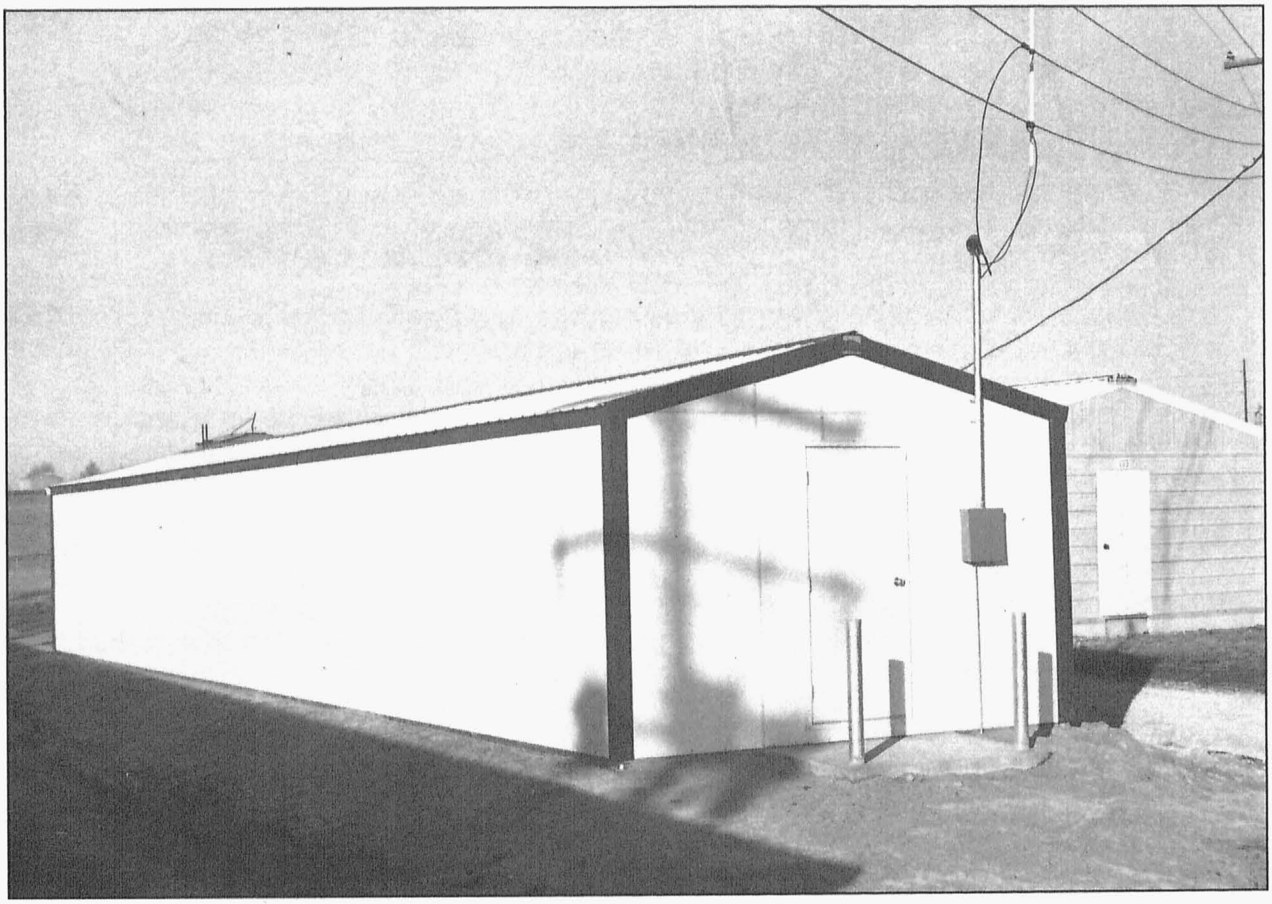
1990 Swine Day Research Report



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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 1990 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 UMC 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
Chairman

GLA/ell

ACKNOWLEDGEMENT

Through 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 to the Pork Producers in the industry. Presentation of research results will continue on an annual basis.

Participants from off-campus and from other faculties assemble with resident staff from the University of Missouri Animal Science faculty to review, discuss and update technology related to the industry opportunities and problems evaluations. 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.

Cover: New hot nursery, donated by the Missouri Pork Producers Association.

COMPANIES AND ORGANIZATIONS CURRENTLY SUPPORTING UM SWINE RESEARCH - 1990

Addison Biological Laboratory, Inc., Fayette, MO
Archer-Daniel-Midland, Mexico, MO
Biokyowa, Inc., Chesterfield & Cape Girardeau, MO
Bio Techniques Laboratories, Inc., Redmond, WA
Diamond V. Mills, Inc., Cedar Rapids, IA
Estrogenix, Inc., Boulder, CO
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Missouri Department of Agriculture Marketing Division,
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Missouri Soybean Merchandising Council, Jefferson City, MO
Monsanto Company, St. Louis, MO
National Pork Producers Council, Des Moines, IA
Pfizer, Inc., Lee's Summit, MO
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United States Department of Agriculture, Washington, DC
Wilson Food Corporation,Marshall, MO
The Upjohn Company, Kalamzoo, MI

SPECIAL CONTRIBUTORS TO 1990 UMC SWINE DAY

Pork Chop Lunch	-- Cargill, Incorporated - Nutrena Feed Division Pfizer, Incorporated
Swine Day Proceedings and Activities	-- MFA, Incorporated Diamond V. Mills, Inc. Biokyowa, Inc. Frederick B. Miller Endowment Purina Mills, Inc. Moorman Manufacturing Company
Guest Speaker	-- Frederick B. Miller Endowment Eli Lilly and Company

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EFFECTS OF INDIVIDUAL VERSUS GROUP PENNING ON THE PERFORMANCE OF NURSERY PIGS

MARIA JAMTGAARD AND G. W. JESSE

SUMMARY

Individual versus group penning of nursery-aged barrows and gilts was investigated in a switchback design during two trials. Group size was four pigs per pen. During one trial (Trial 2) individually-penned pigs grew faster (P<.10) and ate more feed (P<.05) than group-penned pigs. Feed efficiency was not affected by penning treatment in either trial.

Although the performance data are inconsistent, it appears that pigs will do equally well whether fed individually or as a group. Therefore, it is conceivable that individually-fed test station boars can express their genetic potential for growth rate without having penmates.

INTRODUCTION

Research on the effect of individual versus group penning on the performance of swine is limited. Historically, in the United States, swine evaluation stations have collected performance data on boars by testing either sibs or half sibs, housed as a group of three or four per pen. Therefore, feed intake and feed efficiency are determined on a pen basis. It can be argued that a disadvantage of this approach to the identification of genetically superior pigs is the absence of individual feed intake and consequently, efficiency of feed utilization. In 1988 the National Swine Improvement Federation suggested that feed consumption be measured on an individual basis. Realizing that feed costs account for approximately 60% of the total cost of producing pork, it seems quite apparent that the swine industry needs to identify the genetically superior breeding stock in the most effective manner.

The objective of this experiment was to compare the performance of weanling pigs housed either individually or in groups. Measures of performance included growth rate, feed intake and feed efficiency.

PROCEDURES

During two separate trials, university-raised, crossbred weanling pigs averaging 4 weeks of age were used to compare two penning arrangements, individual versus group. As shown in Table 1, the experimental design was a switchback which included three test periods; hence, all pigs were tested in both individual and group penning arrangements. Half of the pigs were tested in a group pen for two periods and individually for one period compared to the other pigs that were fed individually for two periods and as a group for one period. These treatment sequences are hereafter referred to as group-individual-group (G-I-G) or individual-group-individual (I-G-I). Each test period was 7 days in length with a 4 day acclimation period preceding each weekly test period. Therefore, the total duration of each treatment sequence was 33 days (4 d + 7 d for Period 1 + 4 d + 7 d for Period 2 + 4 d + 7 d for Period 3).

TABLE 1. EXPERIMENTAL DESIGN

Period[a]	Treatment sequence 1	Treatment sequence 2	Initial day[b] Trial 1	Initial day[b] Trial 2
1	G	I	Apr 20	July 13
2	I	G	May 1	July 24
3	G	I	May 12	Aug 4

[a]Refers to 7 day test periods.
[b]Both trials were conducted in 1987.

Each trial utilized 40 pigs consisting of littermate pairs of the same sex (barrows or gilts). One pig from each pair was randomly assigned to the G-I-G treatment and the other pig to the I-G-I treatment. Five replicates of eight pigs per replicate (four littermate pairs with all eight pigs being of the same sex) were used during each trial. This included four pigs for each treatment sequence (G-I-G and I-G-I). Trial 1 included four replicates of gilts and one of barrows and Trial 2 three and two, respectively. Average initial weights for the G-I-G and I-G-I treatment sequences were 20.7 and 21.8 lbs and 18.3 and 18.6 lbs for Trials 1 and 2, respectively.

All pigs were housed at the University of Missouri Swine Research Complex (SRC) in a totally-enclosed, slatted floor nursery building using 4' x 4' pens. These pens were divided by gates made of vertical pipe, which enabled pig to pig contact. Each pen had one nipple waterer and a one-hole Smidley feeder. One pen within each replicate was used to accommodate the group-fed pigs (4 hd) during all three test periods. Four pens of the same dimension were used to house the four individuals of each replicate; these pigs were littermates to those in the group pen.

During the first 11 days (4 d acclimation + 7 d of Period 1) all pigs were full-fed a pelleted, commercial complete diet (19% crude protein). At the end of Period 1 the pigs were switched to an 18% corn-soybean meal diet (meal form) which included carbadox. This diet was fed for the duration of the study.

Daily gain, feed intake and feed efficiency were compared for each test period using pen means as the experimental unit. The data were analyzed by analysis of variance. In addition, arithmetical differences (AD) were compared according to Brandt:

$$AD = (GP1 + GP3) - 2IP2) \quad \text{or} \quad (IP1 + IP3) - 2GP2)$$

where G refers to the group penning and I the individual penning for periods 1, 3 and 2, respectively.

RESULTS AND DISCUSSION

As shown in Table 2, average daily gain (ADG) and feed efficiency (F/G) for Trial 1 were not affected by penning treatment. Daily feed intake (FI) was .29 lb higher ($P<.05$) during Period 1 for those penned individually. However, feed consumption during Periods 2 and 3 was not influenced by treatment. Although not determined, feed wastage appeared to be more of a problem with the individually-penned pigs. Consequently, the difference in feed intake during Period 1 may be confounded with feed wastage. Feed conversion (F/G) was not affected by treatment.

TABLE 2. AVERAGE DAILY GAIN (ADG), DAILY FEED INTAKE (FI) AND FEED EFFICIENCY (F/G), LBS

Trial	1		2	
Treatment	1	2	1	2
Trt sequence[a]	G-I-G	I-G-I	G-I-G	I-G-I
Initial wt[b]	20.70	21.76	18.26	18.59
Final wt[b]	56.89	58.06	45.85	50.69
ADG by period				
1	.75	.66	.59	.79*
2	1.54	1.39	1.01	.86
3	1.65	1.83	1.03	1.50*
FI by period				
1	1.10	1.39*	.86	1.28
2	2.04	2.16	2.31	1.85
3	3.28	3.21	2.33	3.23*
F/G by period				
1	2.22	2.59	1.22	1.50
2	1.53	2.14	2.35	1.85
3	2.08	1.82	2.97	2.30

[a]Refers to the first, second and third 7 day period (G = group pen and I = individual pen).
[b]Initial and final weight were not statistically compared.
*Means within trial are different ($P<.05$).

For Trial 2 ADG was higher (P<.05) for individually-penned pigs during Periods 1 and 3 (.79 vs .59 lb and 1.50 vs 1.03 lb, respectively). Daily feed consumption was not affected by treatment during Periods 1 and 2; however, during Period 3 the individually-penned pigs ate .90 lb more feed per day (P<.05) than the group-penned pigs. As with Trial 1, feed efficiency was not affected by treatment.

Table 3 shows the arithmetical differences (AD) between individual versus group penning on a weekly basis, which statistically speaking, is the preferred method of expressing the results of this switchback design. For Trial 1, gain and feed intake were not affected (P>.05) by penning treatment. The results of Trial 2 show differences in gain (P<.10) and feed intake (P<.05) in favor of the individually penned pigs. The individually-penned treatment resulted in 1.67 lb more weekly gain (.24 lb/d) and a 3.98 lb greater weekly feed intake (.57 lb/d). Feed efficiency differences were not significant.

TABLE 3. ARITHMETICAL DIFFERENCES FOR GAIN (G), FEED INTAKE (FI) AND FEED EFFICIENCY (F/G) FOR GROUP VERSUS INDIVIDUAL PENNING ON A WEEKLY BASIS, LBS[a]

	Trial	
Item	1	2
G	-.68	-1.67*
FI	-.73	-3.98**
F/G	.16	.22

[a]A negative value implies a faster growth rate and a larger feed intake for the individual penning treatment.
*(P<.10).
**(P<.05).

EFFECTS OF ISOLATED-INDIVIDUAL VERSUS GROUP PENNING ON PERFORMANCE AND PHYSIOLOGICAL PARAMETERS OF NURSERY PIGS

MARIA JAMTGAARD AND G. W. JESSE

SUMMARY

In summary, the results of this experiment agree with the previous experiment which compared the performance of nursery pigs housed either in groups of four or individually. Nursery aged barrows and gilts that were penned individually and not allowed visual or physical contact with other pigs (isolation) performed equally as well as pigs fed in groups. Similar plasma cortisol and triiodothyronine values for the two treatments (group penned versus isolated individually penned) indicates that those pigs housed and fed individually were not stressed; at least no more so than the group housed pigs.

Hence, as a result of this experiment and the first experiment (Effects of individual versus group penning on the performance of nursery pigs) it appears that boars housed in pens with solid wall partitions in Swine Test Stations should perform satisfactorily. Perhaps auditory and olfactory sensations allow the pig to overcome any detrimental effect of isolation, if such an effect exists.

INTRODUCTION

The initiative for this experiment was based upon inconclusive, but strong evidence from our first experiment (see previous paper "Effects of individual versus group penning on the performance of nursery pigs") that individual penning was not detrimental to the performance of nursery pigs. Individually-penned pigs in the first experiment were allowed physical and visual contact with pigs in neighboring pens. Realizing that some swine facilities have solid pen partitions with a single row of pens, this experiment was designed to investigate the effects of isolation (no visual or physical contact) on the nursery pig.

The objectives of this experiment were to evaluate production and physiological parameters in isolated-individual versus group penned nursery pigs. Dependent variables determined were growth rate, feed intake, feed efficiency, cortisol and triiodothyronine concentrations.

PROCEDURES

Forty university-raised, crossbred weanling pigs were utilized in each of three separate trials to compare two penning arrangements, isolated-individual versus group. The experimental design was a switchback which has been described in the previous paper. As shown in Table 1, the pigs were subjected to three 7 day test periods with the treatment sequence being either group-isolated individual-group (G-II-G) or isolated individual-group-isolated individual (II-G-II). Each test period was preceded by a 2 day acclimation period rather than a 4 day period used during Experiment 1; hence, the total duration of each trial was 27 days (2 d acclimation + 7 d Period 1 + 2 d acclimation + 7 d Period 2 + 2 d acclimation + 7 d Period 3).

TABLE 1. EXPERIMENTAL DESIGN

Period[a]	Treatment sequence 1	Treatment sequence 2	Initial day[b] Trial 1	Initial day[b] Trial 2	Initial day[b] Trial 3
1	G	II	Dec 5	Feb 27	Jul 2
2	II	G	Dec 14	Mar 7	Jul 11
3	G	II	Dec 23	Mar 16	Jul 20

[a]Refers to 7 day test periods.
[b]Trial 1 was in 1987 and Trials 2 and 3 in 1988.

Each trial consisted of five replicates of eight pigs per replication (four pigs per treatment) with each replicate including four littermate pairs, all being of the same sex (either barrows or gilts). One pig from each pair was randomly assigned to Treatment 1 (G-II-G) and the other to Treatment 2 (II-G-II). Trials 1 and 2 included three replicates of barrows and two of gilts and Trial 3 five replicates of barrows. Average initial weights for the G-II-G and II-G-II treatments were 15.9 and 17.1 lb, 17.8 and 20.2 lb, 15.8 and 15.2 lb for Trials 1, 2 and 3, respectively.

All pigs were housed at the University of Missouri Swine Research Complex (SRC) which is a totally-enclosed, slatted floor nursery building. The original 4' x 4' pens were modified for the individual-isolated treatment by placing plywood on three sides. Since one side of the pen (inside wall) was already solid, this modification resulted in total isolation, thereby preventing both physical and visual pig-to-pig contact. Four isolated pens contained one pig each and one pen contained the group of four for each replicate. During each trial one pen within each replicate was used to accommodate the group of four pigs during all three test periods.

During the first 9 days (2 d acclimation + 7 d Period 1) all pigs were full-fed a pelleted, commercial complete diet (19% crude protein). At the end of Period 1 the pigs were switched to an 18% crude protein corn-soybean meal diet (meal form) which included carbadox. This diet was fed for the duration of the study.

Blood samples were drawn via jugular puncture at the end of each test period during Trial 3. Plasma samples were analyzed for cortisol and triiodothyronine (T_3) in an effort to determine whether or not penning treatment had any affect on stress of the pig.

Daily gain, feed intake, feed efficiency, cortisol and triiodothyronine concentrations were compared for each period using pen mean as the experimental unit. The data were analyzed by analysis of variance. In addition, arithmetical differences (AD) were compared according to Brandt:

$$AD = (GP1 + Gp3) - 2IIP2$$
or
$$= (IIP1 + IIP3) - 2GP2$$

where G refers to the group penning and II to the isolated-individual penning for periods 1, 3 and 2, respectively.

RESULTS AND DISCUSSION

As shown in Table 2, average daily gain for Trial 1 was not affected by penning treatment in any of the three periods; however, daily feed intake was .83 lb higher (P<.05) during Period 1 for the isolated-individual versus the group penned pigs. For Trial 2, ADG was not affected by treatment during Periods 1 and 2; however, during the third period the isolated-individual pigs gained .51 lb more per day (P<.05). Daily feed intake was .38 and .77 lb higher (P<.05) during Periods 1 and 3, respectively for the II group. The increase in feed consumption for the isolated-individually penned pigs during Trials 1 and 2 could have been influenced by the effect of winter or thermal environment; although the study was conducted in an environmentally controlled building. Low temperatures during the winter affect the behavior of individually penned pigs. The inability of the isolated, single pigs to huddle probable affected their performance, since they were in continuous contact with an unheated floor and may have lost more heat by conduction and therefore needed extra energy to maintain body temperature.

For Trial 3, ADG and FI were not affected by penning treatment during Periods 1 and 3. However, during Period 2 daily gain and feed intake were .18 and .15 lb higher (P<.05) respectively for the isolated-individual pigs versus those group penned. Feed efficiency was not affected in any of the three trials by penning treatment.

Table 3 shows the arithmetical differences between II and G penning treatments on a weekly basis. For Trial 1, growth rate and feed intake were not affected by penning treatment. Differences in feed intake during Trial 2 favored (P<.05) the II pigs compared to the G pigs (2.11 lb). For Trial 3, differences in gain and feed intake favored (P<.05) the isolated-individual penning (.70 and 1.03 lb, respectively). Feed efficiency was not affected by penning treatment for any of the three trials.

TABLE 2. AVERAGE DAILY GAIN (ADG), DAILY FEED INTAKE (FI) AND FEED EFFICIENCY (F/G), LBS

Trial	1		2		3	
Treatment	1	2	1	2	1	2
Trt sequence[a]	G-II-G	II-G-II	G-II-G	II-G-II	G-II-G	II-G-II
Initial wt[b]	15.9	17.1	17.8	20.2	15.8	15.2
Final wt[b]	41.8	40.7	43.3	47.7	34.8	34.3
ADG by period						
1	.86	.57	.97	1.03	.62	.62
2	1.19	.99	1.61	1.43	.66*	.48
3	1.21	1.50	.81	1.32*	1.10	1.21
FI by period						
1	.75	1.58*	.68	1.06*	.81	.81
2	1.08	1.41	2.16	2.13	1.34*	1.19
3	2.16	2.13	1.89	2.66*	2.00	2.27
F/G by period						
1	1.90	3.51	.86	1.19	1.42	1.68
2	1.00	1.85	1.70	1.62	2.39	2.77
3	1.96	1.46	2.55	2.26	1.89	1.98

[a]Refers to the first, second and third 7 day treatment (G = group pen and II = isolated-individual pen).
[b]Initial and final weight were not statistically compared.
*(P<.05).

TABLE 3. ARITHMETICAL DIFFERENCES FOR GAIN (G), FEED INTAKE (FI) AND FEED EFFICIENCY (F/G) FOR GROUP VERSUS ISOLATED-INDIVIDUAL PENNING ON A WEEKLY BASIS, LBS[a]

	Trial		
Item	1	2	3
G	-.70	-1.58	-.70*
FI	-.33	-2.11*	-1.03*
F/G	.11	.12	.16

[a]A negative value implies a faster growth rate and larger feed intake for the isolated-individual penning.
*(P<.05).

Mean serum cortisol concentrations for the G and II treatments for each period are presented in Table 4. There were no differences between penning treatments; however, plasma cortisol values were high for both treatments at the end of Period 1, suggesting that all pigs had been stressed prior to and/or during Period 1. Some possible stressors which may have contributed to this response include a change in housing and penning arrangement, a change to a solid diet and a change in thermal environment.

The triiodothyronine values for group and isolated-individual penning for each period are presented in Table 5. There were no differences (P>.05) between penning treatments for any of the periods. All triiodothyronine concentration values were similar among all animals in both treatments. Therefore, it can be said that isolated-individual penning did not alter the thyroid status.

TABLE 4. PLASMA CORTISOL CONCENTRATIONS (ng/ml) FOR TRIAL 3[a]

Treatment	1	2
Trt sequence[b]	G-II-G	II-G-II
1	65.6	55.9
2	36.3	34.3
3	35.6	41.4

[a]Means were not different (P>.05).
[b]Refers to the first, second and third 7 day test period.

TABLE 5. PLASMA TRIIODOTHYRONINE CONCENTRATIONS (ng/ml) FOR TRIAL 3[a]

Treatment	1	2
Trt sequence[b]	G-II-G	II-G-II
1	.93	1.03
2	.93	.95
3	1.07	1.07

[a]Means were not different (P>.05).
[b]Refers to the first, second and third 7 day period.

EFFECT OF RECEIVING DIET ANTIBIOTIC AND A LACTOBACILLUS ORGANISM (COBACTIN)[1] ON SUBSEQUENT HEALTH AND PERFORMANCE OF THE PURCHASED, COMMINGLED FEEDER PIG

G. W. JESSE

SUMMARY

During the fall of 1988 one hundred and forty-four feeder pigs representing seven different sources were utilized in a 98 day growing-finishing study to compare the effects of including an antibiotic and a lactobacillus organism in the receiving diet. The treatments compared were no antibiotic versus including CSP250 or neomycin or neoterramycin for 28 days. In addition, each of these four antibiotic treatments were fed with or without the addition of a feed grade lactobacillus organism (Cobactin). Upon discontinuing the antibiotic treatment, Cobactin remained in the diet until day 42. Average daily gain for the entire 98 day study was not affected by dietary treatment; however, during the first 28 days pigs on the control diet (no antibiotic) were significantly slower growing than the other three treatments. Cobactin had no effect on growth rate or feed conversion.

INTRODUCTION

As a follow up of a previous study initiated during the summer of 1988, this experiment was designed to evaluate the same antibiotics (CSP250, Neomycin and Neoterramycin) in the receiving diet of purchased feeder pigs; however, the study was initiated in December rather than June. An additional component of this particular study was the inclusion of a lactobacillus organism (Cobactin) in the feed for the first 42 days of the feeding period.

Specific objectives of this study were threefold:

To compare the health and performance of purchased feeder pigs fed a corn-soybean meal diet with or without an antibiotic for the first 28 days.

To compare the health and performance of purchased feeder pigs fed one of three different antibiotics (CSP250, Neomycin, Neoterramycin) for the first 28 days of the growing-finishing period.

To compare the health and performance of purchased feeder pigs fed a corn-soybean meal diet with or without Cobactin for the first 42 days of the growing-finishing period.

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[1]Bio Techniques Laboratories, Inc. of Redmond, Washington provided this product as well as financial support.

PROCEDURES

On December 6, 1988 one hundred and forty-four feeder pigs averaging 50.3 lb were purchased via the Alton Sales Company at Alton, Missouri. These pigs were from nine different farms of origin. The experimental design for this study was a randomized complete block with dietary treatments replicated three times in a two by four factorial arrangement as shown in Table 1.

TABLE 1. EXPERIMENTAL DESIGN

Treatment				
No.	Antibiotic	Cobactin	No. Pigs	No. Pens
1	Control	Yes	18	3
2	Control	No	18	3
3	CSP250	Yes	18	3
4	CSP250	No	18	3
5	Neomycin	Yes	18	3
6	Neomycin	No	18	3
7	Neoterramycin	Yes	18	3
8	Neoterramycin	No	18	3

Level of feed grade medication was as follows:

CSP250 = 250g/ton

Neomycin = 200g/ton of neomycin sulfate which provided 140g/ton of neomycin

Neoterramycin = 100g of oxytetracycline plus 100g of neomycin sulfate/ton

Most pens consisted of three barrows and three gilts; however, a few pens had two and four or vice versa.

The pigs for this study were selected on Monday evening, December 5 upon their arrival at the barn and penned according to owner. On Tuesday afternoon the pigs were eartagged, individually weighed and given an ivermectin injection. Antibiotic treatment was assigned at random at this time and designated by the use of four different kinds of ear tags. During the pigs' stay at the feeder pig market they were off feed and water. On Tuesday evening, after approximately 24 hours at the market, the pigs were transported 350 miles over night, by truck, before delivery to the University of Missouri Southwest Center at Mount Vernon arriving at approximately 7:00 a.m. on Wednesday, December 7.

The test facility was a open-front barn that included 30 pens of identical design. The floor and the pen dividers were solid concrete and the back wall opened to allow for natural ventilation during warm weather. Each 5' x 15' pen was equipped with one nipple waterer and a one-hole self feeder.

Upon arrival the pigs were weighed and assigned at random within sex and previously determined antibiotic treatment to pen. After this the Cobactin treatment was randomly assigned to four pens within each replicate. All pens contained six head. All pigs were full fed a 16% crude protein corn-soybean meal receiving diet in meal form for the first 28 days. As shown in Table 1, eight different receiving diets were compared which included a control diet (no antibiotic) and three diets with antibiotics with all four diets being fed with or without the lactobacillus organism. Antibiotics compared included CSP250, Neomycin and Neoterramycin. All antibiotics were included at a level recommended by the manufacturer. These levels are shown as footnotes in Table 1. On day one at Mt. Vernon all pigs were dewormed using dichlorvos. The lactobacillus organism (Cobactin) was provided daily for the first 42 days of the study. Cobactin (L. acidophilus) in granular form was mixed daily with water to make a liquid concentrate which was then premixed with an estimated daily amount of diet to provide one half ounce of Cobactin per pig. This mixing was accomplished by using a portable concrete mixer.

On day 28 all pigs were switched to a 14% crude protein corn-soybean meal diet which did not include an antibiotic; however, half of the pigs continued to receive Cobactin for an additional two weeks. The entire trial was 98 days in duration.

Pig weights and feed consumption by pen were determined every 14 days. The data were compared by analysis variance.

RESULTS AND DISCUSSION

As shown in Table 2, average daily gain during the antibiotic treatment period (first 28 days), the Cobactin treatment period (first 42 days) and the entire growing-finishing study (98 days) was not significantly different by treatment. However, there was a trend toward significant differences at 28 days (P<.06). Specifically speaking, Treatment 2 produced slower gains (P<.06) than all other treatments. It appears that Cobactin was beneficial when the pigs received no antibiotic; however, feeding of Cobactin in combination with any of the antibiotics seemed to be detrimental, although not significant. Although not included in Table 2, feed intake was not different for these same periods of comparison. However, the Treatment 2 pigs (Control-No) were significantly poorer in feed conversion during the first 28 days than all other treatments. No differences were noted for the 42 or 98 day periods.

A comparison of the main effects of either antibiotic treatment or Cobactin treatment on performance are presented in Table 3. All three antibiotic-fed treatment groups were faster gaining (P<.05) during the first 28 days than the control pigs (1.51, 1.45 and 1.47 vs 1.27 lb for the CSP250, Neomycin and Neoterramycin vs Control, respectively). No differences in growth rate were observed after the antibiotic was removed from the diet (day 28-98). Cobactin had no affect on ADG.

TABLE 2. AVERAGE DAILY GAIN BY TREATMENT, LBS[a]

Treatment			Accumulative day		
No.	Antibiotic	Cobactin	28 d	42 d	98 d
1	Control	Yes	1.38	1.36	1.60
2	Control	No	1.17	1.22	1.51
3	CSP250	Yes	1.49	1.43	1.67
4	CSP250	No	1.54	1.49	1.65
5	Neomycin	Yes	1.41	1.33	1.62
6	Neomycin	No	1.49	1.44	1.72
7	Neoterramycin	Yes	1.41	1.34	1.51
8	Neoterramycin	No	1.52	1.49	1.67

[a]Means were not different (P>.05).

TABLE 3. PERFORMANCE BY ANTIBIOTIC AND COBACTIN TREATMENT, LBS

		Antibiotic				Cobactin	
Item	Period,d	Control	CSP250	Neo	NeoT	Yes	No
ADG	0-28	1.27[b]	1.51[c]	1.45[c]	1.47[c]	1.42	1.43
	0-42	1.29	1.46	1.39	1.41	1.36	1.41
	0-98	1.56	1.66	1.67	1.56	1.60	1.62
FI[a]	0-28	3.5	3.9	3.7	3.7	3.7	3.7
	0-42	4.0	4.3	4.1	4.0	4.1	4.1
	0-98	5.5	5.9	5.5	5.2	5.4	5.5
F/G	0-28	2.7[b]	2.6[c]	2.6[c]	2.5[c]	2.6	2.6
	0-42	3.1[b]	3.0[bc]	2.9[c]	2.9[c]	3.0	2.9
	0-98	4.1[b]	4.0[b]	3.9[bc]	3.8[c]	4.0	3.9

[a]Feed intake is expressed as lb/hd/day.
[b,c]Means within antibiotic treatment or Cobactin treatment by row with different superscripts are different (P<.05).

Feed intake was not affected by antibiotic or Cobactin treatment; however, feed conversion differences due to antibiotic treatment were observed for all three periods. During the first 28 day period the control pigs were significantly less efficient than all of the antibiotic-fed pigs. The Control pigs continued to be the poorest converters; however, feed to gain ratios were not different from the CSP250 treatment during the first 42 days or the CSP250 and Neomycin treatments during the entire 98 day test period. The addition of lactobacillus (Cobactin) to the feed had no effect on feed conversion.

In general the health of the pigs was excellent; however, as shown in Table 4 there were performance differences by source. Of the four pigs removed at day 56, three were from Source A and one from source D. These pigs represented four different treatments (Control-Cobactin; CSP250-Cobactin; Neomycin-Cobactin and Neomycin-No Cobactin). Although the four pigs removed from test on day 56 were not posted, their morbidity appeared to be primarily due to respiratory problems.

TABLE 4. AVERAGE DAILY GAIN BY SOURCE, LBS

Source	No. hd.[a]	ADG by Period		
		0-28	0-42	0-98
A	14 (3)	1.14	1.05	1.42
B	21	1.38	1.33	1.67
C	16	1.49	1.45	1.63
D	7 (1)	1.12	1.10	1.50
E	17	1.79	1.76	1.82
F	20	1.64	1.59	1.68
G	24	1.10	1.30	1.44
Avg for all		1.43	1.39	1.61

[a]Numbers in parentheses represent the number of pigs that were removed from test on day 56.

EFFECT OF VITAMIN AND TRACE MINERAL SUPPLEMENTATION ON THE PERFORMANCE OF WEANLING PIGS

KYLE KESSLER[1] AND G. W. JESSE

SUMMARY

During the fall twenty-four university-raised, crossbred weanling pigs were used in a 28 day nursery study to determine the effects of feeding a diet which had the vitamin and trace mineral premixes omitted. As expected, pigs fed the vitamin and trace mineral deficient diet were slower growing (37%) and less efficient (7%) at converting feed to gain. Except for a significant decrease in feed intake (32%), appearance and behavior (health) of the pigs did not appear to be affected by treatment during the four week study. However, at the termination of the study, the farm manager did notice several of the pigs that had been fed the vitamin-trace mineral deficient diet were showing some signs of abnormality. One of these pigs died within a week and was diagnosed as having a selenium deficiency. We were surprised that additional deficiency symptoms had not appeared during the 28 day study; however, overall performance was significantly affected. This study does point out that a drastic decrease in performance should be investigated immediately.

INTRODUCTION

Realizing that feed costs represents approximately 60% of the total cost of producing pork, it is important that economical and well balanced diets be provided during all phases of the growing-finishing phase. During the early 1900's swine producers knew that providing a source of animal protein and/or good quality pasture was essential to adequate performance of the growing pig. However, during the last few decades this practice has been replaced by the fortification of primarily corn-soybean meal diets with vitamins and trace minerals. Although vitamins and micro minerals are not needed in large quantities, their impact on performance is profound. Vitamin and trace mineral supplementation is more important today than ever before since most swine producers feed a simple diet which contains fewer ingredients than producers fed years ago. In addition, most hogs are fed in confinement; hence, they are denied access to natural sources of vitamins and minerals.

The stimulus for this experiment was the realization that feed mixing mistakes do occur occasionally, both on the farm and at the commercial mill. We assumed that a common mistake might be to inadvertently omit the vitamin and trace mineral premix.

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[1]An undergraduate General Agriculture major from St. Joseph.

The objectives of this experiment were twofold: first, to determine the effect of vitamin and trace mineral deficiencies on the performance of weanling pigs and secondly, to see if any of the classical vitamin and/or mineral deficiency symptoms would become evident within a 4 week feeding period.

PROCEDURES

Twenty-four university-raised, crossbred barrows and gilts of Landrace, Yorkshire and Duroc descent averaging five weeks of age were used for this study. These pigs, farrowed at the University of Missouri Swine Research Complex (SRC), which is a total confinement unit, were weaned on September 22 when the contemporary group averaged 4 weeks of age. At this time they were moved to a totally enclosed grower unit which had 4' x 4' pens. The floor was concrete slats. Pigs were assigned at random, within sex to one of 6 pens, with each pen containing two barrows and two gilts; hence, the study included three replicates.

During the first week, all pigs were full-fed a pelleted, commercial complete diet (19% crude protein). On day seven the pigs were switched to their previously determined test diet. The control pigs (Treatment 1) were fed an 18% crude protein corn-soybean meal diet in meal form (S-18). The Treatment 2 (vitamin and trace mineral deficient) pigs received the S-18 diet without the vitamin and trace mineral premix as shown in Table 1. Supplementation of the macro minerals calcium and phosphorus was the same for both treatments; however, the Treatment 2 diet did not include a source of salt. Composition of the vitamin and trace mineral premixes used are shown in Tables 2 and 3, respectively.

TABLE 1. DIETS FED

	Treatment	
Ingredients,%	1	2
Corn, ground	69.6	69.6
Soybean meal, 44%	26.4	26.4
Dicalcium phosphate	1.8	1.8
Ground limestone	1.2	1.2
Trace mineral salt[a]	.5	.0
Vitamin mix[b]	.5	.0
Total	100.0	99.0

[a]Formulated to provide the following in the diet: Selenium, .1 ppm; iron, 100 ppm; copper, 15 ppm; zinc, 100 ppm; managnese, 50 ppm; and .5% salt.
[b]Provides the following per ton of complete feed: 5,000,000 I.U. vitamin A; 500,000 I.U. vitamin D_3; 20,000 I.U. vitamin E; 2g thiamine; 5g riboflavin; 25g d pantothenic acid; 30g niacin; 500g choline chloride; .03g vitamin B^{12}; 2g menadione; 1g folic acid; 1g pyridoxine hydrochloride; .4g biotin and 59g ethoxyquin.

TABLE 2. VITAMIN PREMIX

Guaranteed Analysis Per Pound	
Vitamin A, USP Units, minimum	500,000
Vitamin D-3, USP Units, minimum	50,000
Vitamin E, I Units, minimum	2,500
Vitamin B-12, Mgs, minimum	3.5
Vitamin k, Mgs, minimum	200
Riboflavin, Mgs, minimum	500
d-Pantothenic Acid, Mgs, minimum	2,500
Niacin, Mgs, minimum	3,000
Choline Chloride, Mgs, minimum	70,000
Folic Acid, Mgs, minimum	100
Biotin, Mgs, minimum	15
Pyridoxine Hydrochloride, Mgs, minimum	242
Thiamine Mononitrate, Mgs, minimum	218
Ethoxyquin, %, minimum	.0011

TABLE 3. TRACE MINERAL PREMIX

Guaranteed Analysis Per Pound,%	
Calcium, minimum	0.0
Calcium, maximum	1.0
Salt (NaCl), minimum	85.16
Salt (NaCl), maximum	89.86
Zinc, minimum	2.5
Iron, minimum	2.5
Manganese, minimum	.5
Copper, minimum	.3
Iodine, minimum	.01
Selenium, minimum	.002

The study was 28 days in duration with pig weights and feed consumption determined on a weekly basis. Pigs were observed for health on a daily basis.

RESULTS AND DISCUSSION

Average daily gain (ADG), weekly feed intake (FI) and feed efficiency (F/G) by treatment are shown in Table 4. As expected, pigs fed the diet that did not include the vitamin and trace mineral premixes (Treatment 2) performed poorly. The control (Treatment 1) pigs gained significantly faster during the third week and for the entire 28 day study. The Treatment 2 pigs gained 37% slower during the four week trial.

Weekly feed intake per pig increased from 8.5 to 22.1 lb for the control pigs and from 7.8 to 11.4 lb for the vitamin and trace mineral deficient pigs. Feed consumption during the 28 day study was 32% less for the Treatment 2 pigs. When expressed as a percent of body weight, feed intake averaged 6.1 and 5.1% for Treatments 1 and 2, respectively.

Numerically speaking, the control pigs were more efficient than the Treatment 2 pigs in converting feed to gain during all four weekly periods; however, as shown in Table 4, this difference was only significant (P<.05) for the overall 28 day period.

TABLE 4. AVERAGE DAILY GAIN, FEED INTAKE AND FEED EFFICIENCY, LBS

		Treatment	
Item	Period, d	1	2
Initial wt		17.1	17.2
Final wt		52.3	39.4
ADG	0 - 7	.48	.25
	7 - 14	1.30	.82
	14 - 21	.89[a]	.54[b]
	21 - 28	1.84	.99
	0 - 28	1.26[a]	.79[b]
FI (per week)	0 - 7	8.5	7.8
	7 - 14	12.3[a]	8.9[b]
	14 - 21	16.2	12.3
	21 - 28	22.1[a]	11.4[b]
	0 - 28	59.0[a]	40.3[b]
F/G	0 - 7	2.69	4.48
	7 - 14	1.39	1.56
	14 - 21	1.67	1.59
	21 - 28	1.77	1.78
	0 - 28	1.69[a]	1.81[b]

[a,b]Means within a row with a different superscript are different (P<.05).

EFFECT OF ASPIRIN ON IMMUNITY AND SCOURING INDEX OF WEANLING PIGS

S. C. HUANG, K. L. FRITSCHE, AND N. A. CASSITY

SUMMARY

Forty-five crossbred weanling female pigs from 11 sows were used in an experiment to determine the effect of aspirin on lymphocyte proliferation, antibody production, scouring incidence, and post-weaning performance. Piglets at weaning from each sow were randomly assigned either to a basal diet as control (N=23) or to the basal diet supplemented with 150 ppm aspirin (N=22) for two weeks. Mean body weights between the control and aspirin treatment groups were not significantly different at weaning and at the end of this experiment. Scouring scores were not significantly different at days 1, 4, 7, and 10, but were slightly different at day 14 between control and aspirin-treated pigs ($P < 0.09$). No significant differences in blood white cell counts were found between treatment groups. Proliferative responses of peripheral blood lymphocyte to both concanavalin A (Con A, a T-cell mitogen) and pokeweed mitogen (PWM, a T- and B-cell mitogen) tended to be slightly greater in control than aspirin-treated pigs ($P<0.13$). The proliferative response to B-cell mitogen lipopolysaccharide (LPS) was relatively weak and did not differ between control and aspirin-treated animals ($P>0.2$). Primary antibody response to sheep red blood cells between the control and aspirin-treated pigs at day 7 of the experiment was similar but secondary antibody titers at day 14 tended to be a little lower in the aspirin-treated group ($P<0.13$). Two pigs from the control group, and none from aspirin-treated group, died during the experiment (survival rates were not statistically different; $P<0.16$). Results indicate that oral supplementation with aspirin may influence some immunological parameters in weanling pigs.

INTRODUCTION

Young pigs mainly rely on passive transfer of maternal antibodies from colostrum and milk to protect themselves from infection. They have little capability to produce antibodies against pathogens (Segre and Kaeberle, 1962) and have low natural killer (NK) activity (Huh et al., 1981). After weaning, piglets not only face the problem of discontinuation of antibody supply from dam but also face the problem of a variety of factors that enhance susceptibility to disease.

Aspirin is a well-known drug for humans but its use in animal production is a very recent event. Xu et al. (1988) reported that when weanling pigs were fed a starter diet containing 125 to 250 ppm aspirin, they ate more, grew faster, and had a lower scouring index. Furthermore, aspirin had no detrimental effects on blood clotting, hematocrit, and hemoglobin level. Similar results were also seen in a more recent study by Kornegay et al. (1989).

Aspirin can inhibit the function of cyclooxygenase, which is an enzyme necessary for the synthesis of prostaglandins. Prostaglandin E2 has been shown to suppress primary antibody response to liposome in rabbit (Wassef et al., 1989) major histocompatibility class II antigen expression in mice (Tripp et al., 1986). Oral supplementation of aspirin to piglets may affect the prostaglandin synthesis and therefore influence their immune response and scouring incidence. The objectives of this study were to examine the effects of aspirin on lymphocyte proliferative response, antibody production, scouring index, and post-weaning performance.

EXPERIMENTAL PROCEDURE

Forty-five crossbred weanling female pigs from 11 sows were used in this study. Piglets at weaning (3-4 weeks of age) from each sow were randomly assigned either to a corn-soybean meal basal diet as control (N=23) or to the basal diet supplemented with 150 ppm aspirin (N=22). The basal diet was formulated to contained 18% crude protein and 1.1% lysine and 2.0% animal lard (Table 1). Piglets from the same treatment were housed in the same pen (three to four pigs per pen) with feed and water available ad libitum. Animals were weighed on the day the experiment started and at the end of the experiment.

On the first day of the experiment, each piglet was injected intraperitoneally with 2 ml of 10% sheep red blood cell (sRBC). After one week of injection, blood samples were taken from jugular vein and immune sera were separated and analyzed for primary antibody titer. At day 8 of the experiment, piglets received a second injection of sRBC (same dose). Blood samples were collected six day later for the analysis of secondary antibody response. At the end of the experiment, blood samples were collected into heparinized tubes from 14 control pigs and 16 aspirin-treated pigs for testing peripheral white cell count and lymphocyte proliferative responsiveness to mitogen stimulation.

Antibody titer was measured by a direct hemagglutination test on a 96-well micro-titer plate. Each well contained either 100 µl of diluted immune serum in PBS or 100 µl PBS as control, and 50 µl of 0.5% sRBC. The highest dilution factor at which hemagglutination was observed was transformed into natural logarithm and is expressed as antibody titer.

Blood white cell counts were determined by using a Coulter Counter (Model ZIP, Coulter Electronics Inc., Hiaheah, FL). To determine the proliferative response of lymphocytes, heparinized whole blood samples were diluted to $1x10^6$ cells/ml with RPMI 1640 culture medium containing L-glutamine (2 mM), HEPES (25 mM), penicillin (100 units/ml), and streptomycin (100 µg/ml). Cells were cultured in 96-well microtiter plate at 37 C in 5% CO2 and 95% air. Each well contained 0.2 ml diluted blood and 10 µl of culture medium as control, or 10 µl Con A (0.2 µg/µl), or 10 µl PWM (0.05 µg/µl), or 10 µl LPS (0.5 µg/µl). After culturing for 40 hours, cells were pulsed with H^3-thymidine for 8 hours and harvested by a PHD Cell Harvester (Cambridge Technology Inc.) and counted in a beta Counter (Beckman LS 1701, U.K.). The incorporation of H^3-thymidine by lymphocytes, as it is expressed in count per minute (cpm), was used as an indication of lymphocyte proliferation.

The incidence and severity of scours of each pig were evaluated and recorded at days 1, 4, 7, 10, and day 14 of the experiment. The following grading system was used for scoring scour: 1=normal feces (firm or hard, no scour), 2=slightly loose feces (mild scour), 3=loose feces (scour), 4=watery feces (severe scour).

For the statistical analysis, Chi-Square contingency test was used to test for differences in the survival rate and analysis of variance was used for analyzing all other data.

RESULTS AND DISCUSSION

Mean body weights of piglets between control and aspirin treatment groups were not significantly different both at weaning and at the end of this experiment (Table 2). This suggests that oral supplementation of aspirin to weanling pigs for a period of two weeks had no effect on their weight gain. Scouring scores between the control and aspirin-treated pigs were not significantly different at days 1, 4, 7, and 10 (Table 2). At day 14, the scouring scores were slightly higher in the control group than aspirin treatment group. ($P<0.09$). Two pigs from the control group, while no pigs from aspirin treatment group, died during the experiment. There was no statistical difference ($P<0.16$) in survival rates between the treatments according to Chi-Square contingency test.

Peripheral blood white cell counts of piglets at day 14 of the experiment were not significantly different between the control and aspirin treatment groups (Table 2). To further understand whether aspirin has any effect on T and B lymphocytes, we examined proliferative responses to mitogen stimulation. Figure 1 shows the results of mitogen-induced proliferation of whole blood lymphocytes. The proliferative response to both T-cell mitogen Con A and T- and B-cell mitogen PWM tended to be slightly higher in the control group than in the aspirin treatment group ($P<0.13$). The proliferative response to B-cell mitogen LPS was relatively weak and did not differ between control and aspirin-treated animals ($P>0.2$).

Mean antibody titer against sRBC between the control and aspirin treatment groups were not significantly different at day 7 of the experiment (Table 2). Secondary antibody titers at day 14 tended to be a little lower in the aspirin-treated group than the control group ($P<0.13$).

CONCLUSIONS

Results from this experiment suggest that oral supplementation of aspirin to weanling pigs for a period of two weeks have no effect on their weight gain. Aspirin treatment may reduce scouring and improve survival of piglets after a period of oral supplementation. Preliminary attempts failed to demonstrate a beneficial effect of aspirin on antibody production of weanling pigs. Oral supplementation of aspirin to weanling pigs may have some effect on their T-cell proliferation but have little effect on B-cell proliferation.

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TABLE 1. Composition of Basal Diet for Aspirin Study.

Ingredients	%
Ground corn, 8.7% crude protein	66.97
Soybean meal, 44% crude protein	27.21
Animal Fat (choice white grease)	2.00
Dicalcium phosphate	1.80
Ground limestone	0.16
Salt (NaCl)	0.25
Lysine	0.065
Sodium Bicarbonate	0.05
UMC Vitamin mix	0.50
UMC Trace mineral salt mix	0.50

TABLE 2. Least Square Means of Performance, Scouring Scores, Blood White Cell Counts, and Survival Rates of Weanling Piglets fed a Basal Diet with or without Aspirin

Items	Basal Diet	Basal Diet + 150 ppm Aspirin
Initial Body Wt. (kg)	16.4 (0.7)[a]	16.2 (0.8)
Final Body Wt. (kg)	22.2 (0.9)	22.0 (1.0)
Blood White Cell (10^6/ml)	13.75 (0.69)	14.32 (0.99)
Scouring Score:		
Day 1	1.00 (0.00)	1.02 (0.02)
Day4	1.28 (0.09)	1.25 (0.09)
Day 7	1.57 (0.15)	1.35 (0.08)
Day 10	1.57 (0.19)	1.39 (0.13)
Day 14	1.48 (0.12)	1.23 (0.08)[b]
Primary Antibody Titer	2.60 (0.17)	2.53 (0.17)
Secondary Antibody Titer	4.15 (0.19)	3.72 (0.20)c
Survival Rate	91.3%	100%[d]

a: mean and standard error; b: significant at P<0.09; c: P<0.13; d: P<0.16.

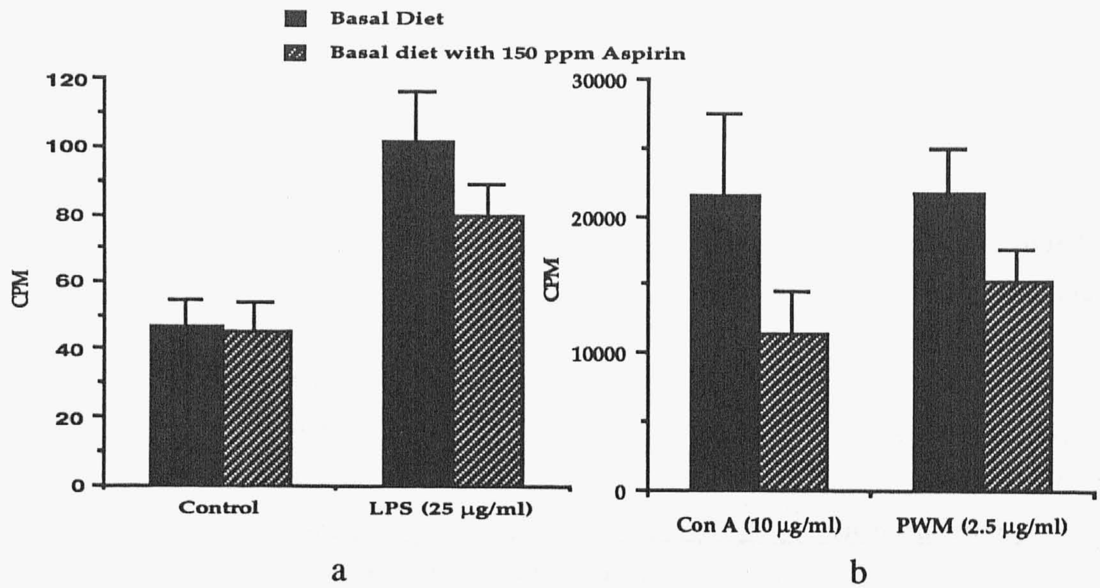

Figure 1a and b. Proliferative response of blood lymphocytes to mitogen stimulation. Control means no mitogen was added in the cell culture.

Effect of Medium Chain Triglycerides in the Ration on Milk Composition of Sows

Francis A. Figueroa, Kevin L. Fritsche, Mark R. Ellersieck and Trygve L. Veum

SUMMARY

An experiment was conducted to evaluate the effect of adding 8% of either medium chain triglyceride (MCT) or choice white grease (CWG) to the sow diet from 7 days before until 7 days after parturition. Feeding MCT increased the percentages of fatty acids in milk containing 8 to 16 carbons; which included caprylic, capric, lauric, myristic, palmitic and palmitoleic acids; and decreased oleic acid compared with feeding CWG.

In conclusion, feeding sows MCT during late gestation and early lactation did change the fatty acid profile of colostrum, milk and plasma (pigs) but did not increase piglet survival rate to day 3 or weaning.

INTRODUCTION

Newborn piglet survival has been a subject of study for many years because of the high mortality that occurs in the period from farrowing to weaning (Bereskin et al., 1973). Improvement in management has increased the survival rate, but mortality still may approach 15% to 20% (Cromwell et al., 1989). About 50% of this pre-weaning mortality occurs within the first 3 days after birth, and the main causes are weakness and being overlaid by the dam (Fahmy and Bernard, 1971).

Pre-weaning survival rate may be increased by adding fat to the sow diet late in gestation, regardless of the type of fat used (Pettigrew, 1981; Moser, 1985). However, providing energy directly to the newborn pig as corn oil (8 ml/pig) did not improve overall survival rate to weaning (Pettigrew et al., 1986). Feeding different sources of fat to the sow has changed the fatty acid profiles in colostrum and milk (Seerley et al., 1981), with the fatty acid profile of milk becoming more like that of the specific fatty acid consumed (Kruse et al., 1977).

The objective of our experiment was to test the hypothesis that MCT fed to sows in late gestation and early lactation will increase the MCT content of the milk.

MATERIALS AND METHODS

Thirty eight Yorkshire x Landrace sows were used in this experiment. All sows were fed 4 lb/day of a basal corn-soybean-oats diet (Table 1) until day 107 of pregnancy when they were divided into two groups by parity and changed to a diet with either 8% MCT or 8% CWG; also fed at 4 lb/day until parturition, Sows were milked in the farrowing crates on days 1, 7 and 14 of lactation with a milking machine modified for milking sows. The pigs were removed from the sow for at least 45 minutes prior to milking and the sow injected i.m. with 100 to 200 USP units of oxytocin to induce milk letdown. Individual milk samples were collected from the three most anterior glands on each side. Five ml of milk from each gland were pooled and stored at $-20^{o}C$ until analyzed.

Two pigs/litter were bled by vena cava puncture at birth and at 7 days of age. Sows were also bled prior to receiving the high lipid diets and on the day of parturition. Plasma was frozen at $-20^{o}C$ until analyzed.

Lipids were extracted from the samples of plasma, colostrum and milk (Folch et al., 1957) and contaminants removed by saponification (Kates, 1972). The fatty acid methyl esters of colostrum, milk and plasma were separated by gas chromatography. Each fatty acid concentration is expressed as a percentage of the total fatty acids present in the sample.

Plasma from two groups of piglets was analyzed for glucose, plasma urea nitrogen and triglycerides. Colostrum and milk were also analyzed for total solids, ash and nitrogen content and gross energy. Data were analyzed by analysis of variance procedures using SAS (1982).

RESULTS

The percentages of caprylic, capric, lauric, myristic, palmitoleic and palmitic acids in milk increased ($P<.01$) from day 1 to day 7 in sows fed MCT compared to sows fed CWG (Figures 1, 2 and 3), except for the decrease ($P<.01$) in oleic acid. By day 14 (post-treatment milk collection) fatty acid percentages for both treatments were similar. Fat source had no effect on energy, protein, fat, total solids or ash content in milk, but colostrum (day 1) had higher concentrations of energy, protein, fat, total solids and ash than milk at days 7 or 14 (Table 2).

Piglets from sows fed MCT had higher plasma percentages of myristic and linoleic acids, expressed as percentages of total plasma lipids, while the percentages of oleic and arachidonic acid decreased compared to the plasma fatty acid profiles of piglets from sows fed CWG (Table 3). Across treatments, plasma from day 7 was higher in palmitic, linoleic and arachidonic acids; and lower in oleic acid (Table 3) compared to plasma levels at birth. Piglet plasma triglycerides (142 mg/dl) and glucose (92 mg/dl) concentrations were not affected by treatment. Feeding sows with MCT during gestation and lactation did not increase number of pigs born alive, survival rate to days 3 or weaning, or weaning weight compared to sows fed CWG (Table 4).

TABLE 1. GESTATION AND LACTATION DIETS COMPOSITION

Item	Gestation			Lactation		
	Standard	MCT	CWG	Standard	MCT	CWG
Ingredients, %						
Ground shelled corn	67.50	65.25	65.39	65.5	60.30	60.42
Soybean meal (44%)	13.75	12.50	12.53	18.5	17.74	17.78
Ground oats	10.0	10.33	10.35	10.0	10.21	10.23
Alfalfa meal	5.0	-	-	-	-	-
Medium chain triglyceride[a]	-	8.15	-	-	8.02	-
Choice white grease[b]	-	-	7.95	2.5	-	7.84
Dicalcium phosphate	2.2	1.85	1.85	1.9	1.83	1.83
Ground limestone	0.55	0.87	0.87	0.6	0.87	0.87
Trace mineral salt	0.5	0.49	0.49	0.5	0.49	0.49
Vitamin premix	0.5	0.54	0.54	0.5	0.53	0.53
Protein, % (analysis)	14.14	12.56	12.59	-	14.45	14.48
Gross energy, kcal/kg	4379.4	4707.4	4850.4	-	4637.1	4784.6

[a]Caprylic, 30%; capric, 66%; butyric, 3%; and lauric, 1%.
[b]Myristic, 1.8%; palmitic, 27.4%; palmitoleic, 3.1%; stearic, 13.5%; oleic, 43.0%; and linoleic, 6.1%.

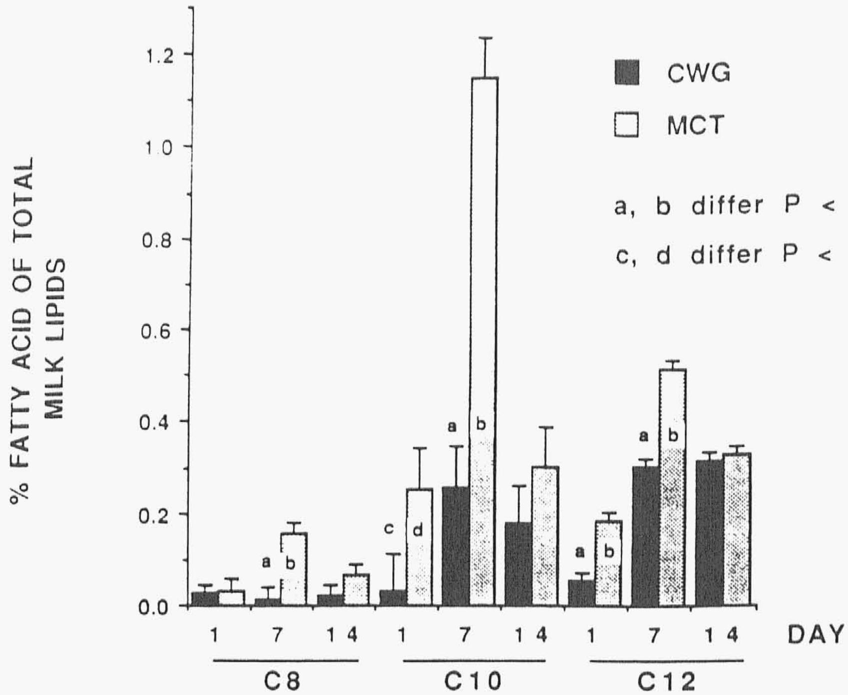

FIGURE 1. Caprylic, capric and lauric acid methyl ester from total lipids in colostrum and milk from sows fed diets with medium chain triglycerides (MCT) and choice white grease (CWG).

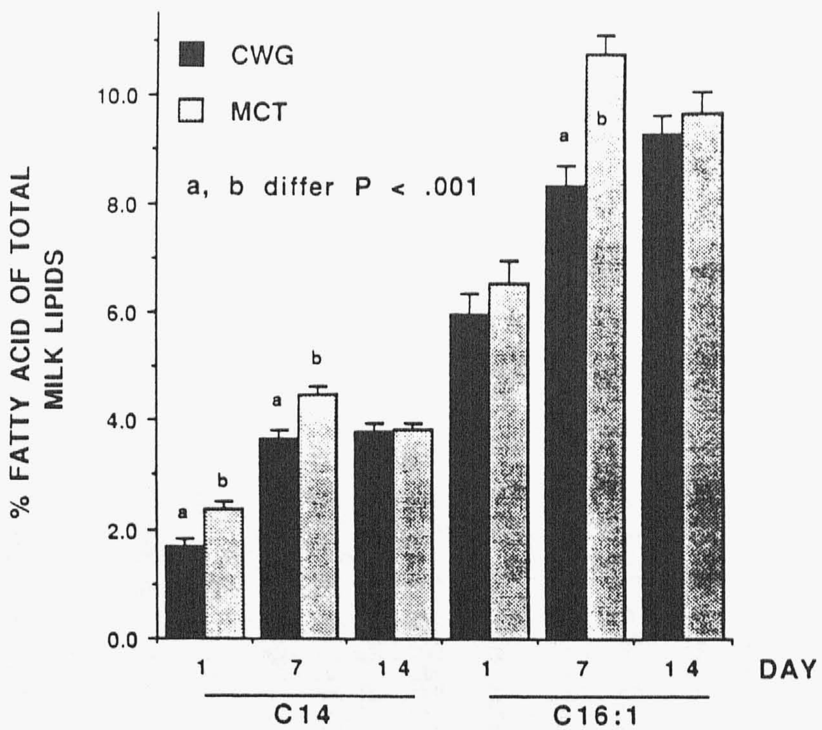

FIGURE 2. Myristic and palmitoleic acid methyl ester from total lipids in colostrum and milk from sows fed diets with medium chain triglycerides (MCT) and choice white grease (CWG).

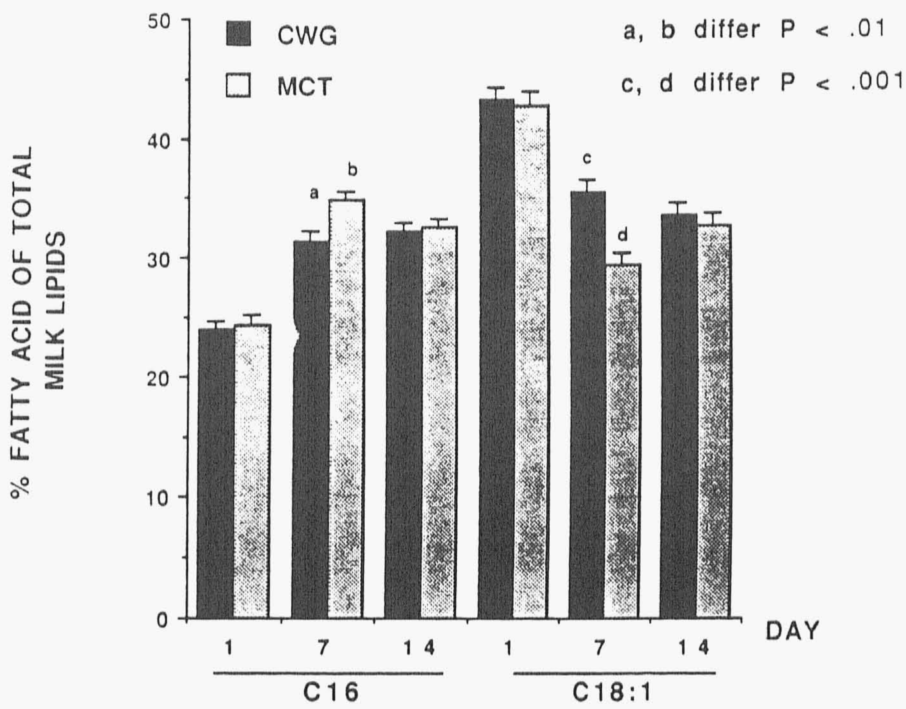

FIGURE 3. Palmitic and oleic acid methyl ester from total lipids in colostrum and milk from sows fed diets with medium chain triglycerides (MCT) and choice white grease (CWG).

TABLE 2. COLOSTRUM AND MILK COMPOSITION (% of fresh product)

	Colostrum (day 1)	Milk (day 7)	Milk (day 14)	SEM
Energy, cal/g	2257[a]	2002[b]	2001[b]	41
Protein, %	8.4[a]	5.8[b]	5.3[b]	± 0.2
Fat, %	7.5[a]	5.2[b]	5.1[b]	± 0.4
Solids, %	20.5[a]	19.0[b]	18.3[b]	± 0.5
Ash, %	0.7[a]	0.8[b]	0.8[b]	± 0.02

[a,b]Means with different superscript in a row differ ($P<.05$).

TABLE 3. PIGLETS PLASMA FATTY ACIDS (% of total lipid) BY TREATMENT AND AGE

	Treatment			Age Effect		
	CWG	MCT	SEM	Birth	Day 7	SEM
No. pigs	25	23		24	24	
Myristic	1.0[a]	1.3[b]	± .09	1.1	1.2	± .1
Palmitic	21.2	22.5	± .5	20.9[a]	22.88[b]	± .3
Oleic	24.9[a]	22.0[b]	± .5	28.2[a]	18.6[b]	± .2
Linoleic	21.1[c]	22.9[d]	± .7	18.2[a]	25.8[b]	± .5
Arachidonic	9.5[c]	8.5[d]	± .4	8.5[a]	9.5[b]	± .3

[a,b]Treatment or age effect means with different superscript in a row differ (P<.05).
[c,d]Treatment or age effect means with different superscript in a row differ (P<.1).

TABLE 4. SOW AND PIGLET PERFORMANCE BY TREATMENT[a]

	CWG	MCT	SEM
No. of pigs born live/litter	10.9	11.1	± .6
No. of pigs born dead/litter	1.3	.9	± .4
Birth weight live pigs, lb	3.3	3.3	± .0
Piglet survival to 3 days, %	95.3	91.3	± .02
No. of pigs weaned/litter	9.2	9.5	± .2
Weaning weight, lb	14.74	14.96	± .2
Survival to weaning, %	88.5	85.3	± .03
Weaning age, days	26.3	25.8	

[a]Least square means.

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Effect of added niacin on pig performance from weaning to market.

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SUMMARY

A study using 336 pigs of age was conducted to evaluate the effect on pig performance of added niacin to corn-soybean meal diets containing marginal or excess levels of tryptophan. Pens of 4 pigs were assigned to one of seven dietary treatments: a low protein basal diet supplemented with 0, 3, 9, 27 or 81 ppm niacin and a high protein diet supplemented with 0 or 81 ppm niacin. Results showed that pigs fed diets containing the higher protein levels had greater feed intakes, daily gains and better feed efficiency than pigs fed the lower protein diets with similar levels of niacin. However, niacin additions only affected feed efficiency from day 36 to 63. In conclusion, the addition of niacin to corn-soybean meal diets does not improve growth performance in pigs from weaning to market.

INTRODUCTION

Niacin, one of the water soluble B-vitamins, is an important precurser in the formation of the coenzymes NAD and NADP which are necessary for many metabolic reactions. Animals must obtain the needed niacin from either dietary sources or by converting the amino acid tryptophan to niacin. Although niacin is present in cereal grains, it is primarily in a bound form which is unavailable to the pig.

As the use of crystalline amino acids increases, the possibility of a niacin deficiency increases because the amount of soybean meal, a good source of niacin, decreases. In addition, the amount of dietary tryptophan available for conversion to niacin is also decreased. Therefore, this experiment was conducted to determine the effects of added niacin in 1) a low protein corn-soybean meal diet fortified with crystalline amino acids and 2) a corn-soybean meal diet meeting the NRC protein and essential amino acid requirements.

PROCEDURES

Three trials (112 pigs/trial) were conducted with pigs weaned at approximately 28 days of age. Pigs were blocked by weight, sex and litter to pens of 2 barrows and 2 gilts. Pens were randomly assigned to one of seven dietary treatments. A low protein basal diet containing the minimum NRC (1979) recommended level of tryptophan and adequate levels of other essential amino acids was supplemented with 0, 3, 9, 27 or 81 ppm niacin (treatments 1 to 5, respectively). A basal diet was formulated to contain the NRC (1979) recommended protein level and was supplemented with 0 or 81 ppm niacin in treatments 6 and 7, respectively.

The experiment was conducted in 5 periods to adjust the basal diets to the growing pigs' nutrient requirement. The periods were as follows: 1) day 1 to 14, 2) day 15 to 35, 3) day 36 to 63, 4) day 64 to 91 and 5) day 92 to 133. Basal diets fed during period 1 are presented in Table1. Nutrient composition of the basal diets for all 5 periods are shown in Table 2. In trials 1 and 2, pig weights and feed consumption were measure every 7 days from day 0 to 35 and every 14 days from day 36 to 133. In trial 3, pig weights and feed intakes were measured every 7 days from day 0 to 35 when the trial was terminated.

Table 1. Basal diets fed during phase 1.

Ingredients	High protein	Low protein
	Percent of diet	
Dried whey	15.00	15.00
Corn gluten meal	5.00	---
Ground corn	54.33	47.35
Soybean meal, 48%	15.00	27.50
Fat	7.50	7.60
Dicalcium phosphate	1.67	1.40
Limestone	.10	.15
Trace mineral mix	.50	.50
L-lysine·HCl	.40	---
Niacin-free vitamin mix	.50	.50
Niacin[1]	---	---

[1]Niacin was added to treatment group as follows: treatment 1 (0 ppm), treatment 2 (3 ppm), treatment 3 (9 ppm), treatment 4 (27 ppm), treatment 5 (81 ppm), treatment 6 (0 ppm) and treatment 7 (81 ppm).

Table 2. Nutrient composition of basal diets.

		Nutrients				
Day	Protein level	Crude Protein %	ME kcal/kg	Lysine %	Tryptophan %	Niacin ppm
0-14	Low	18.07	3416	1.16	.20	22.5
	High	20.01	3414	1.18	.27	20.5
15-35	Low	15.45	3181	1.09	.17	23.2
	High	18.00	3186	1.02	.22	23.1
36-63	Low	13.10	3238	.97	.16	23.1
	High	16.01	3229	.95	.19	23.1
64-91	Low	11.59	3252	.86	.14	23.2
	High	14.01	3256	.84	.16	23.2
91-133	Low	10.45	3259	.77	.13	23.4
	High	13.00	3262	.78	.14	23.3

RESULTS AND DISCUSSION

Linear, quadratic and cubic reponses of niacin additions were determined using data from treatments 1, 2, 3, 4 and 5. In addition, treatments 1, 5, 6 and 7 were analyzed as a factorial design for the main effects and interactions of niacin and protein. Performance data are presented in Table 3. In the factorial analysis, no niacin effects or niacin x protein interactions were detected, so only the protein main effects are included in Table 3.

Niacin additions had no effect (P>.05) on feed intake or daily gain during any period or overall. Feed efficiency was only affected (P<.05) from day 36 to 63 when a linear and cubic response to niacin additions occurred with pigs fed the 9 ppm added niacin diets having the poorest feed efficiency (2.65) and pigs fed the 81 ppm added niacin diets having the best feed efficiency (2.29).

From day 1 to 133, pigs fed the basal diets containing the NRC (1979) recommended protein levels performed better (P<.05) than the pigs fed the lower protein basal diets with similar niacin additions in all criteria measured. Pigs fed the higher protein diets consumed more feed (P<.05) from day 15 to 35, day 64 to 133; had higher daily gains (P<.05) from day 15 to 133; and had better feed:gain ratios form day 36 to 133.

Table 3. Average daily feed intake, average daily gain and feed:gain ratio.

		NIACIN					PROTEIN		
Treatment #		1	2	3	4	5	1, 5	6, 7	
Added niacin, ppm		0	3	9	27	81	0, 81	0, 81	
Protein level		Low	Low	Low	Low	Low	Low	High	
Criteria	Day								SE[a]
Feed	1 - 14	.40	.43	.44	.47	.45	.42	.44	.02
Intake, lb.	15 - 35[b]	1.66	1.72	1.79	1.76	1.77	1.72	1.89	.06
	36 - 63	3.50	3.54	3.67	3.58	3.49	3.50	3.56	.09
	64 - 91[b]	4.99	4.96	5.10	5.07	4.90	4.95	5.37	.13
	92 - 133[b]	6.26	6.21	6.21	6.48	6.04	6.16	6.64	.17
	1 - 133[b]	4.07	4.07	4.15	4.22	4.01	4.05	4.33	.09
Daily	1 - 14	.26	.34	.31	.33	.36	.31	.35	.03
Gain, lb.	15 - 35[b]	1.00	1.04	1.07	1.10	1.00	.99	1.14	.04
	36 - 63[b]	1.47	1.42	1.39	1.45	1.52	1.50	1.74	.05
	64 - 91[b]	1.52	1.55	1.62	1.65	1.53	1.52	1.85	.07
	92 - 133[b]	1.88	1.74	1.91	1.85	1.83	1.85	2.09	.06
	1 - 133[b]	1.40	1.37	1.44	1.45	1.41	1.41	1.63	.04
F:G	1 - 14	1.99	1.49	1.84	1.69	1.65	1.82	1.49	.22
	15 - 35	1.66	1.74	1.68	1.61	1.76	1.71	1.64	.07
	36 - 63[b c]	2.38	2.51	2.65	2.45	2.29	2.34	2.08	.07
	64 - 91[b]	3.29	3.24	3.18	3.13	3.23	3.26	2.98	.09
	92 - 133[b]	3.33	3.57	3.25	3.50	3.32	3.32	3.17	.07
	1 - 133[b]	2.92	2.99	2.89	2.91	2.84	2.88	2.66	.04

[a] Standard error of the means.
[b] Significant ($P<.05$) protein main effect comparing treatments 1, 5, 6 and 7.
[c] Linear and cubic niacin effect ($P<.05$) comparing treatments 1, 2, 3, 4 and 5.

The poor perfomance of pigs fed the low protein diets may have been due to an amino acid imbalance where tryptophan was the most limiting amino acid. The lack of a response to niacin additions in either the higher or lower protein diets tends to indicate that added niacin does not spare tryptophan. It also indicates that niacin is available in corn-soybean meal diets in quantities adequate enough to support normal growth.

EFFECT OF SUBSTITUTING FISH OIL FOR ANIMAL FAT IN SOW DIETS ON FATTY ACID COMPOSITION OF SERUM AND MILK AND ANTIBODY PRODUCTION IN PIGLETS.

K. L. FRITSCHE, S. C. HUANG, N.A. CASSITY

SUMMARY

This study was designed to measure the impact of supplementing a practical sow diet (corn-soybean meal) with fish oil on serum and milk lipid profiles and the ability of weanling pigs to mount a humoral immune response. On day 107 of gestation 24 sows were randomly allotted to 1 of 4 experimental diets, in which fish (menhaden) oil was substituted for animal fat at 0, 3.5, 5.25, 7% of the diet. Diets were isocaloric and formulated to contain 7% added fat and to meet NRC (1988) requirements. On days 1, 7, 14, 21 after farrowing samples of colostrum/milk and serum from the sows and of serum from the piglets were collected for lipid analysis. Ten piglets from each treatment group at weaning (3-4 weeks of age) were tested for primary and secondary antibody response to sheep red blood cells by hemagglutination. Fish oil (FO) feeding significantly increased the content of omega-3 (n-3) fatty acids in the sow's serum. Similar, but less dramatic, changes were reflected in the colostrum and milk lipid profiles, as well as, in the serum lipids of the baby pigs. Primary and secondary antibody responses were not significantly different between treatment groups. Results indicate that supplementing a practical late-gestation and lactation diet with fish oil significantly elevates the content of omega-3 fatty acids in the sow's serum and milk, as well as, in the serum of nursing pigs, but did not enhance antibody production.

INTRODUCTION

In the field of human nutrition there has been a lot of interest in the possible health benefits associated with consuming greater amounts of omega-3 (n-3) fatty acids. Over the last decade researchers have become increasingly interested in the possible health benifits, such as reduced risk for coronary heart disease, cancer, inflammation, associated with the consumption of fish and fish oils. These benefits have been attributed primarily to the n-3 fatty acids present in fish oils. A major area of research involves the immunologic effects of n-3 fatty acids. A common approach is to examine changes in inflammation and immune responses following changes in the dietary lipid composition. To date most research in this area involves laboratory animal experimentation and humans clinical trials. Little attention has been given to the possible beneficial effects inclusion of n-3 rich oils might have in domestic animal production (1-3).

EXPERIMENTAL PROCEDURE

Animals and Treatment Groups

On day 107 of gestation, 24 crossbred sows were randomly allotted to 1 of 4 experimental diets, in which fish (menhaden) oil was substituted for animal fat at 0, 3.5, 5.25, 7% of the diet (treatment groups A, B, C, D, respectively). Feed consumption and changes in body weight for each sow were recorded. Number of piglet born/sow, birth weight, and weaning weights were recorded.

Diets

Diets were isocaloric and formulated to contain 7% added fat and to meet NRC (1988) requirements. See Table 1 for complete composition.

Sample Collection for Lipid Analysis

Baseline serum samples were collected from each sow. On days 1, 7, 14, 21 after farrowing samples of colostrum/milk and serum from the sows and of serum from the piglets were collected for lipid analysis.

Lipids were extracted from serum and milk samples following the Bligh and Dyer method (4). The organic phase containing the lipid extract was collected and reduced in volume under N_2. The percentage of lipid in the milk samples was determined gravimetrically. Methyl esters of fatty acids were prepared by transmethylation using 4% H_2SO_4 in methanol. Fatty acid methyl esters were identified using a Hewlett-Packard gas-liquid chromatograph (Sunnyvale, CA), Model 5890 with a 180 x 0.4 cm glass column packed with 10% SP 2330 on 100/120 Chromosorb W AW (Supelco, Inc., Bellefonte, PA) operated isothermally at 190°C. Results, expressed as percent of total fatty acids, were determined using a Hewlett-Packard 3380A integrator.

Measurement of Antibody Response

Ten piglets from each treatment group at weaning (3-4 weeks of age) were tested for primary and secondary antibody response to sheep red blood cells by hemagglutination. Upon weaning, each piglet was injected intraperitoneally with 2 ml of 10% sheep red blood cell (sRBC). Seven day after that injection, blood samples were taken from the jugular vein and immune sera were seperated and analyzed for primary antibody titer. Ten days after the first injection, piglets received a second injection of sRBC. Blood samples were collected six days later for the analysis of secondary antibody response.

Antibody levels were measured by a direct hemagglutination test in a 96-well micro-titer plate. Each well contained either 100 µl of diluted immune serum in PBS or 100 µl PBS as control, and 50 µl of 0.5% sRBC. The highest dilution factor at which hemagglutination was observed was transformed into natural logarithm and is expressed as antibody titer.

RESULTS AND DISCUSSION

There were no significant differences in feed consumption or weight loss by sows in the various treatment groups (data not shown). Similarly the number of live pig born/sow and birth weights did not differ between groups. Weaning weights for group B (half fish oil/half lard) were significantly lower than the other groups. However, differences in age at weaning accounted for most of the disparity between groups (Table 2).

Fish oil (FO) feeding significantly increased the content of omega-3 (n-3) fatty acids in the sow's serum ($p < 0.0001$). The two major n-3 fatty acids, eicosapentaenoic acid (EPA= 20:5n-3) and docosahexaenoic acid (DHA= 22:6n-3) were elevated as much as 120-fold and 8-fold, respectively. In sows fed the 7% fish oil diet (group D), EPA content of the serum (as a % of total fatty acids) increased from 0.2% to 12.4, 19.5, 23.5, 24.1% at days 1, 7, 14, 21 post-farrowing, respectively (Table 3). Similar, but less pronounced increases in n-3 fatty acid levels were reflected in the colostrum and milk. EPA levels in the milk were elevated as much as 600% by fish oil feeding ($p < 0.0001$). The relative levels of n-3 fatty acids in the milk remained constant throughout lactation ($p < 0.74$). The actual amount of lipid in the milk was not affected by diet treatment (mean=9.4 % wet weight basis).

In piglets suckling sows fed the 7% FO diet (group D) serum n-3 levels were significantly elevated compared to piglets suckling group A sows ($p < 0.0001$). EPA content in the serum from group D piglets was 7.3% within 24 h of birth and reached peak levels at wk 2 (Table 3).

Primary and secondary antibody responses were not significantly different between treatment groups (Figure 1).

CONCLUSIONS

Results indicate that supplementing a practical late-gestation and lactation diet with fish oil significantly elevates the content of omega-3 fatty acids in the sow's serum and milk. Evidence that this supplementation provided an effective means of enriching the serum of nursing pigs with n-3 fatty acids was provided. Preliminary attempts failed to demonstrate a benefical effect of such a transfer of n-3 fatty acids on the humoral immune response of weanling pigs.

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TABLE 1. Composition of Experimental Diets

Treatment Groups:	A	B	C	D
Ingredient		(% composition)		
Ground corn	58.9	58.9	58.9	58.9
Oats	10.1	10.1	10.1	10.1
Soybean meal (44% CP)	20.0	20.0	20.0	20.0
Animal Fat (choice white grease)[1]	7.0	3.5	1.75	---
Fish (menhaden) oil[2]	---	3.5	5.25	7.0
Dicalcium phosphate	2.7	2.7	2.7	2.7
Ground limestone	0.4	0.4	0.4	0.4
Vitamin mix[3]	0.5	0.5	0.5	0.5
Trace mineral salt mix[4]	0.5	0.5	0.5	0.5

[1] Fatty acid composition: C14:0, 1%;C16:0, 25.4%; C16:1, 2.8%; C18:0, 13.7%; C18:1, 42.3; C18:2, 10.8%.

[2] Courtesy of Zapata Haynie Corp. (Reedville, VA); fatty acid composition: C14:0, 6.4%;C16:0, 16.6%; C16:1, 10.4%; C18:0, 2.6%; C18:1, 13.9; C18:2, 1.5%; C18:3n3, 1.2%; C20:1, 2.6%; C20:5n3, 14.3%; C22:1, 1.8%; C22:5n3, 2.2%; C22:6n3, 12.6%. Menhaden oil was stabilized against autooxidation by the addition of 500 ppm of ethoxyquin.

[3] Swine sow supplement 15B (NB-6078) Nutra Blend Corp., Neosho, MO.

[4] University of Missouri Premix.

TABLE 2. Pigs Born/Litter, Birth Weight, Weaning Weight.

Treatment Groups:	A	B	C	D		
Parameter					SEM	P value
# live pigs born/litter[1]	9.4	11.8	9.7	8.2	1.2	0.29
Birth weight (lb)	3.33	3.13	3.09	3.31	0.11	0.25
# pigs weaned/litter	8.0	8.8	7.3	7.3	1.2	0.82
Weaning Wt (lb)	16.8a[2]	13.5b	15.5a	16.0a	0.7	0.007
Age at Weaning (days)	28.8a	25.6b	25.7a	26.8a	0.3	0.0001

[1] Number of litters/treatment group: A=5, B=4, C=6, D=6.

[2] Means in same row with different letters are statistically different via ANOVA.

TABLE 3. Relative Levels of EPA (20:5n3) and DHA (22:6n3) Over Time in Serum and Milk from Sows Fed 7% CWG (Grp A) or 7% Fish Oil (Grp D) and Serum from Piglets Nursing Those Sows.

		(Days After Farrowing)			
Sampling Time:	Initial	1	7	14	21
			Sow Serum		
			EPA Content[1]		
7% CWG[2]	0.5[3]	1.0	0.5	0.6	0.9
7% Fish Oil	0.2	12.4	19.5	23.5	24.1
			DHA Content[1]		
7% CWG	0.8	1.1	0.8	0.9	0.7
7% Fish Oil	0.6	4.6	4.9	5.2	5.3
			Colostrum/Milk		
			EPA Content		
7% CWG	---	0.01	0.8	0.7	0.5
7% Fish Oil	---	3.0	3.7	3.2	3.5
			DHA Content		
7% CWG	---	0.03	1.1	0.8	0.5
7% Fish Oil	---	3.2	4.2	3.1	3.7
			Piglet Serum		
			EPA Content		
7% CWG	---	0.4	0.3	0.4	0.4
7% Fish Oil	---	7.3	13.3	16.3	14.0
			DHA Content		
7% CWG	---	1.2	1.2	1.5	1.5
7% Fish Oil	—	5.2	5.6	5.9	4.9

[1] Expressed as a % of total fatty acids.

[2] Choice white grease.

[3] Values represent the means (n=3-6).

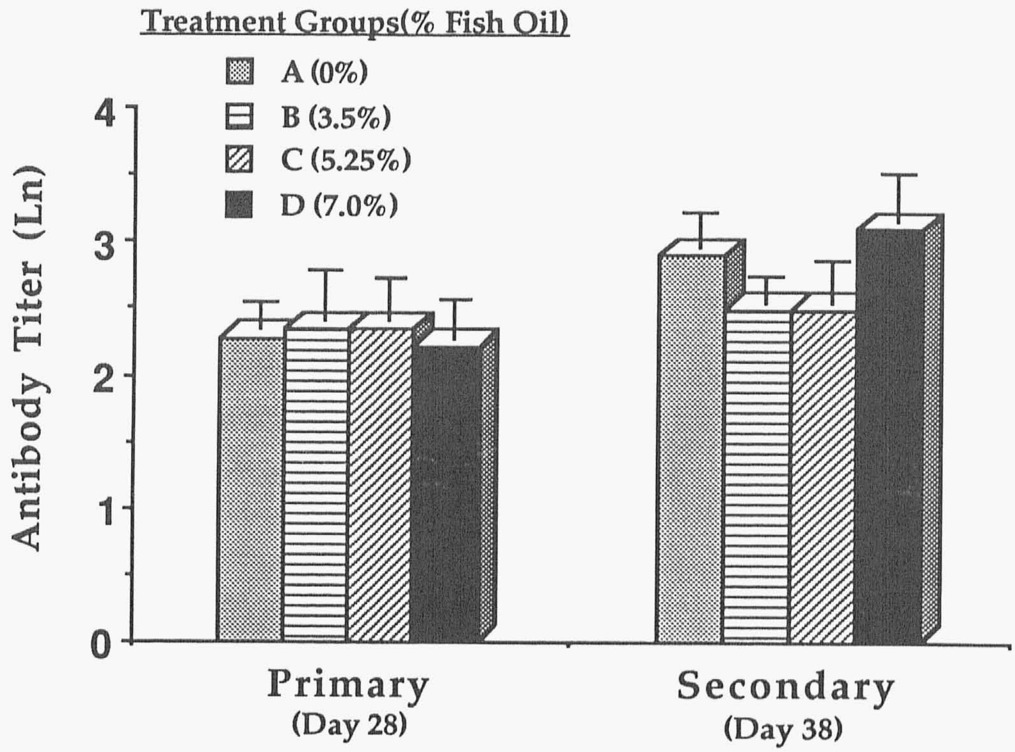

Figure 1. Antibody titers in the serum of piglets who suckled sows fed various levels of fish oil (0-7%). Upon weaning, each piglet was injected intraperitoneally with 2 ml of 10% sheep red blood cell (sRBC). Seven day after that injection, blood samples were taken from the jugular vein and immune sera were seperated and analyzed for primary antibody titer. Ten days after the first injection, piglets received a second injection of sRBC. Blood samples were collected six days later for the analysis of secondary antibody response.

ENERGY SUPPLEMENTATION FOR SOWS LACTATING IN THE SUMMER

R.O. Bates and J.C. Rea[a]

Summary

A sow feeding study during two consecutive summers was conducted to determine if supplementing lactation diets with 7.5% fat would improve lactation performance and subsequent reproductive performance. Litter performance for both summers and subsequent reproductive performance for the first summer is reported here. No significant differences for litter performance were found among sows consuming either the control or energy supplemented diets. The level of preweaning survival and gain were high which left little opportunity for improvement. However, subsequent number born alive tended to be higher, the first summer, among sows consuming energy supplemented diets during lactation.

Introduction

High temperatures and humidity during summer weather can cause discomfort for lactating sows. Heat stress can cause depression of sow feed intake, reduce nursing pig performance, lengthen the interval from weaning to estrus and decrease subsequent litter size. Reports have indicated that supplemental energy for sows lactating during increased temperature may improve milk yield, cause litter weight at 21 days to increase and decrease the interval from weaning to estrus. A study was conducted during the summers of 1988 and 1989 to evaluate the effect of energy supplementation during lactation on sow nursing and subsequent reproductive performance. Sow reproductive performance for 1988 and the combined sow lactation performance will be reported here.

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Methods

During the summer of 1988 three lactation diets were compared on a commercial farm (Bates and Rea, 1989). A control, corn, soybean meal diet was compared to two experimental diets that were formulated to contain 7.5% supplemental fat (table 1). Soybean oil and a dried fat product that contained 80% choice white grease and 4% crude protein were the two energy sources.

For the summer of 1989 two lactation diets were evaluated on the same commercial farm. The control, a corn, soybean meal diet was compared to a diet containing 7.5% soybean oil (table 1). The diets were originally formulated to have a similar calorie to lysine ratio; however, due to a formulation error, the soybean oil diet used in 1989 was recalculated and had slightly less synthetic lysine.

The study was initiated on July 22 in 1988 and July 21 in 1989. There were 175 sows evaluated in 1988 while 166 sows were included in 1989. Females were randomly allotted to diet, within parity, upon placement into farrowing crates. Parity was designated as gilts, sows farrowing their second litter and sows farrowing their their third or later litter. Sows consumed their allotted diet from assignment to weaning. Sows lactated approximately 27 days. Data collected provided information on litter birth weight, piglet survival to weaning, litter weight at 21 days of lactation, number at 21 days, interval from weaning to farrowing and subsequent litter size at birth. Data were analyzed so that the effects of year, farrowing group, and parity were accounted for when comparing differences due to treatment.

Results and Discussion

Sow lactation performance for both years is reported in table 2. The addition of supplemental soybean oil at a rate of 7.5% did not improve performance. Several possibilities exist on why this occurred. Opportunities to show increases in performance were modest. High preweaning survival and rapid preweaning piglet gain allowed little room for improvement. Also, levels of fat fed in this study were lower (7.5% vs 10.0%) than other studies in which significant differences were reported. However, supplementation of energy in sow lactation diets may improve nursing pig performance on some farms. High preweaning death loss and below average litter weight at 21 days may respond favorably to energy supplementation.

Subsequent reproductive performance for sows farrowing in the summer of 1988 is listed in table 3. Days from weaning to next farrowing and number born dead were similar across treatments. On the other hand number born alive at subsequent farrowing did improve with supplemental energy added to the lactation diet. The addition of ether fat or soy oil increased subsequent number born alive by approximately .7 pigs. The diet with added soybean oil did cause the largest increase in subsequent number born alive but was not statistically different when compared to the diet with added dry fat.

Conclusion

A study conducted during the summers of 1988 and 1989 evaluated the addition of supplemental energy to sow lactation diets. No significant differences occurred for number born alive, number at 21 days of age, litter birth weight, litter weight at 21 days and survival from transfer to 21 days of age. Preweaning weaning survival and piglet preweaning gain was high leaving little room for improvement. Also the level of added fat was less (7.5% vs 10.0%) was lower than in other reports. Subsequent number born alive tended to be greater when sows consumed diets with added energy during their previous lactation. It would appear that preweaning death loss and gain would have to be worse than what is reported here for supplemental energy during summertime lactation to be beneficial. However, supplemental energy during lactation in the summer may increase subsequent litter size born.

Table 1. Composition of Diets

Ingredient	Control	Soy Oil-88[a]	Soy Oil-89[b]	Dried Fat
Corn, %	78.1	68.97	69.03	67.17
Soybean Meal (44%), %	18.0	19.5	19.5	19.5
Soybean Oil[c], %	-	7.5	7.5	-
Dried Fat[d], %	-	-	-	9.38
L-Lysine-HCL, %	.05	.18	.12	.10
Limestone, %	.75	.75	.75	.75
Dicalcium Phosphate, %	2.00	2.00	2.00	2.00
Trace Mineral Salt, %	.5	.5	.5	.5
Vitamin premix, %	.6	.6	.6	.6
Calculated Analysis[e]				
Crude Protein, %	14.6	14.4	14.5	14.7
Lysine, %	.76	.88	.83	.84
Calcium, %	.89	.89	.89	.89
Phosphorus, %	.70	.68	.69	.69
Metabolizable Energy (Kcal/lb)	1474.5	1602.5	1602.9	1642.4

[a]Soybean oil supplemented diet used in 1988.
[b]Soybean oil supplemented diet used in 1989.
[c]Crude soybean oil; supplied by the Missouri Soybean Merchandising Council and Archer-Daniel-Midland, Mexico.
[d]A commercial dried fat (MIL-CO-LAC 4-80) containing 80% ether extract and 4% crude protein; supplied by Freeborn Foods, Albert Lea, MN 56007.
[e]National Research Council (1988).

Table 2. LEAST SQUARE MEANS OF SOW LACTATION PERFORMANCE BY TREATMENT FOR 1988 AND 1989[a].

Trait	Control	Soybean Oil
Number born alive	9.7	9.7
Number after transfer	9.8	9.9
Litter birth weight, lbs	30.8	30.6
Litter size at 21 days	9.2	9.0
Litter weight at 21 days, lbs	106.6	106.8
Survival rate from transfer to to 21 days, %	93.6	90.9

[a]Least squares means within each row were not significantly different.

Table 3. LEAST SQUARES MEANS BY TREATMENT OF SUBSEQUENT FARROWING TRAITS FOR SOWS LACTATING DURING SUMMER 1988.

Treatment	Control	Soy Oil-88	Dried Fat
Trait			
Days from weaning to next farrowing	121.9	120.5	121.2
Number born alive	9.2[a]	10.2[b]	9.9[ab]
Number born dead	.24	.45	.35

[a,b]Means within a row with different superscripts differ (P<.14).

EFFECT OF BOAR EXPOSURE ON EXPRESSION OF GENETIC POTENTIAL FOR AGE OF PUBERTY IN GILTS

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University of Missouri-Columbia

SUMMARY

Age at puberty was evaluated in two lines of pigs under two treatments. The treatments were heat checking with or without the presence of a mature boar. The lines were samples from the random control and the seventh generation of selection for decreased age at puberty in a University of Nebraska experiment. The select gilts matured earlier than the control gilts under both treatments. Fifteen minute daily boar exposure hastened puberty in both lines.

INTRODUCTION

Decreasing the age at puberty of gilts can result in their being mated earlier and thus becoming a productive part of the sow herd sooner. This decreases lifetime maintenance costs. Treatment with exogenous hormones has not been found to be an efficient way to decrease the age at puberty of gilts. Daily boar exposure is known to induce an early onset of first estrus. Genetic selection has also been shown to be effective in reducing the age at puberty.

The pigs utilized in this experiment were from the seventh generation of a line selected for early puberty of gilts and from a randomly selected control line of a University of Nebraska study. Selection had been for early expression of puberty when daily heat checks were conducted with a boar. Heat checking was initiated when gilts were no greater than 130 days of age. In their experiment age at puberty decreased 2 to 3 days per generation. The objective of the present study was to determine if genetic differences between lines attained through selection with boar exposure would be expressed in the absence of any boar exposure.

METHODS

Seventy-three gilts from the select line and 48 gilts from the control line of the Nebraska Gene Pool population were used in the experiment. Gilts were divided evenly between treatments. Gilts from the two lines were penned together in pasture lots in groups of 20 at the UMC South Farm Swine Pasture Unit. The two treatments were presence or absence of a boar during a 15 minute daily heat check period. Heat checking was initiated when gilts were 125 days of age. Heat checking for the two treatments was performed in separate outdoor pens.

Blood samples were taken weekly by jugular venipuncture and radioimmunoassayed for progesterone. A value of greater than two ng/ml was used as an indication that ovulation had occurred. A gilt was determined to have reached puberty when she exhibited a standing reflex or had two consecutive high progesterone values.

RESULTS

The mean ages at puberty for the four groups are shown in Figure 1. Boar exposure resulted in reduced ($P < .05$) age at puberty in both lines. The select line expressed puberty at an average of 154 days of age with boar exposure versus an average of 164 days of age without boar exposure. The control line expressed puberty at an average of 164 days of age with boar exposure versus an average of 177 days of age without boar exposure.

The select line retained its advantage over the control line in age at puberty in both treatments (154 vs 164 and 164 vs 177 days for boar exposure and non-boar exposure, respectively; $P < .05$). There was no interaction between treatment and line.

The distribution of ages at which gilts expressed puberty is shown in Figure 2. It is apparent that the advantage for the select line and for the boar exposure treatment resulted from shifting the proportion of gilts which expressed puberty early (less than 160 days of age) rather than from reducing the proportion of gilts which had late puberty. Differences among groups were greatest at 160 days of age; by 190 days almost no differences existed.

In general, puberty was expressed early in this experiment. Only ten of 121 gilts had failed to express estrus by 200 days of age. The early expression of estrus may have been due to the population utilized, the experimental conditions or a combination of the two.

CONCLUSIONS

Age at puberty can be effectively decreased through daily exposure to a mature boar or by genetic selection. These two methods act additively thus it is possible to simultaneously take advantage of both.

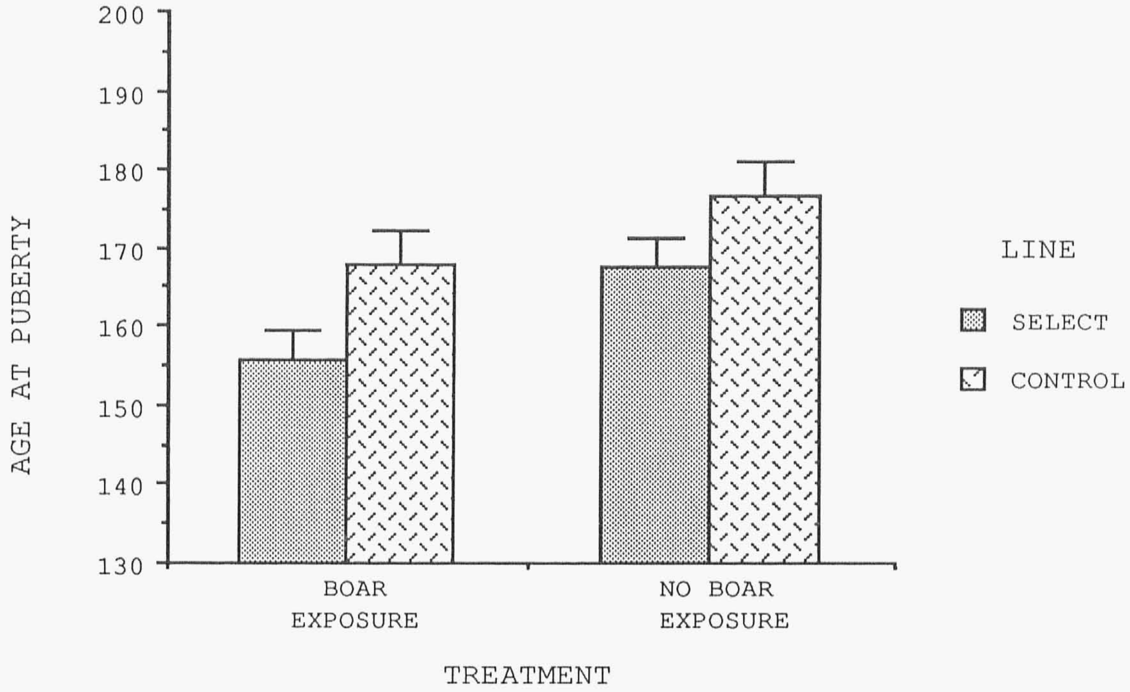

Figure 1
Mean Age at Puberty by Treatment and Line

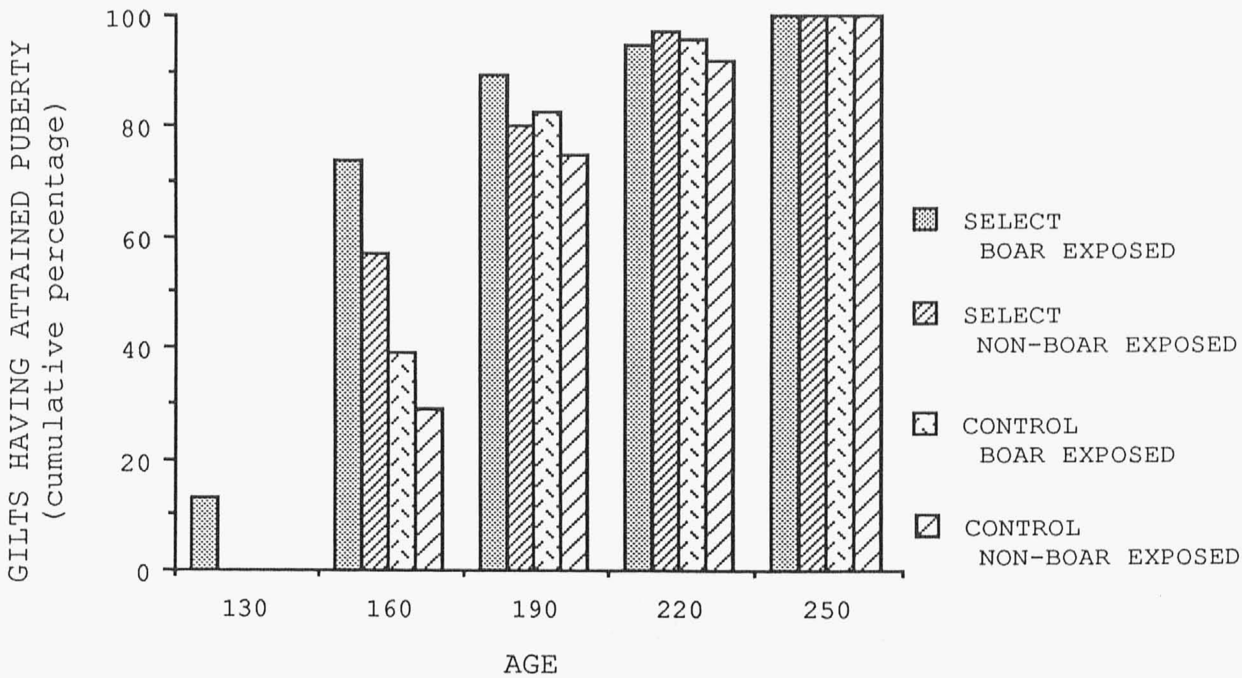

Figure 2
Distribution of Expression of Puberty by Line and Treatment

TESTICULAR DEVELOPMENT AND ENDOCRINE FUNCTION OF BOARS FROM A LINE OF SWINE SELECTED FOR EARLY PUBERTY

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T. J. Safranski and V. K. Ganjam
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SUMMARY

Measures of sexual maturity were evaluated in boars from a line of swine which had undergone seven generations of selection for early puberty of gilts. These measures were compared to similar measures taken in boars from an unselected line. Testicular volume was estimated from measurements taken at 6 week intervals. Testosterone levels were evaluated at biweekly intervals. Samples of semen collected at 180 days of age were evaluated for volume, sperm number, percentage motile and live to dead ratio. Testicular volume and testosterone production indicated tendencies for earlier puberty in the selected line. No differences were evident for semen characteristics.

INTRODUCTION

Reducing the age of puberty of boars and gilts decreases the length of the development period during which time they are unproductive. Hormone therapy has not been found to be particularly efficient in reducing the age of puberty. Selection for decreased age at puberty in gilts has been shown to be effective. Age at puberty declined by 2-3 days per generation of selection in an experiment conducted at the University of Nebraska. Samples of the selected and control lines from generation seven of the Nebraska experiment were obtained by the University of Missouri for further evaluation. The objective of this study was to determine if selection for early puberty in gilts had had an associated affect on boars.

METHODS

Twelve boars from each line were utilized in the study. Blood samples were collected biweekly from 10 to 24 weeks of age. Levels of testosterone were measured using radioimmunoassay. Length and width of the paired testicles were measured at 8, 14, 20 and 26 weeks of age. Volume of the paired testicles was mathematically predicted using length and width measurements. Three ejaculates of semen were collected from each boar over a 2 week period. The first ejaculate was discarded. The subsequent two ejaculates were evaluated for volume, percentage motile sperm, sperm numbers and live to dead ratio.

RESULTS

Predicted testes volumes are presented in Figure 1. Volumes were initially similar between the two lines. Testes growth between 8 and 20 weeks of age was more rapid among boars in the line selected for early puberty than in boars from the control line. Differences between lines were statistically significant at 20 weeks of age. After 20 weeks of age testes growth slowed in the early puberty line. The difference between lines was diminished and no longer statistically significant by 26 weeks of age.

Testosterone levels were similar between lines from 10 to 14 weeks of age (Figure 2). Levels increased significantly in select line boars from 14 to 22 weeks of age while levels in control line boars remained constant. Levels were again similar at 24 weeks of age.

No differences between lines were noted for any semen characteristic.

CONCLUSIONS

These results suggest that boars from the select line tended to reach sexual maturity earlier than those from the control line. Selection for early puberty in gilts thus may result in correlated changes in age of puberty in boars. Differences in testosterone production and testes size apparent at 20 weeks of age had diminished by 24 weeks of age. Semen characteristics were not different at 180 days of age but differences might have been found if examined at an earlier age.

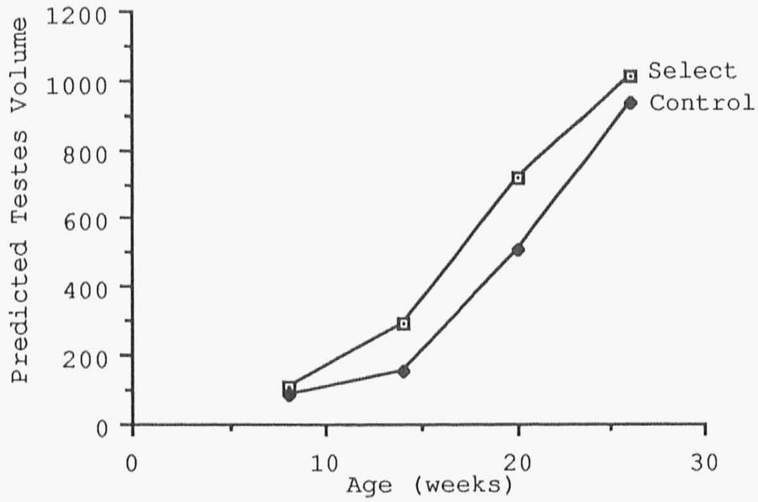

Figure 1
Predicted Testes Volume of Select vs Control Line Boars

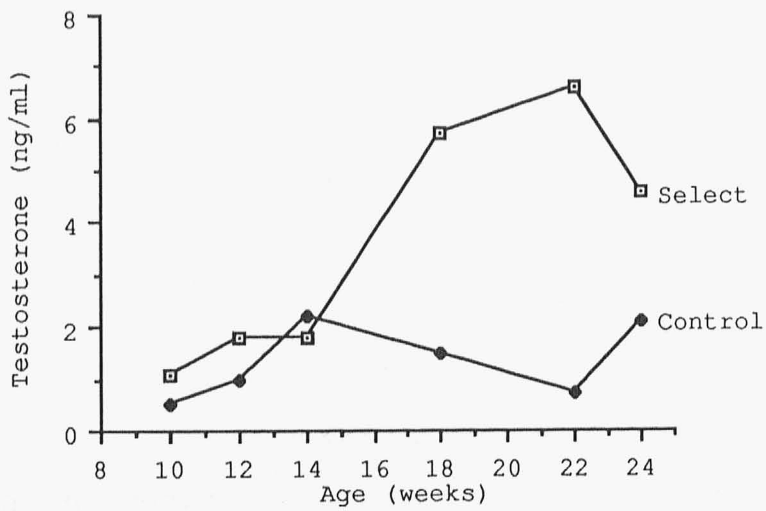

Figure 2
Serum Testosterone of Select vs Control Line Boars

THE EFFECT OF RECOMBINANT PORCINE SOMATOTROPIN (rPST) ON REPRODUCTIVE PERFORMANCE IN SWINE

S.L. Terlouw, A.R. Rieke and B.N. Day

SUMMARY

Gilts selected to enter the gilt pool were injected with rPST during the growing-finishing phase (118-242 lbs.). Upon cessation of treatment at market weight (242 lbs.), evaluation of reproductive performance indicated no detrimental effects of previous rPST treatment. Interval from boar exposure to puberty, age at puberty, length of the first estrus period and estrous cycle length were not adversely affected by rPST treatment. Pregnancy rate, ovulation rate and embryonic survival in rPST treated gilts were not different from control gilts. These data indicate that normal reproductive performance can be expected from gilts selected to enter the breeding herd following rPST treatment during the growing-finishing phase.

INTRODUCTION

Porcine growth hormone of pituitary origin (pGH) or recombinant porcine somatotropin (rPST) have similar effects in pigs and both cause a dramatic decrease in body fat when given during the growing-finishing period. Although body size and composition appear to be major determinants of age at puberty in cattle, there is not such a close relationship in pigs. Even so, concern has been expressed about a possible delay in puberty and poor reproductive performance in replacement gilts following treatment with rPST. Acceptance by the producer will depend not only on enhanced production characteristics and increased carcass quality but also on how these gilts will perform when selected to enter the gilt pool. Therefore, the following study was conducted at the University of Missouri to examine the indirect effects of rPST on reproductive performance in gilts following cessation of treatment at market weight.

PROCEDURES

Forty crossbred gilts, including nineteen pairs of littermates, weighing 118 lbs. were chosen for this study to be conducted in an environmentally controlled swine finishing facility. Twenty control gilts received a 1 ml injection of a carrier solution daily and twenty rPST treated gilts received 6 mg of rPST reconstituted in 1 ml of carrier solution as a daily injection. Treatment was continued until a pen (four rPST and four control) averaged 242 lbs. Gilts were then moved to an environmentally controlled breeding/gestation unit and boar exposure was begun. Daily heat checks were used to determine age at puberty and estrous cycle length. Gilts were bred at second estrus and embryo recovery was performed at day 11 to determine ovulation rate and fertility level.

RESULTS

Growth rate was increased significantly by daily injections of rPST. Body weight gain was greater for rPST treated gilts than for control gilts (Table 1). Ultrasonic measurements of body composition indicated a significant reduction in backfat and an increase in loin eye area (Table 1). These data show a typical and positive response to rPST treatment and provide a basis to pursue the main question of this experiment; what are the effects of these changes in rate of body growth and body composition on subsequent reproductive performance?

Tables 3 and 4 summarize the reproductive characteristics of the control and treated gilts. All 20 control gilts and 19 of 20 rPST treated gilts reached puberty before eight months of age. Puberty was attained at an average of 182 days of age for both treated and control gilts. Interval from boar exposure to pubertal estrus was not altered by rPST treatment (Table 3). Length of the first estrous period and the number of days between the pubertal estrus and the second estrus (estrous cycle length) was not affected by previous rPST treatment (Table 3).

A 100% conception rate was obtained in all gilts expressing a second estrus (Table 4). These data indicate fertility level is unaffected by rPST treatment during the growing-finishing phase. Also, as shown in Table 4, embryonic survival rate and ovulation rate were not altered subsequent to these changes in growth rate and body composition.

Results of this study provide evidence that the alterations in growth rate and body composition induced by previous rPST treatment in growing gilts is without detrimental effects on age at puberty, estrous cycle length, ovulation rate and embryonic survival. Therefore, gilts treated during the growing-finishing phase with rPST can be selected at market weight to enter the gilt pool and can be expected to perform normally in the reproductive herd.

Table 1. Effect of rPST on body weight gain in gilts treated from 118 to 242 lbs. of body weight.[a]

Treatment	rPST/gilt/ day, mg	No. of gilts	Initial weight, lbs.	Final weight, lbs.
Control	0	20	118.5±2.4[b]	235.8±3.9[c]
rPST	6	20	118.4±2.4[b]	249.7±3.9[d]

[a]Least squares means ± SEM.

[b,c,d]Means within the same column with different superscripts are significantly different (P < .05).

Table 2. Effect of rPST on ultrasound measurements of body composition of gilts.[a]

Treatment	No. of gilts	Body weight, lbs.	Backfat in.	Loin eye area, $in.^2$
Control	20	235.8[b]	.98[b]	5.0[b]
rPST	20	249.7[c]	.62[c]	5.7[c]

[a]Least square means.

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

Table 3. Effect of rPST on age at puberty and first estrus.[a]

Parameter	Control	rPST	SEM	P
Gilts, no.	20	20		
Gilts exhibiting estrus, no.	20	19		
Age at puberty, days	182.1	182.4	3.3	NS
Boar exposure to estrus, days	12.8	14.2	2.8	NS
Duration of estrus, days	1.8	1.9	0.1	NS
Estrous cycle length, days	20.2	20.6	0.4	NS

[a]IM injection of 6 mg rPST/d from 118 to 242 lbs. of body weight.

Table 4. Effect of rPST on ovulation rate and embryo survival[a]

Treatment	No. of gilts		Number of corpora lutea	Embryonic survival rate, %
	bred	pregnant on d 9 to 12		
Control	19	19	14.3±0.6	76.2
rPST	19	19	14.9±0.9	87.9

[a]Least squares means ± SEM

THE EFFECTS OF HEAT ON PERFORMANCE AND CARCASS RESPONSES OF FINISHING HOGS TREATED WITH A SINGLE PORCINE SOMATOTROPIN PROLONGED RELEASE IMPLANT(PST-I)

B.A. Becker[1], C.D. Knight[2], G. W. Jesse[3], H.D. Hedrick[3] and C.A. Baile[2]

SUMMARY

A study was conducted to compare the effects of 100 mg porcine somatotropin(PST-I) on performance and physiological responses of swine exposed to thermoneutral or hot environmental conditions. Hogs were supplemented with a PST-I or sham implant and maintained under either thermoneutral or hot environmental conditions for 28 or 35 days before slaughter. Performance and physiological responses were determined. At the end of the trial hogs were slaughtered and carcasses evaluated. Both PST-I and heat had varying effects on the different parameters measured; however, no additive effects were found on performance responses of average daily gain, feed intake and feed efficiency. The results suggests that the beneficial effects of the PST implant on performance were obtained despite the imposed thermal stress.

INTRODUCTION

Porcine somatotropin(PST) is a growth enhancer for finishing swine that is being developed by several commercial companies. Hogs supplemented with PST during the final phase of finishing are leaner, gain body weight and consume feed more efficiently. In order for this product to become commercially acceptable, the benefits must be established across a variety of environmental conditions. The objective of this project was to compare the effects of thermoneutral(64 to 68° F) and hot(80 to 95° F) environments on the performance and physiological responses of finishing hogs receiving a 100 mg PST implant delivery system.

[1]USDA-Agricultural Research Service, Animal Physiology and Nutrition Unit
[2]Monsanto Co.,St. Louis Mo.
[3]Department of Animal Sciences, UMC.

EXPERIMENTAL PROCEDURES

Forty finishing hogs, with intial body weights of 160 to 180 lbs., were used for this experiment. Four experimental treatments were: 1) thermoneutral environment of 64 to 68° F with hogs receiving a sham-implant; 2) thermoneutral conditions, with hogs receiving PST 100 mg implant(Monsanto, Co., St. Louis, Mo.); 3) cycling heat of 80 to 95°F with hogs receiving a sham implant; and 4) cycling heat with hogs receiving PST implant. The hot environmental conditions simulated a typical day of very hot weather in Missouri in the summer of 1988. Hogs were individually penned in 1 of 4 environmentally controlled chambers in the Brody Animal Climatology Laboratory at the Animal Science Research Center. Hogs were fed and watered ad libitum until body weights reached approximately 220 lbs. Implants were inserted into the right ear of each pig respectively on day 0 and pigs were slaughtered 28 or 35 days later depending on weight gain.

The diet fed was a corn-soybean meal base with 18% crude protein. The energy was increased with 6% soy oil. Analyzed amino acid concentrations were 1.28% lysine, .7% threonine and .62% methionine + cystine. Calcium and phosphorus were supplemented at .86% and .66% respectively.

Hog body weights and feed consumptions were determined weekly. Blood samples were taken on days 0,7,21 and prior to slaughter. Respiration rates and rectal temperatures were taken during the week. Carcass measurement and quality assessments were also determined. Blood samples were analyzed for various hormones and metabolites.

RESULTS

The performance of pigs treated with PST-I and the effect of environment are shown in table 1. PST-I had no effect on daily gain. Feed intake was reduced significantly with PST-I as was feed efficiency. The hot environment caused a reduction in daily gain and feed intake, with no effect on feed efficiency. No significant interaction between the environment and supplementation with PST-I was found.

The carcass parameters of pigs treated with PST-I and the effect of environment are shown in table 2. Supplementation with PST-I did not affect final body weight, slaughter weight, hot carcass weight or dressing percent. Animals in the hot environment had a reduction in final body weight in comparison to the weights from pigs in the thermoneutral environment. No other effects due to heat were found. No interaction between environment and PST-I was found on any of the carcass parameters.

Supplementation with PST-I resulted in a decrease in 10th rib backfat,a reduction in leaf fat and a slight increase in carcass length(table 3). Hot environmental temperatures also resulted in a reduction in 10th rib backfat, and leaf fat, but had no effect on carcass length. A significant interaction between environment and PST-I was found on leaf fat,with a smaller reduction being found in the PST-I treated pigs in the hot environment than the reduction found in PST-I treated pigs in the thermoneutral environment. No other signficant interactions on carcass measurements were found. Neither PST-I, the environment, or the interaction of the two had an effect on muscle, color, marbling, or firmness score(table 4).

The rectal temperature and respiration rate data(not shown) showed that the hot environmental conditions imposed on the pigs in this study was sufficent to impose a thermal stress. The physiological data showed that PST-I caused in increase in concentrations in the blood of PST, insulin-like growth factor-I and triiodothyronine and reduced concentrations of blood urea nitrogen. Similarly, the environment had an effect on levels of all parameters but blood urea nitrogen. A significant interaction between PST-I and environment was observed only for insulin-like growth factor-I and triiodothyronine. Blood urea nitrogen was the only blood parameter that was consistently affected by PST and not by environment.

DISCUSSION

The results of this study show that the beneficial effects of supplementing finishing swine with porcine somatotropin(PST-I) can be achieved under hot environmental conditions. The PST-I 100 mg implant was effective during the 28 or 35 day finishing period. The hot environmental conditions, which were modeled after a very hot Missouri day in the summer of 1988, imposed a significant thermal stress on the hogs. The PST implant had no effect on average daily gain, but did reduce feed intake and improve feed efficiency. The hot environment caused a reduction in gain and in feed intake; however, no effect on feed efficiency was observed. Despite these effects of PST-I and hot environment on performance, no additive effects of the two were demonstrated. This is illustrated by comparable rates of gain, feed intake reductions and improvements in feed to gain within environment.

The physiological data demonstrated that concentrations of various hormones and metabolites were effected by the PST supplementation and the hot environment. Such effects were additive on some but not all factors measured. This suggested that the animals may make physiological changes to cope with the PST supplementation and the imposed thermal stress; however, the animals were able to maintain the enhanced performance, on which no additive effects of PST and evnvironment were found. In conclusion, the data together demonstrate that there was no overriding effect of the hot environment on the finishing hogs' abililty to respond to PST-I 100 mg implant.

Table 1. Performance responses of hogs with a PST-I implant or sham implant(control) maintained in either a thermoneutral(TN) or hot(heat) environment.

Treatment	Gain(lb/day)	Feed intake(lb/day)	Feed/gain
Control	1.98	6.81	3.48
PST-I	2.00	5.93	2.95
TN	2.25	7.05	3.27
Heat	1.74	5.69	3.16
Control,TN	2.20	7.52	3.41
PST-I,TN	2.27	6.59	2.91
Control,heat	1.74	6.11	3.55
PST-I,heat	1.76	5.27	2.99

Table 2. Carcass responses of hogs with a PST-I implant or sham implant(control) maintained in either a thermoneutral(TN) or hot(heat) environment.

Treatment	Final Body Weight(lb)	Slaughter Weight(lb)	Hot carcass Weight(lb)	Dressing %
Control	229	213	163	76.3
PST-I	232	218	163	74.9
TN	236	214	161	75.2
Heat	225	218	165	76.0
Control,TN	234	217	166	76.6
PST-I	238	219	165	75.4
Control,Heat	224	210	160	76.0
PST-I,Heat	225	218	162	74.4

Table 3. Carcass measurements of hogs with a PST-I implant or sham implant(control) maintained in either a thermoneutral(TN) or hot(heat) environment.

Treatment	Loin muscle Area(in^2)	10th Rib Backfat(in)	Leaf Fat(oz)	Carcass Length(in)
Control	4.6	1.3	60.3	30.9
PST-I	4.5	1.0	47.7	31.5
TN	4.5	1.2	60.2	31.1
Heat	4.7	1.0	47.9	31.3
Control,TN	4.4	1.4	71.4	30.7
PST-I,TN	4.5	1.1	49.1	30.5
Control,Heat	4.7	1.1	49.4	31.2
PST-I	4.6	0.9	46.4	31.4

Table 4. Carcass scores of hogs with a PST-I implant or sham implant(control) maintained in either a thermoneutral(TN) or hot(heat) environment.

Treatment	Scores(1-3)			
	Muscle	Color	Marbling	Firmness
Control	1.98	1.96	1.86	2.11
PST-I	2.15	2.00	1.69	1.99
Heat	2.14	2.00	1.82	2.05
TN	1.99	1.96	1.74	2.04

score of 1 ="least"; 3 ="most"

DEVELOPMENT OF RESTRUCTURED PORK/SOYBEAN HULL FOOD PRODUCTS: A FEASIBILITY STUDY*

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University of Missouri-Columbia

SUMMARY

The results of these studies indicate that soy hulls, when combined with pork to develop a human food, can increase product yield, reduce caloric fat and cholesterol content, and provide a snack that is nutritious, tender, and has processing qualities more favorable than that of pork alone.

INTRODUCTION

High quality, nutritious, and low-calorie products are of major interest to consumers and processors alike. Our objective was to research such products made from two of the major agriculture commodities in the state of Missouri - pork and soybeans. Pork is known to be nutritious, but in the 80's it has also become known for its relatively high calorie and high cholesterol contents. We sought to combine pork with a high fibrous, low-calorie portion of the soybean - soybean hulls - that are known to have good zinc and iron bioavailability, have good levels of calcium and protein, and contain over 75% dietary fiber. In developing such a snack, the physical, chemical, thermal, and dietary properties must be determined.

MATERIALS AND METHODS

Initial studies were conducted to determine the effect of temperature, moisture, and particle size on the water and lipid absorptive characteristics of processed and unprocessed soybean hulls. Results indicated that processed hulls could absorb up to ten times their weight in water and absorb almost twice as much water as unprocessed soy hulls. Using a coarser particle and subjecting it to increasing water availability at higher process temperatures, increased the water absorptive qualities of the soy hulls. Compared to lipid and lipid/water emulsions, water was preferentially absorbed and absorbed to a greater extent then the lipids.

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*Research partially funded by grants from Quincy Soybean Company and Missouri Pork Producers Association.

After determining the absorptive characteristics of soy hulls, the processed and unprocessed soy hulls of two particle sizes (coarse and fine) were mixed at five different levels with ground pork shoulder. Physical and thermal properties, lipids, and cholesterol and cholesterol oxide contents were determined on the various pork/soy hull mixtures. Compared to pork alone, the addition of soy hulls resulted in a 25 - 50% reduction in caloric content, less lipid content, less lipid retention, increased moisture content, and higher product yield. The addition of soy hulls at increasing levels resulted in more moisture retention and acceptable textural characteristics. Evaluation of physical and thermal properties indicated that the addition of soy hulls to pork increased the tenderness of the product because of greater moisture retention, resulted in little difference in density, and increased heat capacity, thermal conductivity and thermal diffusivity values. Most of the latter characteristics were a result of increased moisture retention by the soy hulls in the pork product. There was little difference between processed and unprocessed soy hulls and little difference between particle sizes.

In a related study, the effect of a restructured pork/soy hull formula on cholesterol and cholesterol oxides using unprocessed coarsely ground soy hulls indicated that cholesterol content could be lowered by as much as 25% by the incorporation of approximately 5% soy hulls by weight in the mixture. Upon heat processing, there was no formation of the deleterious cholesterol oxides that are often formed under heat processing in conventional meat products.

SWINE - LIVE ANIMAL EVALUATION

Maurice Alexander
Supervisor Livestock Measurements

Live animal testing is designed to help swine producers select herd sires and replacement gilts that can produce market hogs that gain rapidly and efficiently and provide acceptable products for the consumer. Swine producers are becoming more conscious of the importance of a good swine selection and breeding program. In order to maximize genetic improvement, breeding stock must be selected on performance records.

The On-Farm Performance Testing Program is available to Missouri swine producers on a fee basis and is designed to give purebred producers, as well as commercial producers, the performance information they need. This service is available upon request through the University Extension Office and Area Extension Livestock Specialists.

The timely collection of records is essential. If a producer has the time and commitment to collect records, study the results and use them for within herd selection, he will make genetic improvement.

Backfat, loineye area and days adjusted to 230 lbs are important carcass and production traits. Producers should be selecting for leanness, as well as more muscle, together with an animal that will ultimately reach market weight in as few days as possible.

A comparison of results for 1978 and 1985 through 1989, shown in table 1, indicates that a large number of producers are using ultrasonics to record backfat thickness and loineye area. It also indicates that most emphasis is placed on the herd sire. Although more animals were tested in 1978, the trend is to evaluate more and more seed stock each year.

The total number of animals measured in 1989 increased only slightly. Backfat remained the same while loineye area increased in area. Days to 230 lbs increased by one day.

During 1987 we instigated measurements for % muscle adjusted to 160 lbs carcass weight and figured the information for cooperating breeder's use. Since most breeders produce their own female replacements, and add only boars to change the genetic base, most of the improvement on genetic change will come from the paternal side of the pedigree. There were 980 boars and 262 gilts measured for % muscle in 1987. In 1988 there were 3,019 boars and 568 gilts measured for % muscle. During 1989 4,004 purebred boars and 665 purebred gilts were measured for % muscle. The results are in table 2.

Table 1. Swine Sonoray Comparison Overall Averages for 1978 and 1985 through 1989

Year	Avg. Number Head	Avg. Weight	Avg. BF 230#	Avg. LEA 230#	Days 230#
1978	6,327	226	.85	5.66	166
1985	4,621	242	.74	5.92	163
1986	4,820	241	.78	5.89	164
1987	4,929	241	.77	5.82	160
1988	5,997	241	.79	5.83	169
1989	6,021	241	.79	6.01	170

Table 2. A Comparison of Purebred Boars and Gilts for 1987 through 1989 on Backfat, Loineye Area, Days to 230# and % Muscle on 160# Adjusted Carcass Weight

Year	Sex	Total Head	Avg. Wt	Avg. BF 230#	Avg. LEA 230#	Avg. Days 230#	Avg. % Musc. 160# Carc.
1987	Boar	980	241	.78	5.81	165	57.12
	Gilt	262	224	.81	5.69	172	55.50
1988	Boar	3,019	238	.76	5.92	162	57.83
	Gilt	568	228	.84	5.57	173	56.80
1989	Boar	4,004	245	.75	6.05	162	58.89
	Gilt	665	237	.82	5.97	178	57.72

Remaining Competitive in the Pork Industry

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The Industry

The pork industry is an important economic force in the Midwest economy. It is undergoing structural change and forces which can have dramatic implications for the industry. Economic events that shook the agricultural industry in the early 1980s profoundly affected many hog producers. Future changes are uncertain and open to much debate. This report evaluates the Midwest's comparative advantage in pork production and points out the need to isolate those factors that may serve as expanders or inhibitors of the Midwest's potential.

In the midwest swine represents a major share of cash farm income for farmers. Swine also provides a market for much home-grown grain. In effect, pork is largely a value-added product for the area.

Pork production continues to be heavily concentrated in the Midwest, with 80 percent of the 1987 production in states from the northern plains to the eastern Corn Belt. Iowa and Southern Minnesota continues to be the major swine producing area usually accounting for around one-third of national production. However, volume alone is not sufficient to maintain that leadership role. A clearer understanding of the reasons behind this dominance is needed if its swine industry is to grow and expand. The current dominant share of the industry does not guarantee that it will remain the leading force in the future.

The swine industry, like other industries will be affected by the development of new products. These will include specialty products tailored to the fast-food market and microwave-ready products. Products must also be developed to meet the dietary and health needs of consumers.

The hog slaughter industry has been going through significant restructuring due to excess capacity and large wage rate differentials among packers. While some plants have closed, others have reopened or expanded capacity, and a large number of buyers in the Iowa-Minnesota area and adjacent states continue to compete for hogs. At the same time, in Iowa, the top four firms slaughter about 69 percent of the total hog slaughter and will likely increase their market share further. The impact that increased plant concentration will have on hog prices remains somewhat clouded.

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[a]This report is based on a Swine Task Force Report recently completed at Iowa State University.

Swine Task Force members were:
James Kliebenstein, coordinator, Professor of Economics; Lauren Christian, professor of animal science; Gene Futrell, professor of economics; Marvin Hayenga, professor of economics; Palmer Holden, professor of animal science; Vernon Meyer, professor of agricultural engineering; Robert Rust, professor of animal science; Vaughn Speer, professor of animal science; Emmett Stevermer, professor of animal science; and Larry Trede, associate professor of agricultural education.

The market share for farmers marketing from 1,000 to 100,000 head of market hogs per year has changed dramatically during the last 20 years. In 1969 these farmers marketed 13 percent of all hogs (Figure 1). Their market share increased to 70 percent in 1986. It was 34 percent as recently as 1978. With the trend toward fewer and larger hog operations, those marketing 1,000 head of hogs or more now comprise more than 70 percent of the market.

Contract and multiunit production are growing in intensity. This is occurring nationwide as well as in Iowa. In 1970, single units accounted for 97 percent of farm marketings in Iowa. This declined to 49 percent during the 1983-86 period. Multiunit and contract production represents a significant and increasing share of Iowa's market-hog production.

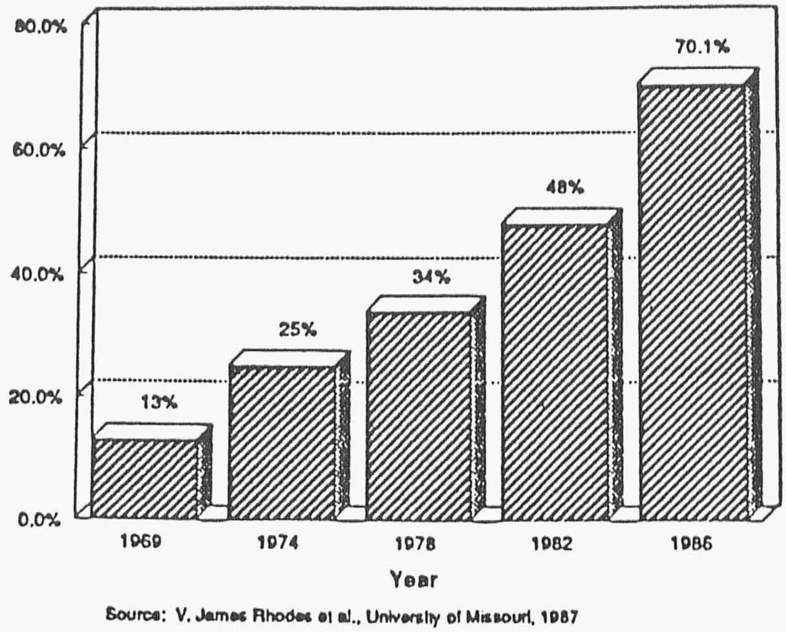

Figure 1. Market share of 1,000 to 100,000 head swine farm

Hog producers have become more efficient in their production practices. Improvements in production efficiency have been particularly significant since 1979. From 1979 to 1987, the U.S. breeding-herd inventory decreased by 30 percent. During this time, farrowings per sow per year increased so that total farrowings decreased by only 22 percent. When coupled with increased average litter size, pig crop declined by only 15 percent. While this was occurring, total production - or pounds of carcass pork - declined only 6 percent because a smaller proportion of the pigs born were required for the breeding herd and average weight of slaughter hogs increased.

<u>Production Cost-Return Comparison</u>

Controlling production costs and being a low-cost producer is important for long-run industry survival and leadership. For the Midwest to remain competitive it must remain a low-cost producing area.

Iowa swine producers have exhibited a wide variation in swine production costs and returns. The difference in profit between the top one-third and low one-third has been staggering. During the 1981-87 period, the average difference in net income per year between the top and low one-third was $43,796 with $47,151 for the top one-third as compared to $3,355 for the low one-

Table 1. **Net profit and return to management, Iowa farrow-to-finish swine operations, 1981-87**

Year	Iowa Producers Top One-third	Iowa Producers Low One-third	Difference
1981	$ 4,724	$-32,376	$37,100
1982	75,230	17,506	57,724
1983	11,730	-32,138	43,868
1984	39,019	-15,710	54,729
1985	47,201	11,875	35,326
1986	88,406	49,331	39,075
1987	63,746	24,994	38,752
Average	47,151	3,355	43,796

Table 2. **Comparison of Iowa producers with competition (1983-1986)**

	Iowa Producers Top One-Third	Iowa Producers Low One-Third	Intensively Managed Operations
Feed cost/cwt [a]	23.76	28.27	21.24
Fixed cost/cwt	6.77	9.76	5.50
Total cost/cwt	38.20	48.40	34.14
Pigs/sow/yr	15.01	13.72	18
Feed efficiency	3.72	4.09	3.4
Avg hd mkt yr	1422	1171	5000

[a] Assumes an average corn price of $2.50/bushel. Competition feed cost is adjusted according to diet cost relationship exhibited between Iowa average and competition shown in table 10.2.

Table 3. **Comparison of Iowa top 10 and 20 percent with competition, 1986 (farrow to finish)**

	Iowa Producers Top 10%	Iowa Producers Top 20%	Iowa Producers Average	Intensively Managed Operations
Feed cost/cwt	18.77	19.41	22.56	20.11
Fixed cost/cwt	4.05	4.23	6.53	N/A
Total cost/cwt	29.30	30.78	38.02	32.50
Pigs/sow/yr	13.95	14.42	14.12	18.5
Feed efficiency	3.61	3.63	4.05	3.4
Avg hd mkt/yr	1036	1260	1249	5000
Pigs weaned/litter	7.93	8.10	7.98	8.8
Litters/sow/yr	1.76	1.78	1.77	2.1
Death loss	15.02	14.95	16.10	10
Diet cost/cwt	5.22	5.38	5.80	6.01

third (Table 1). This is attributed primarily to production and management efficiencies, as average number of hogs sold did not vary greatly between the two groups. It includes breeding and farrowing performance, feed conversion, disease control and pricing and marketing. High-net-income producers had especially good control of facility utilization (fixed cost) and feed utilization (feed cost).

Comparison of production costs between the average Iowa producer and the "large" operations located primarily in the Atlantic coastal region and the midsouth creates cause for concern (Table 2). The top 20-25 percent of Iowa producers had production costs on par with these large operations (Table 3). Alternatively, 75 percent of Iowa producers had production costs that exceeded those of the competition. The top Iowa producers are very competitive and are industry cost leaders. However, for the Iowa top 20 percent, production efficiency measures such as feed efficiency, pigs weaned per litter, and litters per sow per year were not as good as what the competition was achieving. The one advantage was in the diet (ration) cost. The swine producing areas in Iowa-Minnesota are surplus corn areas. Thus, it has relatively low corn prices a key factor in making it a prime location for pork production. Nevertheless, the industry as a whole has room for improvement.

Remaining Competitive

The Midwest swine industry is in good shape but facing a challenge. A challenge that can be met aggressively with the aim of maintaining or even improving its share of the market. Or, it can be met passively with a reduction in market share the likely result. A major issue is if a passive approach will lead to an outcome similar to what was seen with the cattle feeding industry. Some claim it is within the realm of possibilities.

There appears to be little reason to feel that pork production will shift in mass to larger operations and regions outside the midwest. However, the fact that the large volume competition has been able to offset the regional advantages of Iowa producers indicates that the intrinsic advantage of pork production in the Corn-Belt region can, to some degree, be offset by advanced technology, management expertise, and, to some extent, size of operation. The competitive advantage which appears to be currently held by the relatively large operations is related in large part to the intensity of management mandated in the operation. It is not the fact that they are ultra large or the specific type of technology they are currently utilizing.

The relatively large operations have internalized many of the information analysis areas. They have streamlined this process and only have swine production to contend with. The typical midwest pork producer has from 2 to 6 or more enterprises. It can be quite difficult to stay current on all enterprises and new production technologies which are continually coming on stream. Dynamic forces are continually interacting causing price etc. shifts. To remain competitive it may be necessary for independent producers to stay abreast of two or three of the enterprises and obtain guidance and information on the other enterprises through organizations offering this service. In effect the producer becomes a specialist in managing some of the enterprises and relies upon someone else (consulting etc.) for the intensive management information for the other enterprises. The producer remains in control but develops working relationships for infusing intensive management into their operation. This holds the possibility of capturing some of the advantages of both diversification and specialization.

To become or remain competitive it is necessary to have records to document where we are. Producers need to know production levels and establish goals to achieve levels similar to what top producers are now achieving. This includes many factors of production including reproduction, feed usage, labor and facility utilization.

Competitiveness in pricing and marketing will be another need for survival and profit in the years ahead. The relatively large operations appear to be able to extract volume discounts for products they buy and volume premiums for hogs they sell. The small independent producers may have to change the way they typically buy and sell to achieve some of the same advantages. Through membership in a marketing organization they can possibly pool hogs and sell on a volume basis also. Input purchase discounts can also come from volume buying. An approach such as group buying may provide some of these advantages.

Producers will need to produce a more uniform product of high quality. They will need to stay abreast of consumer preferences and produce a product that will satisfy those needs. To do so will require effective production and marketing skills and information. Effective marketing starts at the production level. Someone effective at marketing has available what will sell for the greatest profit. That first requires a product that consumers want and then developing the marketing strategies to sell the product. This will likely require volume marketing to command price premiums something that can be gained through marketing organizations.

Pressures for contract production of hogs are likely to continue, as packers and retailers look for uniformity in weight and quality and as packers seek ways to more nearly assure adequate supplies for their processing capacity. The profitability of hogs and financial conditions in midwest agriculture may have considerable influence on future growth of contract production. Contracting, however, is not likely to be a necessary condition for remaining in the hog business. Moderate sized hog operations that are well managed should be competitive and in position to provide the consistently high quality hogs that the market will demand.

Summary

Smaller operations in the Midwest can be competitive and survive. The key to success is first and foremost good and effective management. However, to be competitive it is necessary to be a cost leader. The swine production industry is characterized by a large number of producers who produce a similar product - namely market hogs. Opportunities for product diversification are limited. Thus, the method of leadership which rapidly surfaces is that of cost leadership. The highly intensified and specialized operations appear to be cost leaders presently. While diversity in the business can create management problems it can provide positive survival features as well. A smaller proportion of the costs may be out-of-pocket and this may have some potential for other farm enterprises to moderate the impact on the total business of temporary periods of poor returns.

For survival, the midwest swine industry in general needs to become more cost competitive. If the level of cost competitiveness doesn't increase, the potential exists for dramatic shifts in where pork production occurs. The way to build a strong pork industry is through cost leadership. That requires intensive management and efficient production. Moreover, it will be difficult to build a strong industry through selectivity in production techniques allowed or disallowed unless all competitors are under the same regulations. The ultra large operations do not appear to have many advantages that are strictly due to their immensity. The typical midwest swine producer can compete very effectively. However, it will take top notch management to do so.

The list below points out some of the necessary ingredients to remain competitive in the swine industry. This list no doubt can be long and interrelated. None-the-less, it would include the following:

- Improving record keeping so producers know what is happening in the pork production unit.

- Improving production efficiency measures:
  - reproductive
  - feed
  - facility use
  - labor.

- Getting the bottom 75 percent of the producers more near what the top 25 percent are accomplishing.

- Maintaining competitive packing/processing industries.

- Produce lean pork with incentives for lean pork production.

- Increased variety of high quality convenience products which are retail and consumer ready.

- Improved product quality - lean and wholesome.

- Develop appropriate research and extension programs.

- Develop needed institutions and organizations.

- Need to be production cost leader - bottom line.