicosanoid production, particularly PGE_2. Considerable evidence exists demonstrating that dietary n-3 PUFA can beneficially influence the immune response of laboratory animals. For example, when mice were fed fish oils, rich in n-3 PUFA, antibody production was significantly enhanced (6). Dietary n-3 fatty acids have been shown to enhance cell-mediated cytotoxicity in mice (7). Little is known about the influence of dietary n-3 PUFA on the immune response of chickens and pigs.

A study conducted in this laboratory demonstrated that feeding Leghorn-type chickens a diet rich in n-3 PUFA (7% menhaden fish oil) led to a two-fold enhancement in antibody production ($p < 0.05$) and reduced lymphocyte proliferation by 30-50% in response to the polyclonal mitogens (8). Not all sources of n-3 PUFA had the same effect. When flaxseed oil, rich in LNA, was fed no enhancement of antibody production was observed, yet lymphocyte proliferative responses were depressed to levels similar to the fish oil-fed chickens. However, high n-3 PUFA intake does not always influence the immune system in predictable ways. For example, we recently found that antibody-dependent cellular cytotoxicity (ADCC), a measure of anti-viral and anti-bacterial disease resistance, was reduced in broiler chickens fed diets rich in n-3 PUFA (unpublished observations). Furthermore, we found that, unlike laying hens, primary and secondary antibody responses in broiler chickens were not enhanced upon fish oil feeding. Similarly, others (9) have reported no difference in antibody response when chickens fed soybean oil were compared with those fed fish oil. At this time it is difficult to explain the lack of a consistent n-3 PUFA effect on antibody production. Clearly, differences in animals studied (i.e., species and strain), diets, and immunological methods utilized make direct comparisons between studies problematic.

One of the newest and most exciting areas in nutrient-immune system interactions has to do with cytokine production. Cytokines are important regulators of the immune response. For instance, interleukin 1 (IL-1) is involved in the regulation of T and B cell development and functional activation as well as, the induction of biosynthesis of other cytokines and cytokine receptors. Membrane IL-1 can serve as a co-stimulatory factor for growth of activated T-cells. Fish oils have been reported to have inhibitory and stimulatory effects on IL-1 production (10-13). Other cytokines which have been shown to be influenced by n-3 PUFA include: tumor necrosis factor-alpha (TNF-a); interleukin-2 (IL-2), a T-cell growth factor; and IL-6, a stimulator of growth and differentiation of T- and B-lymphocytes.

It was once thought that fish solubles contained "unknown growth factors." Some researchers have shown that fish oils promoted growth as well as, but not better than, corn oil (14). In 1990, Nir (15) reported that male broiler chickens fed 1.5% redfish oil had a higher body weight than those fed 1.5% soybean oil. However, no difference in feed efficiency was noted. More recently we noted a increased food intake and daily gain in laying hens fed a diet containing 7% menhaden fish oil compared with the same amount of either lard, corn oil, or flaxseed oil (8). No similar stimulatory effect of fish oil on food intake or growth was noted with broiler chickens or piglets nursing fish oil-fed sows (unpublished observations). However, other researchers (16) have reported that the addition of 4% fish oil (FO) to the diet of chickens actually depressed growth. Since, these authors did not stabilize their FO with synthetic antioxidants, it is likely that the reduced growth observed was a result of decreased palatability of the diets from auto-oxidation of the highly unsaturated FO. There is ample documentation supporting the necessity of synthetic antioxidants use in fish oil-containing diets (17).

WHAT ABOUT FISH MEAL?

Evidence exists for some benefit associated with the inclusion of fish meal in the diets of poultry and swine. Limitations in space prevent me from reviewing these data here. Pike (18) discussed several possible explanations for this fish meal effect. More recent, it has been stated that the "ultimate value of fish meal as a protein source depends on its quality and its effect on total amino acid balance of the diet" (19). In a well-designed study, these researchers demonstrated an improvement in average daily gain and average daily food intake when menhaden fish meal replaced soybean meal in the starter diets of early weaned pigs. These improvements were not associated with differences in dietary crude protein, lysine, total energy, calcium, or phosphorus, since diets were formulated to be balanced in these nutrients. Since diets were fortified with Se (0.3 ppm) it is unlikely that the additional selenium contributed by the fish meal was responsible for the increase in food intake and subsequent growth. The authors suggest that improved palatability or increased preference for the fish meal may explain their findings. Poultry show a similar preference for fish meal-containing diets.

The question has been posed, whether some of the beneficial effects of fish meal are associated with the ether-extractable fraction, in particular the n-3 PUFA. This may seem impossible at first glance, but the impact of n-3 PUFA are dependént on total fat intake and the ratio of n-6 PUFA to n-3 PUFA. Fish meals are on average only 10% fat of which only 25% of this would be n-3 PUFA. This translates into 0.5% n-3 PUFA intake when fish meal is fed at 20% (usually the highest fed under practical conditions). With corn contributing approximately 2% n-6 PUFA (all in the form of linoleic acid, 18:2n-6) the ratio of n-6 to n-3 PUFA in the diet would be 4:1, compared to the 50:1 or greater in the absence of fish meal. Differences of this magnitude have been shown to have a significant impact on immune cell eicosanoid production in laboratory animals (13). Defining the ideal n-6 to n-3 PUFA ratio has been a subject of considerable debate. While a ratio of 10:1 has been suggested as optimal, there is little scientific evidence to support this particular value.

As far as this author is aware, there have been no studies looking at the impact of fish meal on the immune system. However, it seems unlikely that the major impact of fish meal on performance is associated with the effects of endogenous n-3 PUFA on the immune response. On the other hand, it is possible that 5-20% fish meal may provide enough n-3 PUFA to meet some, as yet, poorly defined requirement of those tissues which have high levels of n-3 PUFA (e.g., retina, gonads, and brain).

CONCLUSION

Currently, there is a re-examination of EFA requirements in humans beyond the scope of just growth and reproduction, such that scientists are trying to define requirements based on producing optimal health. This author believes such a re-evaluation for swine and poultry may be worth considering.

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SWINE LAGOON DESIGN AND MANAGEMENT

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Anaerobic lagoons are earthen waste impoundments sized to provide biological treatment and long-term storage for animal wastes. Anaerobic lagoons are larger than manure holding basins, which generally do not provide significant biological treatment, or long storage periods. On the other hand, anaerobic lagoons are smaller than aerobic lagoons which are designed to provide a higher degree of treatment with less odor production. Anaerobic lagoons represent a useful compromise in size between holding or storage basins, and aerobic lagoons. This paper outlines considerations in anaerobic lagoon design and management for swine, and hereafter the term "lagoon" refers to the anaerobic swine lagoon.

Advantages commonly associated with lagoons include the following.

- Sufficient treatment is obtained to allow manure to be handled hydraulically with flushing systems, sewer lines, pumps, and irrigation systems.
- Long-term storage is provided at a relatively low cost.
- High nitrogen reduction in lagoons minimizes the land area required for effluent disposal.

Disadvantages associated with lagoons may include the following.

- Perception by the public that a lagoon is an "open container of manure".
- Undesirable odors may be produced during seasonal changes due to "turnover", and spring start-up after the winter period of relatively little biological activity.
- High nitrogen reduction limits nutrient availability as a fertilizer if manure is desired as part of a crop fertility program.

Lagoon Location

The most important step in insuring that the lagoon is a successful part of the production enterprise is proper site selection and location. As production systems become larger, it becomes more important to locate facilities with the proper construction and management of the waste system in mind, as well as traditional considerations such as access, existing utilities, etc. Following are items which should be considered in locating facilities for a livestock production system utilizing a lagoon.

- Sufficient land area to receive lagoon effluent in an environmentally sound manner. Required land area is generally based on the amount of nitrogen estimated to be available from the lagoon on an annual basis.

- Geology and soils available for lagoon construction. Proximity of groundwater, and the presence of soils with sufficient clay to seal and provide a barrier against effluent movement to groundwater are important considerations in locating a lagoon.

- Odor production and movement. Because odors will be produced by the production facilities, as well as the lagoon, consideration should be given to prevailing wind direction, and air drainage patterns when winds are calm, and humidities are high. Experience has shown that odors remain concentrated and follow flow lines similar to water during periods of high humidity and low air movement.

- Separation distances. Odors tend to dissipate with increased distance from a facility. Distance from an odor source to a potential receptor should be considered in locating a lagoon. Separation distances to property lines and/or non-owned dwellings are suggested by some states in waste management guidelines. Unfortunately, no precise separation distance can be given which will guarantee that odor controversy will not develop in any given case. Separation distances of one-quarter to one-half mile to non-owned dwellings are the range most often suggested. The relationship of facility size to the increased separation distance necessary is not well established.

- Access, utilities, and existing support facilities. These items have traditionally been the primary criteria in locating livestock production facilities. However with larger operations, and emphasis on environmental considerations, resources should be allocated to building access roads, and bringing utilities and support facilities to areas conducive to good waste management.

- Develop and document a defensible site selection procedure. Given the possibility of future litigation, a defined site selection procedure should be utilized in selecting a site, and that procedure should be followed and documented. It can then be used as supporting evidence in defense of the site selected, should the location be legally challenged. Successful defense of a legal case against a livestock production facility generally requires that all local, state, and federal regulations are complied with.

LAGOON DESIGN

Proper design, or sizing of a lagoon insures that sufficient volume is available for the required storage period, and that there is a suitable environment for the bacteria in the lagoon to degrade solids and provide the desired degree of treatment. Lagoons should be designed according to accepted standards to aid in proper performance, and to provide evidence of proper size in the case of legal challenge.

Standards for designing lagoons may originate from several sources. Some state regulatory agencies have developed standards for sizing animal waste lagoons. Other entities such as the Soil Conservation Service, and the American Society of Agricultural Engineers have developed standards for designing lagoons. Most accepted standards provide volume fractions in the lagoon for the following.

1. Minimum design, or permanent volume. This fraction of the lagoon volume provides sufficient dilution to insure the proper environment for bacteria to degrade the incoming waste. This volume fraction is not removed from the lagoon in pumpdown operations.

2. Manure storage volume. This fraction of the lagoon volume provides storage for the volume of manure the lagoon will receive during the design storage period, and is removed when the lagoon is pumped. Storage periods generally range from 6 months to 1 year, with longer storage periods offering greatest flexibility in scheduling pumping operations.

3. Runoff volume. This fraction of the lagoon volume provides storage for the runoff from open lot areas during the design storage period, and is removed from the lagoon during pumping operations.

4. Net rainfall/evaporation on the lagoon surface. This fraction of the lagoon volume provides storage for the net gain of rainfall over evaporation on the lagoon surface, and is removed when the lagoon is pumped. This may be a negative value in areas of low rainfall and humidity.

5. Sludge storage. Some fraction of the manure solids entering a lagoon remain as a bottom sludge. While the sludge buildup rate in animal waste lagoons has not been precisely defined, most standards suggest a volume allowance for sludge a accumulation if sludge removal is not accomplished when the lagoon is pumped.

Items 2 and 3 above are climate (rainfall) related, and as such, are usually calculated based on some given frequency or return period. This return period may vary from the average year rainfall, to the rainfall occurring the wettest year in ten years, or be based on a single storm event such as the 25 year, 24 hour storm, depending upon the viewpoint of the designer.

Table 1 gives typical lagoon sizes for a 500 sow farrow-to-finish operation located in northern, central, and southern United States, based on ASAE EP403.1, the lagoon sizing practice developed by the American Society of Agricultural Engineers.

Table 1. Lagoon size and effluent disposal area required for a 500 sow farrow-to-finish operation designed according to the American Society of Agricultural Engineers Standard for livestock lagoons.

	Northern U.S.	Central U.S.	Southern U.S.
Lagoon volume cubic feet	2964000	2421000	2161000
Waterline dim. LxWxD, ft.	533x533x12	485x485x12	460x460x12
Lagoon volume cuft/lb live wt.	4.46	3.65	3.25
Effluent disposal area, acres	133	133	133

Assumptions:
- Farrowing - 80 @ 400 lbs
- Nursery - 1350 @ 40 lbs
- Finishing - 2700 @ 150 lbs
- 1 yr. manure storage period
- 5 yr. sludge storage period
- Effluent disposal area based on 100 lb/acre annual nitrogen

LAGOON CONSTRUCTION

Proper lagoon construction will insure that groundwater resources are protected, and the lagoon will perform as required during its useful life. The following steps are included in most guidelines for accepted construction techniques and methods for lagoons.

1. Site preparation. All trees, grass, and organic matter should be removed from the site. Topsoil should be stockpiled adjacent to the construction site for later use in seeding berms.

2. Soils investigation. Backhoe pits or soil borings may be required to ascertain if soils are suitable for constructing an impermeable seal. Depth to groundwater, bedrock, or permeable horizons should be determined before excavation. A geologic investigation by a qualified geologist may be advisable to determine sensitivity to groundwater contamination.

3. Excavation. Rocks, sand lenses, gravel, and any material not suitable for sealing should be removed from the impoundment. Excavation sufficient to obtain proper lagoon volume plus any required overexcavation for seal construction should be accomplished. Typical lagoon depths are in the range of 8 to 20 feet.

4. Seal construction. Lagoons should have a bottom seal sufficiently impermeable to protect groundwater. Seal construction guidelines generally call for overexcavation and recompaction of seal material in lifts not exceeding 6 inches compacted depth. A given permeability or leach rate such as 1 x 10-7 cm/sec may be a seal construction specification. Compaction with a sheepsfoot roller is suggested to achieve proper compaction of the seal. Soil amendments such as bentonite or soda ash, or in extreme cases, artificial liners, may be required to obtain a proper seal. A lagoon bottom seal should be covered with water immediately after construction to prevent drying and cracking of the seal.

5. Length/width ratio. Lagoon length/width ratio should be as near circular or square as possible for homogeneous bacterial activity. Length/width ratios up to 4:1 are acceptable if manure is properly distributed.

6. Surface water. Surface water, unless needed for filling or dilution should be diverted away from the lagoon.

7. Embankments. Lagoon embankments should be constructed to allow for settlement, mowing, and erosion prevention. Slopes in the range of 2:1 to 3:1 are typical. Freeboard in the range of 1 - 3 feet above full pool level is recommended.

8. Manure inlets. If manure will enter the lagoon via a pipe or sewer line, the line should enter the lagoon below the minimum pumpdown level, or above the full pool level. This will prevent ice from breaking the inlet pipe. The pipe should extend into the lagoon and be supported so there is a minimum of 3 feet of liquid under the pipe. Inlets above the liquid surface are susceptible to freezing at the end if small dribbling flows are present. Also cold air can move up the sewer line into the building if a trap is not provided. Pipe inlets below the minimum pumpdown level are generally preferred.

9. Safety and appearance. A stock-tight fence should be provided to prevent animal access to the lagoon. Lagoon berms should be seeded with a suitable grass to prevent erosion and enhance general appearance.

LAGOON MANAGEMENT

Proper lagoon design and construction are fruitless if the lagoon is not properly managed. Many problems associated with lagoons can be solved with proper management.

Lagoons should be filled one-third to one-half full with water before manure is introduced into the lagoon. This will assure the sufficient dilution is available for bacterial activity to become established, and start-up odors will be minimized. Starting a lagoon in the late spring or early summer months will allow a bacterial population to be established before cold weather, and will help prevent excessive odors the following spring.

Lagoons perform best when they are loaded continuously. Therefore, a waste management system should be devised which loads the lagoon at least weekly, and preferably daily. Flushing systems provide ideal loading conditions for lagoons.

Bedding and fibrous material will break down very slowly, or not at all in a lagoon. It is recommended that this material be excluded from the lagoon if at all possible. Non-degradable material leads to excessive sludge buildup and/or crusts forming on the lagoon, both of which interfere with pumping operations.

Pumping and irrigating from the lagoon is the single most important management item. In addition to preventing overflow and the associated pollution potential, pumping removes dissolved and suspended solids and allows room for the addition of dilution water through rainfall or other means. If lagoons are not pumped and diluted, salt concentrations may increase to levels which can inhibit bacterial activity. Salt levels in mature lagoons should be monitored yearly to insure they remain at safe levels. Electrical conductivity (EC) is a convenient field measurement which indicates salt content. EC levels above 10000 micromhos/cm indicate probable decreased bacterial activity, solids buildup, and increased odor levels.

Sludge removal should also be considered if sludge levels build to a significant percentage of total lagoon volume. Although a somewhat difficult operation requiring agitation and solids handling equipment, regular sludge removal can extend the life of a lagoon virtually indefinitely.

Efforts should be made to make a lagoon as aesthetically pleasing in appearance as possible. Berms and embankments should have a good grass cover, and be mowed and maintained on a regular basis. Such practices enhance good access to all parts of the lagoon as well as improving appearance. If a lagoon is within public view, a visually screening row of trees may be desirable. A well-maintained lagoon is less likely to attract attention, and cause controversy than a lagoon with an offensive appearance.

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LIVESTOCK WASTES - NEW ISSUES FACING PRODUCERS

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Environmental issues of concern to livestock producers in the past have dealt primarily with point sources of waste, and the effect of the nitrogen in the waste on groundwater resources. Predictably, the design of waste management systems to address these concerns focused on minimizing nutrient loss to groundwater with little concern for nutrient loss (such as ammonia volatilization) to the atmosphere. New issues and concerns now facing producers include potential contamination from non-point sources, the impact of phosphorus on surface waters, and the effects of compounds such as ammonia and methane volatilized to the atmosphere. New system designs will seek to minimize contaminant release to the atmosphere as well as minimize nutrient loss to groundwater.

Phosphorus Limits in Land Application of Waste

Traditional land application of manures based on nitrogen content typically results in overapplication of phosphorus. If soil conditions dictate consideration of a phosphorus rather than nitrogen limit, more land area will generally be required to assimilate the waste. The following table outlines the relative land area required with a phosphorus versus nitrogen limit.

Relative Land Area Required to Dispose of Livestock Waste with Phosphorus Versus Nitrogen Limit

	Swine		Dairy	
	slurry	lagoon	slurry	lagoon
corn	1.5	0.9	1.3	2.9
fescue	1.2	0.8	1.1	2.4

In general, invoking a phosphorus limit will significantly increase the amount of land a producer must have available to receive livestock waste.

Atmospheric Considerations

The effect of discharge of potential contaminants to the atmosphere will be scrutinized more closely in the future. Ammonia, methane, hydrogen sulfide, and particulates, all typically produced in livestock production systems, may be addressed in the upcoming Clean Air Act. Precedent suggests the possibility of fees being assessed to generators of air contaminants based on annual accumulation of emissions. Extensive data on emissions from livestock operations is lacking.

Systems designed to reduce emissions will include more "closed" manure treatment/storage facilities, and possible attenuation of exhaust ventilation air. Such measures will undoubtably increase the cost of livestock production. Reduced emissions can have other impacts also. Any compound, such as ammonia, formerly discharged to the atmosphere must be assimilated in land application. For example, elimination of a conventional anaerobic lagoon, which volatilizes about 80% of the input nitrogen to the atmosphere, will require about 5 times as much land as formerly needed, to assimilate the nitrogen that formerly went to the atmosphere.

EUROPEAN DEVELOPMENTS IN LIVESTOCK WASTE

Experience has shown that many environmental issues of future concern in the USA may be current issues or developments in Europe. Population density, and animal density in parts of Europe are possible indicators of future similar conditions in this country. Hence an observance of current developments in Europe may serve as a "window" of future concerns for USA producers.

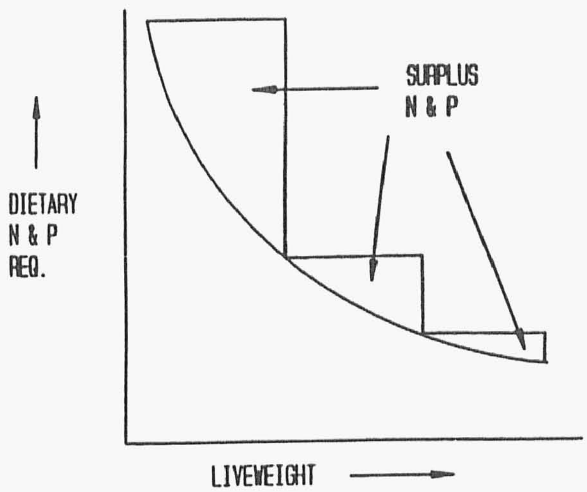
Regulation/Governance of Livestock Waste in Europe

Land application of manure is governed by law in some areas of Europe. This governance is typically based on nitrogen, or phosphorus, or both. In an attempt to address odor emissions, distance diagrams are used to determine allowable separation distances between swine farms and urban areas in Germany and the Netherlands. Allowable swine numbers on a farm are restricted by land available to receive nitrogen in Germany, France, and Denmark. In the Netherlands, starting a new swine farm, or expanding swine numbers on an existing swine farm, is allowed only if the farmer **owns** sufficient land to receive the manure nitrogen.

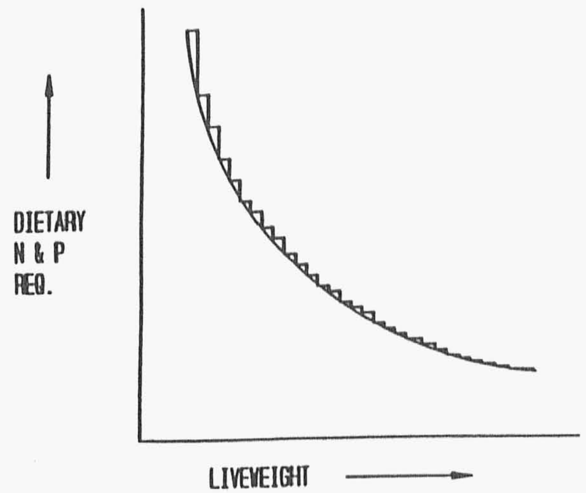
European Research to Lower Nutrient Levels in Manure

Research to lower levels of nitrogen and phosphorus in manure is receiving much attention in Europe. Experiments using only inorganic phosphorus in rations, or microbial phytase have resulted in up to 30% reduction of phosphorus in manure. This reduction is highly significant if phosphorus is a limiting nutrient in land application. The following figures describe research on more frequent adjustment of dietary levels of nitrogen and phosphorus to closely match animal requirements as growth proceeds.

OLD PRACTICE



NEW PRACTICE



The reduction of surplus dietary N and P in manure may be accomplished by more frequent changing of ration makeup as shown in the above figures. In some areas of Europe, producers are required to keep records of manure N and P produced, and may be charged a fee for excess N and P that may occur.

Ammonia Emissions

Ammonia emissions in the Netherlands have been shown to contribute significantly to acid rain. Study has also indicated that most ammonia emissions in the Netherlands is of manure origin. The following table shows the relative contribution of different phases of animal production enterprises to ammonia emissions in the Netherlands.

Percentage of Total Ammonia Emissions from Animal Production in the Netherlands

animal housing & manure storage	manure land application	grazing land
40	50	10

The Netherlands have adopted a political goal of reducing ammonia emissions by 70%, to be accomplished by the year 2000. If this goal is not attained, swine numbers in the country will be reduced. Research in the Netherlands has identified some techniques and practices which are effective in reducing ammonia emissions. Frequent flushing of manure from buildings, and storage of manure in covered or closed tanks helps reduce ammonia emissions. The use of injectors in applying manure slurry, and bio-filters, or air scrubbers for ventilation exhaust air are also practices which reduce ammonia emissions. An unconventional confinement building called the "deep-litter" or "sawdust" system is also receiving much attention. In this system, swine are grown on a litter bed consisting of about 24" of sawdust. Manure and sawdust are mixed weekly so that a continuous composting process occurs. The manure/litter mixture tends to self-dry with the heat generated in the composting process. Little ammonia is generated with this system, and there is no liquid slurry to manage.

While developments in European countries can offer insight to potential issues and concerns in the USA, it should be noted that parameters such as animal density, and human population density may be vastly different in Europe than in the USA. Such parameters may strongly influence the degree to which these issues become important in the United States. The following table shows swine animal density in several European countries as compared to Missouri.

Swine Density in Some European Countries and Missouri

country	swine per square mile
Netherlands	891
Belgium	489
West Germany	255
United Kingdom	89
Spain	81
Italy	77
France	57
Missouri	43

While animal density per square mile does not depict localized conditions of concentrated animal numbers, the fact that swine in Missouri are likely to be much more dispersed than some of the countries shown would perhaps suggest that environmental problems with swine production will be less acute than those experienced in some areas of Europe.

Summary

Past emphasis on protection of groundwater will continue, with new emphasis being placed on minimizing or reducing emission of contaminants to the atmosphere. Waste management systems will become more complex as they are designed to provide a higher degree of treatment. Cost of production will increase.

Nutritional Factors Influencing Lean Gain Efficiency[a]

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Pork production excellence has been commonly defined by traits, such as average daily gain, feed conversion, and feed cost per pound of live weight gain. The goal should be to improve the efficiency of lean production to meet the current and future consumer demand. Lean growth rate and lean tissue feed conversion may better define the true economic value of pork production. Lean growth rate is defined as carcass lean weight gain per day. Lean feed conversion, sometimes called lean tissue feed conversion, is the ratio of the amount of feed consumed divided by the carcass lean weight gain.

Technologies that improve lean development in market pigs are increasingly important. As consumers demand more nutritious meat products, greater research efforts are being made by genetic suppliers to produce animals with improved lean gain potential. Currently, pork processors are evaluating more accurate ways of estimating lean content ultimately providing producers increased payment incentive.

An interesting survey conducted by University of Wisconsin researchers reported that an estimated 28% of the hogs sold in the United States are bought on some type of carcass merit program. Since 1984, there has been a change in the amount of incentives paid to producers based upon the amount of backfat. Price differential for .1" backfat was $.06/cwt in 1984. Difference increased to $.45/cwt in 1988, and more recently it has been suggested that $1.20/cwt is common. Increased incentives for leaner pigs well continue to be a major industry trend.

<u>Growth and Development</u>: In order to understand ways of manipulating the nutritional program to optimize carcass value, a rudimentary understanding growth and development is necessary. Growth relates to the gain and weight brought about by cell multiplication, cell enlargement, and the incorporation of material directly into the cell. Development relates to the change in shape, form, and the function of the animal as growth progresses.

The body composition of pig depends on genetic background, live weight, and sex, but is also highly influenced by nutrition. Daily body protein formation increases up to 90-150 lbs. live weight, and plateaus there to market (220-240 lbs.). Daily body fat formation increases almost linearly with increasing body weight and feeding intensity (Figure 1).

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[a]Presented at Missouri Swine Day Conference, February 28, 1992.

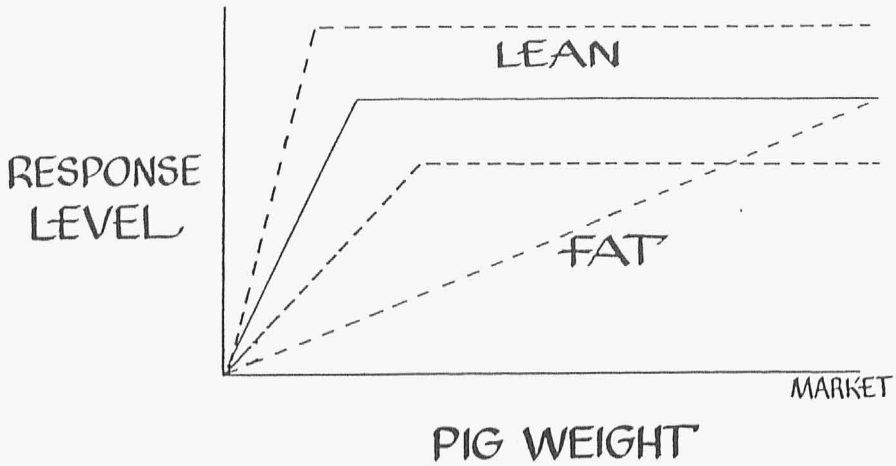

Figure 1. Tissue Deposition in Growing-Finishing Pigs

Lean gain occurs at varying rates during the grower-finisher phase, providing a rainbow-like curve as illustrated in Figure 2. This curve is best illustrated for genetically superior animals. Whereas, the unimproved pigs have less lean gain potential and their lean development curve is slightly different.

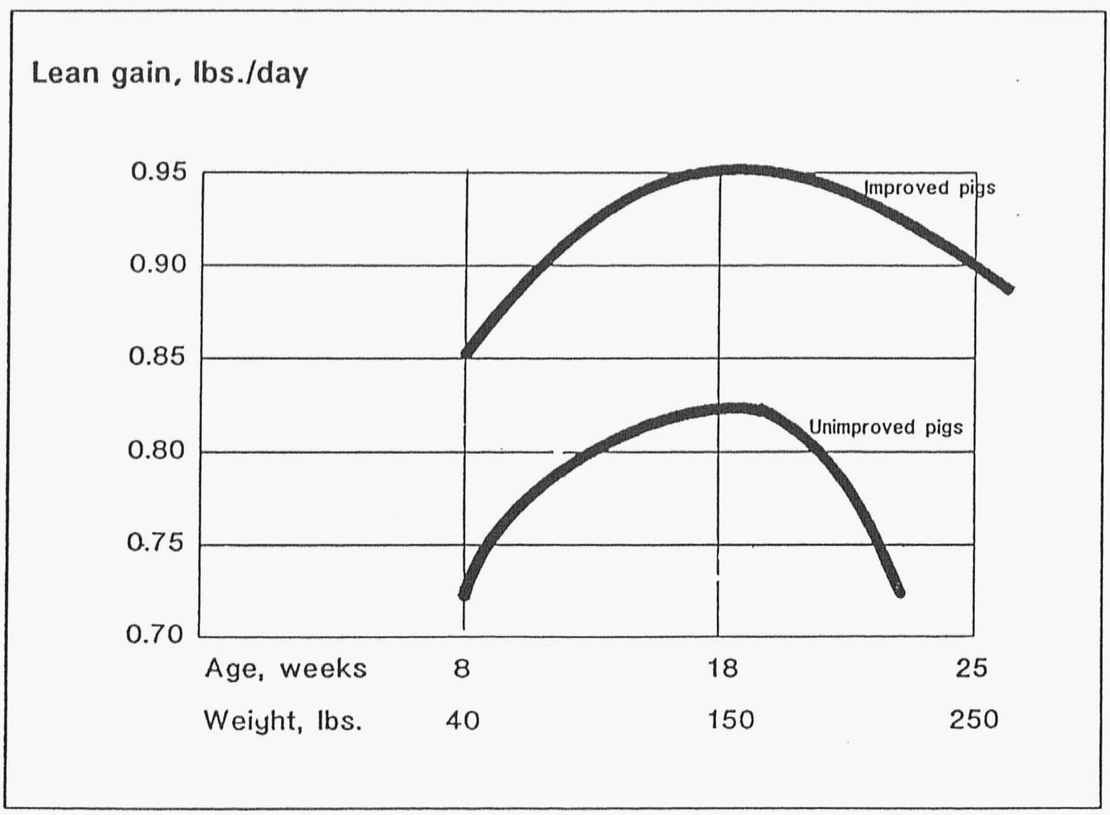

Figure 2. Lean Development Curve for Grower-Finisher Pigs

Improved pigs plateau in lean gain at approximately 140-180 pounds, depending on gender. Lean gain is lower from approximately 200 pounds to market weight than in the earlier stages of the development curve. Unimproved animals reach lean gain maximum at lighter weights (120-150 pounds), accelerating fat deposition rates during the finishing phase. Commonly, swine producers observe *"stall out"* at 180-210 pounds in some genetic lines, which is related primarily to inherently reduced lean development.

Lean efficiency, the amount of feed required per unit of lean gain, is better in the earlier stages of the pig's life and decreases as it nears market weight (Figure 3). Unimproved pigs are less efficient (higher feed/lean gain) in the finishing phase than genetically-improved ones.

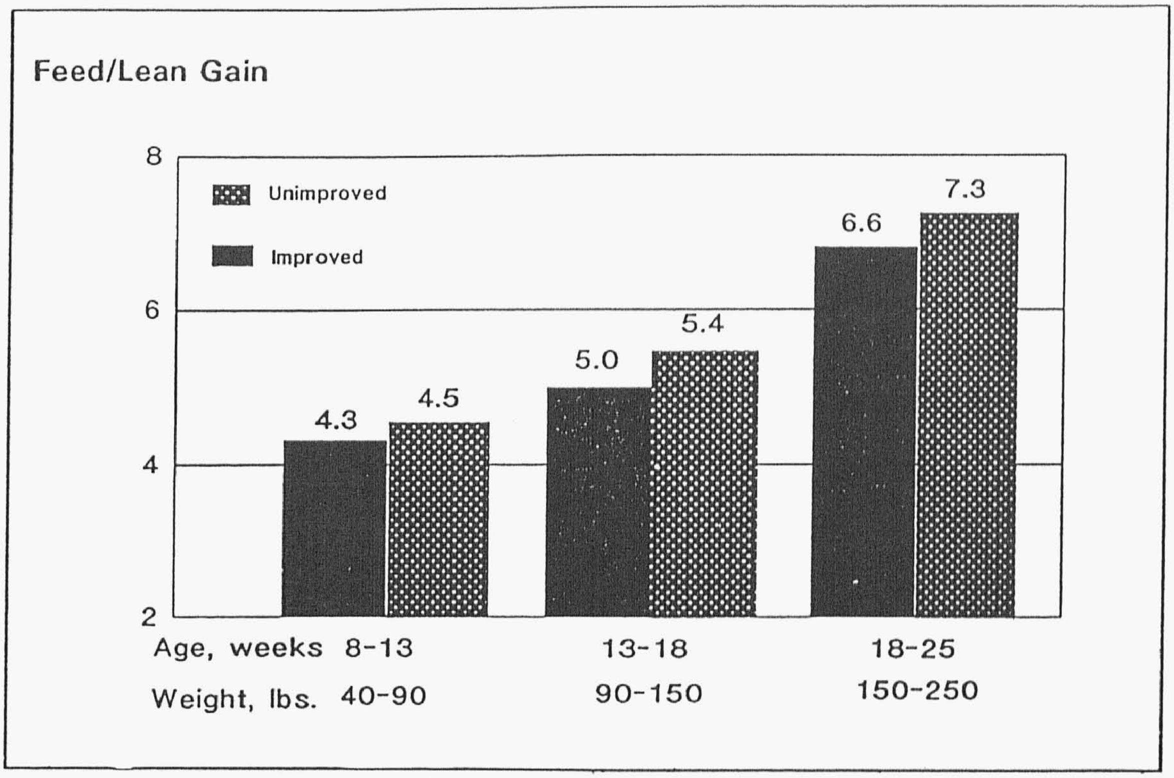

Figure 3. Lean Efficiency for Grower-Finisher Pigs

<u>Nutritional Manipulation</u>: Some fundamental concepts of nutritional carcass composition include:

1. An optimum rate of protein formation occurs only if the animals daily intake of essential nutrients and energy are sufficient.

2. Insufficient protein intake reduces growth rate, feed conversion, and lean development.

3. Excessive protein intake improves carcass leanness, but usually reduces daily gain and feed conversion.

4. Energy intake above that necessary for maintenance and maximal muscle formation increases fat formation.

5. Insufficient energy supply results in satisfactory carcass leanness, but growth rate and feed efficiency deteriorate.

The production of lean and uniform carcasses require diets optimized for essential nutrients in relationship to energy. In terms of energy and protein, the nutritional value of the diet should be based upon available amino acids and metabolizable energy.

Amino Acid Availability. Several decades ago, researchers documented that pigs do not require protein but several essential amino acids. When a pig consumes a protein ingredient, only a part of the amino acids present are digested and absorbed. The unabsorbed portion is excreted in the feces and urine. The digestion process is not consistent for all feed ingredients, indicating differences in amino acid availability. Variables, such as processing extremes, heat and/or pressure application, moisture content reduction, fiber content, and anti-nutritional factors inactivation, influence availability of amino acids. As a consequence, the amino acid availability of commonly-used feed ingredients may vary from 5% to 95% (i.e., feather meal to dried milk powder).

There is a definite need to consider nutrient bio-availability differences when formulating diets. Unfortunately, no laboratory or indirect assay of ingredient availability accurately estimates the true bio-availability to the animal. Central Soya has spent years developing available amino acid formulation so that the producer can achieve optimum performance at the lowest feed cost with his pigs. Available amino acid formulation allows more correct ingredient combinations in order to maintain constant formulation and performance. Unfortunately, diets based on crude protein or total amino acids can vary in available amino acid density.

Lysine is generally considered the first limiting amino acid in swine diets. As a result, Texas A&M researchers conducted trials with grower pigs averaging 44 pounds to determine if formulation on an available lysine basis would improve performance compared to a total lysine basis. Results of the studies are shown in Tables 1 and 2. Data summarized in Table 1 are for pigs fed a diet containing .70% total lysine and available lysine ranging from .50% to .58%. Pigs fed .58% available lysine gained faster (11% to 16%) with improved feed efficiency (5.0% to 6.4%) compared to the group fed .50% available lysine diet. In the second test, pigs were fed diets with available lysine at .58% and total lysine content varied from .70% to .83% (Table 2). There were no differences among treatments on gain and feed conversion in the second test. The authors concluded that more uniform pig performance would result when diets are formulated on an available lysine basis.

Table 1. Formulation of Swine Grower Diets on Available Lysine Basis[a]

Total Lysine, %		.70	
Available Lysine, %	.50	.54	.58
Trial 1			
Average daily gain, lbs.	1.54	1.65	1.79
Feed/gain	2.79	2.68	2.65
Trial 2			
Average daily gain, lbs.	1.63	1.70	1.79
Feed/gain	2.98	2.94	2.79

[a]Initial weight, 44 lbs.; 29-day test; minimum of 14 pigs fed individually. Texas A&M, 1985.

Table 2. Formulation of Swine Grower Diets on Available Lysine Basis[a]

Available Lysine, %		.58	
Total Lysine, %	.70	76	83
Trial 1			
Average daily gain, lbs.	1.79	1.76	1.76
Feed/gain	2.65	2.58	2.55
Trial 2			
Average daily gain, lbs.	1.79	1.81	----
Feed/gain	2.79	2.82	----

Texas A&M, 1985.

Supplemental Fat. Feed fats are a major source of energy for all types of feeds. Since the first significant amounts of fats were utilized in feeds in the early 1950's, growth of this market has been sizable. Trends toward higher energy feeds will continue to impact the use of fats. The addition of various levels (up to 16%) and types of fats (lard, tallow, yellow grease, poultry fat, soy oil, dried fats) to swine diets has yielded a general trend toward improved rate and efficiency of gain, reduced feed intake, and a tendency for increased backfat. However, the results have been somewhat inconsistent. Many times, weight gain is not affected while feed efficiency is consistently better with supplemental fat. A University of Nebraska researchers summarized 37 different tests with 2% to 20% added fat concluded:

1. A significant effect on weight gain may not occur until greater than 5% fat is added to the diet.

2. Feed efficiency is improved at all dietary supplemental levels over 2% fat.

3. Backfat does not appear to be influenced with less than 2-3% fat. However, over 4% supplemental fat will result in a slight increase in backfat, if the diets are not properly formulated.

Kansas State researchers (1988) conducted tests to evaluate the value of adding fat to finishing pig (average initial weight 83 to 98 pounds) diets year round. Although the fat level fed was 0% or 5% in all four seasons, the major application question is the value of fat during the cold-weather months. Fat addition significantly improved gain and feed conversion, regardless of season (Table 3). It is interesting to note that feed intake was substantially increased (about 14%) during the winter months, showing increased maintenance demand during the colder months. Lysine intake (grams/pig/day) was lower during the summer months. Therefore, logically, instead of changing the energy content (increased fat level) of the diet in summer months, amino acid density should be increased to minimize the performance influence of feed intake reduction.

Table 3. Effect of Fat Supplementation to Finisher Pig Diets Fed in Winter and Summer (Kansas State, 1988).

Season	Summer[a]			Winter[b]		
Fat Level, %	0	5		0	5	
Avg daily gain, lbs	1.93	2.07	(7.3)[c]	1.75	1.79	(2.3)
Avg daily feed intake, lbs	5.57	5.15	(7.5)	6.49	5.77	(11.6)
Feed conversion	2.89	2.48	(14.2)	3.72	3.20	(14.0)
Lysine intake, g/day	18.0	16.6		20.9	18.6	

[a]Summer, July to September, 1986.

[b]Winter, January to April, 1987.

[c]Numbers in parentheses represent % improvement due to fat addition.

<u>Calorie:Protein Ratio</u>. Pigs will, within limits, attempt to satisfy their energy requirements by altering feed consumption. Feed intake is dependent on maintenance requirement and nutrient needs for growth and development. If the calorie:protein (kcal of metabolizable energy per gram of protein) ratio is not adjusted to compensate for anticipated changes in feed intake, pig performance will be impaired. The importance of calorie:protein ratios has been demonstrated for a number of years by poultry nutritionists.

In 1983, Central Soya Feed Research introduced a refinement of calorie:protein ratio formulation. The concept was called *"potency formulation"*, a dietary balance of available amino acids with metabolizable energy designed to optimize gain, feed efficiency, and carcass merit. The effect of potency formulation on grower-finisher pig performance is shown in Table 4. The high-potency diet improved gain and feed efficiency 11% and 18%, respectively, compared to the low-potency (no added fat); lower metabolizable energy, lower available amino acid density. The high-potency diet improved gain 6% and feed conversion 14% compared to a medium-potency diet (corn/soybean meal equivalent with no added fat).

Our work continues to demonstrate that high-potency feeds, particularly if a producer is interested in optimizing production capacity (reducing days to market), will be the most profitable.

Table 4. Influence of Diet Potency on Grower-Finisher Pig Performance[a] (Central Soya, 1987).

	Low	Medium	High
Average daily gain, lbs.	1.87	1.96	2.07
% Improvement	100	105	111
Feed/gain	2.85	2.74	2.42
% Improvement	100	104	114

[a]Initial weight, 43 pounds; final weight, 230 pounds.

Recent studies have shown that there are different amino acid densities necessary to complement various production goals (gain, feed conversion, carcass merit) as demonstrated in Figure 4. The pigs' nutrient requirements to optimize gain, feed conversion, and carcass merit are different. To optimize carcass value of market pigs, higher levels of available amino acids are necessary compared to amounts recommended for gain and feed conversion.

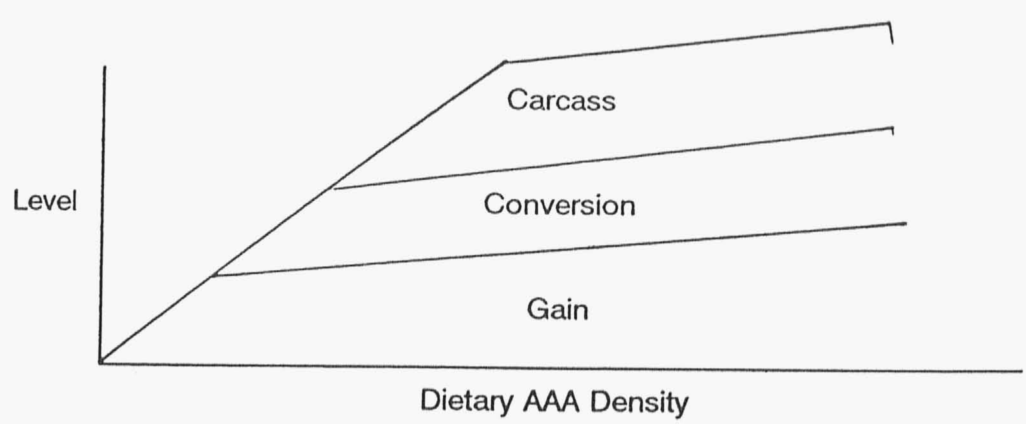

Figure 4. Dietary AAA Density - Influence on Performance

In a study comparing *"medium"* to *"high"* potency feeds, we have been able to demonstrate some very interesting findings (Table 5).

Table 5. Grower-Finisher Diet Potency Effects (Central Soya Feed Research, 1989)[a]

Item	Medium Potency	High Potency
Performance:		
Avg daily gain, lbs.	1.94	1.96
Avg daily feed intake, lbs.	5.37	5.04
Feed/gain[b]	2.77	2.57
Carcass:		
10th rib backfat, inch[c]	.95	.79
Loin-eye area, sq. inch[c]	5.81	6.26
% lean[c]	50.9	53.6
Lean gain, lbs./day[c]	.77	.84
Feed/lean gain[b]	7.08	6.12
Economics:		
Feed cost/lb. of gain, $	.162	.159
Carcass premium, $/pig	3.26	6.02

[a]Initial wt., 47 lbs.; final wt., 237 lbs.; 24 pigs/treatment.

[b]$P<.10$

[c]$P<.05$

Observations:

1. Gain was slightly increased with high potency compared to medium potency diet.
2. Feed efficiency was improved 7.2% with the high potency diet.
3. Backfat at the 10th rib was reduced by .16 inch or 17%.
4. Loin-eye area was increased by 7.8%, increasing the percent lean by approximately 3 percentage units.
5. Lean gain was improved 9.1% and feed per lean gain conversion by 13.6% with the high potency diet.
6. Feed cost/pound of gain was reduced and carcass premium increased with the high potency diet.

These results indicate that with fast-growing, lean pigs, the diet potency has a significant effect on performance, lean gain efficiency and, most importantly, profitability of commercial swine operations.

Phase Feeding. Scientists working in the broiler industry have studied phase feeding, the optimal number of diets and transition weight, to improve production efficiency. There is beginning to be similar emphasis evaluating increased number of diets during the grower-finisher phase. Traditionally, two diets have been used for grower (40-125 pounds) and finisher (125 pounds to market weight) pigs. Although the two-phase feeding program is relatively simple to implement, there are some inherent disadvantages to optimize lean development, especially for high lean genotypes.

Feeding multiple diets during the grower-finisher period more closely match the pig's nutrient needs and improve efficiency of lean gain. Excessive amino acid intake, especially during the finishing phase (200 pounds to market weight) can impair performance. This depression is apparently due to physiological burden of processing and eliminating extra protein consumed above the pig's biological needs. The magnitude of the excess and, thus, the metabolic burden is of economic significance. Therefore, multiple diets during the grower-finisher phase will improve performance and minimize extra feed costs.

University of Kentucky researchers (1991) have conducted studies evaluating amino acid density for grower-finisher pigs with varying lean gain potential. Their studies indicated that high lean genotypes required higher levels of amino acids (% of diet) than NRC minimum requirements. The Kentucky research illustrated the difference between feeding one, two, or three diets, during the grower-finisher period, on days to market (Table 6).

Table 6. Effect of Multiple Diets on Days to Market[a]

No. Diet(s)	% Total Lysine	Days to 240 Pounds
1	.95	100
1	.80	102
1	.65	107
1	.50	131
2	.80, .65	100
2	.95, .80	98
3	.95, .80, .65	96
3	.80, .65, .50	105

[a]Adapted from University of Kentucky research, 1991.

Feeding one diet with high lysine levels (.95 or .80%) reduced days to 240 pounds (29 to 31 days) dramatically compared with those fed a .50% lysine diet. Obviously, feeding higher lysine levels increased feed cost per ton. The traditional two-phase program promoted similar days to 240 pounds compared with the higher amino acid, single-phase programs. Perhaps, the most intriguing aspect was that the use of three diets further reduced days to 240 pounds, if amino acid densities were greater than those recommended by NRC. Based on these results, multiple diets, if properly fortified and sequenced, will reduce days to market and lower feed costs relative to feeding one or two high amino acid density diets.

Central Soya researchers compared a three-phase (Central Soya's PremaLean option) program with a traditional two-diet sequence (Table 7). The two-phase program was a grower diet from 45 to 150 pounds and a finisher diet from 150 to 250 pounds. The feeding program used Phase-I diet from 45 to 90 pounds, Phase-II diet from 90 to 150 pounds, and Phase-III diet from 150 to 250 pounds. Constant caloric density was maintained for all diets with the relative available amino acid (AAA) densities shown below:

Diet	Relative AAA Density, %
Grower	100
Finisher	85
Phase-I	107
Phase-II	96
Phase-III	85

Pigs fed the three-phase program increased gain 2.8% and improved feed efficiency 4.8% compared with the two-phase feeding program. Concurrently, lean gain (2.5%) and feed/lean gain (3.1%) were improved with the three-phase program. Importantly, the grower diet transition occurred at 150 pounds which was generally heavier (20-50 pounds) than commonly used under commercial conditions. One of the major advantages of the three-phase program was increased available amino acid levels for pigs less than 90 pounds. Therefore, the response of feeding three-phase feeding probably would have been greater if the transition from control grower diet was at 100-130 instead of 150 pounds. The results of this study indicated that the three-phase program improved lean development without dramatic changes in feed cost.

Table 7. 3-Phase vs. Traditional 2-Phase Grower-Finisher Feeding Program[a]

	2-Phase	3-Phase
Item	Grower 45-150 Lbs. Finisher 150-250 Lbs.	Phase-I 45-90 Lbs. Phase-II 90-150 Lbs. Phase-III 150-250 Lbs.
Gain, lbs./day	2.11	2.17
Feed intake, lbs./day	5.74	5.62
Feed/gain	2.72	2.59
Lean gain, lbs./day	.79	.81
Feed/lean gain	7.06	6.84

[a]Central Soya Feed Research PT-1140; 98- day study; total of 144 pigs used.

An additional study (ST-91205) was conducted to compare two-phase and phase feeding programs. Pigs fed the two-phase program received grower from 38 to 135 pounds and finisher from 135 pounds to market weight. Grower diet was fed for eight weeks. Phase-fed pigs were significantly

(P<.05) heavier at 4, 8, and 12 weeks of the test compared with those on the two-phase program (Figure 5).

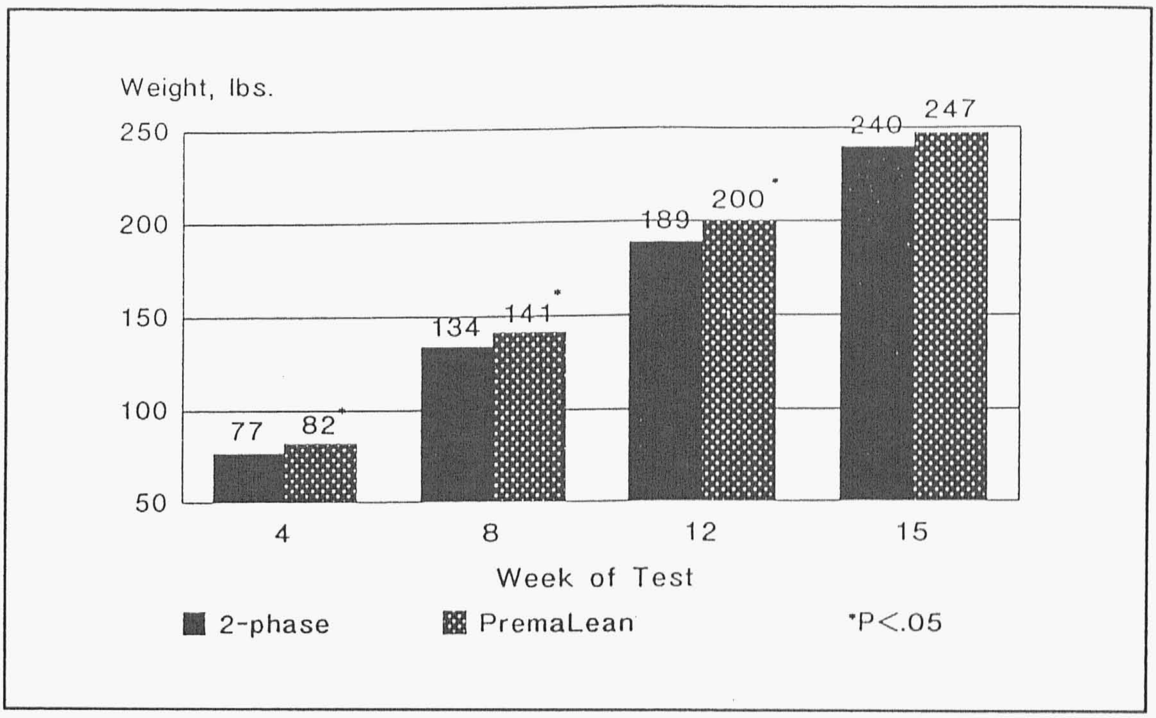

Figure 5. Comparison of Traditional 2-Phase vs. PremaLean on Weight Gain (Central Soya Feed Research ST-91205)

As shown in the earlier study (Central Soya Feed Research PT-1140), average daily gain and feed conversion (P<.10) were improved with the three-phase program (Table 8). There were some dramatic findings with the phase program on carcass composition.

1. Increased carcass weight, 6 pounds.

2. Increased (P<.05) yield (dressing percentage) by 1.4 percentage units.

3. Tended to decrease backfat thickness (.78 versus .83 inch).

4. Increased loin and ham (P<.05) weights by 2.2 and 4.9%, respectively.

Table 8. Comparison of Traditional 2-Phase Vs. 3-Phase Feeding Program on Market Pig Performance and Carcass Composition[a]

	2-Phase	3-Phase
Gain, lbs./day	1.94	2.00
Feed intake, lbs./day	4.80	4.84
Feed/gain[b]	2.47	2.41
Carcass weight, lbs.	170	176
Yield, %[c]	75.3	76.7
Backfat, inch	.83	.78
Loin weight, lbs.	37.0	37.8
Ham weight, lbs.[c]	40.7	42.7
% lean[d]	51.0	51.6

[a]Central Soya Feed Research ST-91205; average initial weight, 37.5 pounds.

[b]$P<.10$

[c]$P<.05$

[d]Based on Purdue University prediction equation.

A recent industry survey showed that average loin and ham weights were 35.6 and 36.8 pounds per pig, respectively. Whereas, in this study, the loin and ham weights were 6.2% and 16.0% heavier for the phase-fed group compared to industry averages at comparable slaughter weights. The phase-fed pigs tended to have higher lean content. Lean percentage estimates were based on Purdue's formula using backfat thickness as a single component in the prediction equation, which may not accurately assess lean values.

These studies demonstrate that three-phase feeding improves growth, feed conversion, and lean development. As carcass merit buying programs continue to be improved, phase feeding programs can add to market pig profitability, especially for producers with pigs having greater genetic potential.

Summary. The bottom line of these research tests show that grower-finisher pig nutrition may limit genetic expression. If superior genetic potential is available and pigs are fed marginal diets, inferior performance may result. The greater the potential for lean deposition, the greater the importance of the nutritional program. Diet potency has significant effects on lean development efficiency. Phase feeding has also been shown to improve lean development. As carcass lean incentive programs continue to develop, nutritional programs that optimize lean gain can have significant impact on profitability.

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