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EC90-219 1990 Nebraska Swine Report

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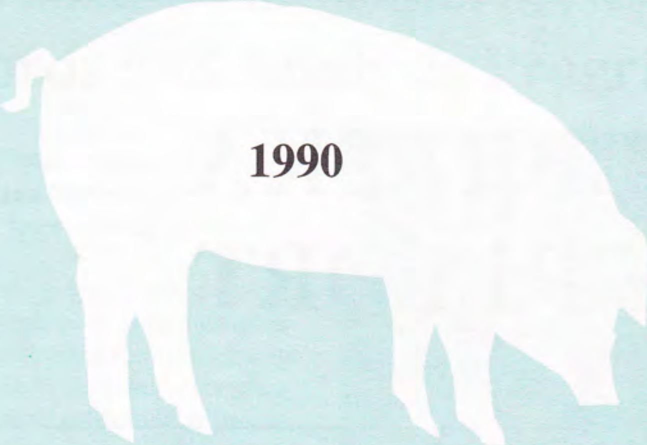

NEBRASKA SWINE REPORT

- Breeding
- Disease Control
- Nutrition
- Economics
- Housing

Prepared by the staff in Animal Science and cooperating Departments
For use in Extension, Teaching, and Research programs

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Institute of Agriculture and Natural Resources

1990 NEBRASKA SWINE REPORT

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The 1990 Nebraska Swine Report was compiled by William T. Ahlschwede, Extension Swine Specialist, Department of Animal Science.

ON THE COVER:

Randy Papenhausen (top) of Coleridge and Norman Wichman (bottom) of Pender are two of the first pork producers to enroll in the **Nebraska Swine Enterprise Record Keeping Program.**

Nebraska Swine Enterprise Records and Analysis Program

by
Mike Brumm
Jan Mohrmann
Larry Bitney[1]

The pork producing industry today is characterized by increased competition from large sized commercial units and agribusiness companies. For many producers, pork production is the last major livestock enterprise that family sized farms can use to increase their net income, diversify their risk and use labor the year around.

The Nebraska Swine Enterprise Records program was started in 1987 to provide a recordkeeping and decision making tool to help producers remain competitive. An advisory group including an ag lender, veterinarian, two producers, extension agents and specialists, helped establish the program to meet the following objectives:

1) To offer a sound recordkeeping program for the average size, farmer-owned and operated enterprise;
2) To build a reliable data base that allows producers to compare their performance to group averages and aid in identifying extension program needs;
3) To have recordkeeping as the primary function of the program rather than focus on trouble shooting and management assistance to individual producers.

On the advice of the advisory board, the program has grown slowly. There were 75 producers enrolled in northeast Nebraska in 1988. In 1989, the number grew to 185 in the northeast and southeast areas of the state. In 1990, the program will be available to all producers in the northeast, southeast and south central regions of the state, with startup programs conducted in the west central and Panhandle regions. In 1991, the program will be available to all Nebraska pork producers, regardless of size or location.

The Swine Enterprise Records Program is primarily a do-it-yourself program. Producers record information in a hand-kept record book. The program is designed to help producers collect the information necessary to determine their cost of production, as well as their level of efficiency for selected parameters.

The current program cost is $60 per hog enterprise per year. For this fee, new enrollees receive two training sessions on data collection, assignment of shared expenses, determination of fixed expenses and two individual 6-month summaries.

The individual producer data is summarized semi-annually in the local extension programming unit, with summary files forwarded to state specialists for inclusion in the state summary. Producers then compare their individual summary with the state summary in area wide wrap-up meetings, usually held in early September and March.

Producer records are divided into four categories based on the proportion of pigs farrowed that were sold as market hogs or feeder pigs. The farrow to finish category includes those producers who sold 75 percent or more market hogs from the pigs they farrowed. The feeder pig producing group marketed 75 percent or more of the pigs farrowed as feeder pigs while the combination group includes those who farrowed pigs and marketed 26-74 percent as butchers. The fourth category is feeder pig finishers who do not farrow.

Category averages from the state summary for the first six months (January thru June) of 1989 are given in Tables 1 through 4. Each summary shows the number of farms that were included and the average results of all farms summarized. Each summary also has a column which is the average of producers that ranked in the high 1/3 for profit and the low 1/3 for profit.

For producers who enrolled in the program and kept accurate cost of production records for the first time, a major eye opener was comparison with the state average. For the first time, many of these producers are comparing their cost of production with the average of their peers where all costs are accounted for in a similar manner. When asked for their opinion about the program, first time participants most often volunteered that their biggest surprise was discovering that their enterprise was not average or that they were surprised how far from average their enterprise was for some parameters.

As a result of the information gained from this program, many producers have indicated a change in their management and decision making process. The program has forced them to consider pork production as a profit center in their farming operation. With this change in attitude, many of these producers will be able to compete as pork production edges towards the 21st century.

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[1]Mike Brumm is Extension Swine Specialist, Northeast Research & Extension Center, Jan Mohrmann is Extension Program Coordinator; and Larry Bitney is Extension Economist, both at the department of Agricultural Economics.

Table 1. Selected Items For Farrow-Finish Enterprises.

Item	*Average*	*High Profit*	*Low Profit*
No. of Farrows	47	16	16
Total feed expense/cwt pork produced	$27.84	$ 25.33	$ 30.78
Feed/lb pork produced, lb	3.70	3.52	3.93
Average cost of diets/cwt[a]	$ 7.54	$ 7.21	$ 7.88
Total variable cost/cwt pork produced	$39.06	$ 34.37	$ 44.50
Total cost[b]/cwt pork produced	$43.17	$ 38.12	$ 49.23
Profit[b]/cwt pork produced	$ .52	$ 6.47	$ -6.40
Profit[b]/female[c]/6 months	$21.55	$127.41	$-87.47

[a]Corn = $2.49/bu, Milo = $4.09/cwt;
[b]Economic life depreciation basis;
[c]Includes replacement gilts.

Table 2. Selected Items For Farrow-Feeder Pig Enterprises.

Item	*Average*	*High Profit*	*Low Profit*
No. of Farrows	19	6	6
Total feed expense/cwt pork produced	$33.21	$ 33.06	$ 36.38
Feed/lb pork produced, lb	3.67	3.60	3.71
Average cost of diets/cwt[a]	$ 9.19	$ 9.35	$ 9.92
Total variable cost/cwt pork produced	$52.11	$ 48.59	$ 57.56
Total cost[b]/cwt pork produced	$60.73	$ 56.94	$ 65.62
Profit[b]/cwt pork produced	$ 5.21	$ 17.07	$ -8.85
Profit[b]/female[c]/6 months	$33.20	$100.05	$-51.25
Average weight of feeder pig sold, lb	48.1	47.2	47.2

[a]Corn = $2.49/bu, Milo = $4.09/cwt;
[b]Economic life depreciation basis;
[c]Includes replacement gilts.

Table 3. Selected Items For Combination Enterprises.

Item	*Average*
No. of Farrows	9
Total feed expense/cwt pork produced	$28.03
Feed/lb pork produced, lb	3.67
Average cost of diets/cwt[a]	$ 7.61
Total variable cost/cwt pork produced	$42.85
Total cost[b]/cwt pork produced	$46.55
Profit[b]/cwt pork produced	$ 1.74

[a]Corn = $2.49/bu, Milo = $4.09/cwt;
[b]Economic life basis.

Table 4. Selected Items For Feeder Pig Finishing Enterprises.

Item	*Average*	*High Profit*	*Low Profit*
No. of Farrows	12	4	4
Average wt/hd of feeder pig purchased, lb	$49.1	$47.0	$ 48.5
Average price paid/hd purchased	$40.82	$40.80	$ 42.31
Total feed expense/cwt pork produced	$26.07	$23.41	$ 28.53
Feed/lb pork produced, lb	3.44	3.12	3.76
Average cost of diets/cwt[a]	$ 7.64	$ 7.57	$ 7.64
Total variable cost/cwt pork produced	$31.62	$28.21	$ 34.88
Total cost[b]/cwt pork produced	$34.98	$30.11	$ 39.58
Profit[b]/cwt pork produced	$ -1.13	$ 4.71	$ -7.84
Profit[b]/head sold	$ -2.44	$ 8.64	$-15.63

[a]Corn = $2.49/bu, Milo = $4.09/cwt;
[b]Economic life basis

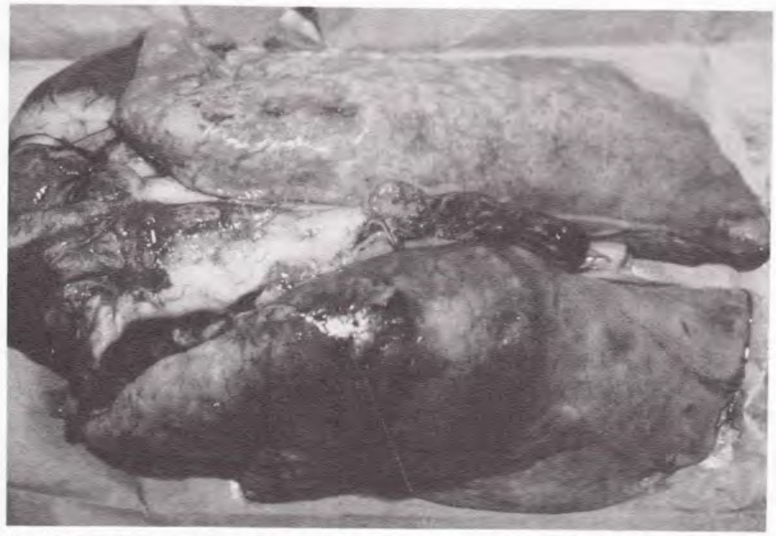
Actinobacillus (Haemophilus) pleuorpneumoniae: Future Vaccines

By
Paula J. Fedorka-Cray
Pushpa Srikumaran
Sally A. Breisch
Steven J. Weiss
Gary A. Anderson[1]

Actinobacillus (Haemophilus) pleuropneumoniae (APP) causes porcine pleuropneumonia, a disease which results in severe respiratory distress and an often fatal pneumonia in pigs of all ages. At least ten serotypes have been identified worldwide with serotypes 1, 5, and 7 commonly found in the United States. The disease appears to be increasing because of intensified production practices with the relative incidence of disease up to 24 percent. Estimated annual financial loss is reported in excess of $200 million dollars. From March to September this year, 1 percent of the isolates from submitted lung tissue were confirmed APP by the diagnostic center in the Department of Veterinary Science.

Current vaccines for controlling APP in confinement herds consist of chemically inactivated whole-cell bacterins. These bacterins contain a combination of APP serotypes and confer only partial protection from the disease. They may illicit an immune response to antigens that are exposed on the surface of the bacteria, but not necessarily to certain "virulence factors" which cause disease. Interestingly, it has been reported that survival from natural infection with any one serotype protects pigs from reinfection with any other serotype. This suggests that commercial bacterins, while containing the appropriate serotypes found in the United States in whole-cell form, lack an adequate level of other specific antigens or virulence factors that are important in the development of the disease.

Some of these virulence factors have been indentified and studied. These include outer membrane proteins, endotoxin, capsular polysaccharide, and exotoxins including permeability factor, cytotoxin and hemolysin. Endotoxin, outer membrane proteins, and capsular polysaccharide have been used in vaccine trials with protection equal to, but no better than, the vaccines that are currently available.



Typical *A. pleuropneumoniae* lung lesion 7 days post-challenge with serotype 1. Left cavdal and middle lobes affected.

Our focus has been to determine the role of secreted exotoxins in the development of disease. From work conducted in our laboratory and other published reports, we know that APP secretes hemolysin and cytotoxin into culture media. It has been shown that hemolysin is toxic to certain white blood cells which are important in clearing bacteria from the body. When these white blood cells are damaged, they may release factors that cause vascular damage, irritation, and fibrin deposition. In this damaged environment void of a clearing mechanism, rapid growth of the bacteria is almost assured. From these reports, we presume that these toxins play a significant role in the development of the characteristic pneumonia observed following infection with APP.

Our purpose in these studies was two-fold. First, to determine the degree of cross-protection following a simulated natural infection between APP serotypes 1 and 7; and second, to determine the efficacy of secreted factors with and without the presence of chemically inactivated whole-cells as compared to control groups in vaccine trials.

Procedure

In the cross-protection study, 9 pigs were given a sublethal dose of APP serotype 7 by spraying the bacteria into the nasal cavity. Pigs were monitored daily for signs of clinical disease and blood was collected weekly. Clinical signs that were monitored included respiration rate, depression, temperature, and feed consumption. The serum was frozen for evaluation of the immune respone using an enzyme-linked immunosorbent assay (ELISA) to whole-cells that was developed in our laboratory. This ELISA assay allows us to monitor the animal's immune response to the whole bacteria as the animal's immune system responds to the presence of the bacteria.

Seven weeks after challenge with serotype 7, all 9 pigs were rechallenged with a LD_{50} dose (a dose of bacteria to achieve 50 percent mortality in a control group) of APP serotype 1. Clinical signs were monitored and serum collected weekly as described above. All surviving pigs were necropsied 12 weeks after challenge with serotype 7 (five weeks after rechallenge with serotype 1).

Vaccine trials were conducted in which concentrated secreted factors from APP serotype 1 were given as a vaccine or in combination with chemically inactivated whole-cells. These chemically inactivated whole-cell preparations consisted of a combination of serotypes 1, 5, and 7 in equal amounts. Two trials were run separately, each with their own control groups. The control groups were given phosphate buffered saline (PBS) in place of the secreted factors. In both trials adjuvant was incorporated into the secreted factor, secreted factor plus whole-cells, and PBS. Pigs were vaccinated on days 0 and 21 by intramuscular injection and challenged by spraying the bacteria into the nasal cavity on day 35 a LD_{50} dose of serotype 1. Pigs were necropsied as they died, and all surviving pigs were necropsied on day 42 or 50. Blood was drawn on days 0, 21, 35, and at necropsy for evaluation in the ELISA assay. Clinical signs were monitored for 48 hours after vaccination and daily after challenge until day 42 or 50. Disease was determined by subjectively assigning a percent value for the amount of disease that was present on each of the seven lung lobes observed at necropsy. Percent lung lesion scores are cummulative totals of assessed percent disease for each of the seven lung lobes.

Results

Following vaccination on days 0 and 21, pigs vaccinated with secreted factors, or secreted factors plus whole-cells, experienced mild depression and a 1°F increase in temperature as compared to the control groups. Pigs were clinically normal 24 hours after vaccination for both day 0 and 21. All pigs (100%) survived the initial challenge with serotype 7 and eight pigs (89%) survived rechallenge with serotype 1. Pigs exhibited increased respiration rates, moderate depression, elevated temperatures (1 to 3°F) and were off feed for 48 to 96 hours following challenge with serotype 7. These clinical signs were less severe following rechallenge with serotype 1. However, one pig died 72 hours after rechallenge with serotype 1 and had 50% total lung lesions. The eight surviving pigs were clinically normal 5 days after rechallenge. At necropsy twelve weeks from the initial challenge, seven of eight pigs had adhesions in the thoracic cavity. These were classical APP adhesions. Table 1 shows the ELISA titers to pooled pig sera after challenge with serotype 1 and 7 including cross-reaction titers. At 7 weeks after challenge with serotype 7 (day 49), titers to homologous serotype 7 were greater than or equal to 1024 and less than or equal to 32 for the heterologous serotype 1. Five weeks after challenge to serotype 1 (day 84), titers were 1024 to homologous serotype 1 and 1024 for the heterologous serotype 7.

Table 2 shows the number of vaccinated vs unvaccinated control pigs surviving infection after challenge with APP serotype 1. No deaths were observed in the group vaccinated with secreted factors alone (100% survival rate) and one pig died in the group vaccinated with both secreted factors and whole-cells (94% survival rate). Three of five (60%) and seven of eight (88%) pigs died in the respective control groups. Table 3 shows the percent total lung lesion for the pigs vaccinated with secreted factors and the sercreted factors plus whole-cells as compared to their control groups. In both cases there is a significant difference between the vaccinated and control groups. In all cases clinical disease lasted longer and was more severe for the control groups.

Discussion

These data indicate that cross-protection is not complete for serotypes 7 and 1 following a natural infection. They also suggest that while both serotype 1 and 7 secrete virulence factors, these factors alone may be only partially protective. Furthermore, we can speculate, based on the data obtained from the ELISA results, that virulence factors other than whole-cell and secreted factors are important in disease; that there may be significant differences in the structure or function of secreted factors; or that the level of factors secreted during serotype 7 infection is inadequate to protect from reinfection with serotype 1. However, data from the vaccine trials indicated that secreted factors from serotype 1 provide significant protection from disease as compared to the control groups. These figures for the vaccinated groups are also significantly different when compared to those reported for current commercial bacterins which have an average of 47% lung lesions and mortality of greater than or equal to 40%. Therefore, these data indicate that a vaccine containing secreted factors outperforms the bacterins that are currently available.

In conclusion, the next generation of bacterins will need to incorporate secreted factors to improve their efficacy.

Table 1. Serum ELISA titers

		ELISA Whole-cell Antigen	
Day[a]	*Challenge Serotype*	*Serotype 1*	*Serotype 7*
49	7	32[b]	>1024[c]
84	7,1	1024[d]	1024[e]

[a]days from the initial challenge with serotype 7

[b]heterologous serotype

[c]homologous serotype

[d]titer represents sera 5 weeks post-challenge with serotype 1

[e]titer represents sera 12 weeks post-challenge with serotype 7

Table 2. Number of survivors in vaccinated and control groups post-challenge with serotype 1

Group	*Number of Survivors*
Secreted factor	5/5
Control	2/5
Secreted factor + whole-cells	16/17
Control	1/8

Table 3. Percent Lung Lesions

Group	*% Lung Lesions*
Secreted factors	10
Control	42
Secreted factors + whole-cells	21
Control	55

From these data we may also infer that not all of the factors responsible for the pathogenesis of the disease have been identified. It will be necessary to test secreted factors from serotypes 1, 5 and 7 in homologous and heterologous vaccine trials, determine the appropriate concentration required for maximum protection, and finally assure that the entire procedure is cost effective for manufacturing and marketing. Until this additional work is completed, bacterins will continue to be only partially protective, although better than most current bacterins.

[1]Paula J. Fedorka-Cray is Assistant Instructor, Pushpa Srikumaran is Research Technician III, Sally A. Breisch is graduate student, Steven J. Weiss is student employee, and Gary A. Anderson is an adjunct Associate Professor (currently employed by CEVA Laboratories, Lenexa, KS) in the Department of Veterinary Science.

Examining Boars for Breeding Soundness

by
Don Levis[1]

Sub-fertile boars frequently cause a reduction in farrowing rate and litter size born alive. It has been estimated that about 20 percent of all boars are deficient in some aspect of reproductive capacity. The level of reproductive function in boars depends upon their ability to produce high quality semen for fertilizing ova, to pursue and mount females and to perform a successful copulation (mating).

To help eliminate reproductive losses due to boar infertility, replacement boars should be purchased and isolated a minimum of 60 days before being used. During the 60-day isolation period the boars should be examined for breeding soundness. The 60-day period allows time for boars to adjust to their new environment, and to recover from any sickness. The isolation period also allows time to replace boars because of an unsatisfactory breeding soundness examination. A breeding soundness evaluation should include a physical soundness and health examination, a sexual behavior evaluation, an examination of the reproductive tract, and a semen evaluation.

Physical Examination

A physical soundness and health examination should include visual observation of body condition, structural soundness of feet and legs, presence of external parasites, and signs of sickness and disease.

Body Condition. Strong boars in good condition are preferred. Thin boars will not have the stamina, especially when pen mating, to breed the required number of sows during a breeding period. Fat boars tend to lack vigor and will not be satisfactory breeders.

Feet and Legs. Unsound boars should not be purchased. If boars are purchased on order, examine for soundness before accepting the boars. Mating tests provide the functional test for soundness of feet and legs. Boars which successfully pursue estrous females, mount and copulate are judged to be sound.

Sickness and Disease. Replacement boars need to be carefully observed for sickness and disease during the 60-day isolation period. Any sickness or disease that causes a rise in body temperature may cause a reduction in fertility. A procedure for introducing replacement boars to the breeding herd is given in *Swine Reproductive Management*, EC 89-212.

Sexual Behavior Evaluation

Libido, or sexual desire, can be adversely affected by psychological and physiological events. To get an indication of a replacement boar's level of sexual behavior, expose the boar after 7 months of age to one estrous female of about the same size as the boar. Small sows being bred for their second litter are preferred because they express standing estrus (rigid immobilization) longer than gilts. Sexual behavior evaluations should last 15 minutes and be at least 24 hours apart. One evaluation is adequate if the boar mates satisfactorily. However, if a boar has not mated satisfactorily by the fourth evaluation, he should be replaced. During evaluation closely observe the boar's desire to pursue a female and his ability to mount and copulate. Be very conservative on diagnosis, because it is better to re-examine a questionable boar than to pass a subfertile animal as a satisfactory breeder.

Reproductive Tract Examination

During the sexual behavior evaluation the reproductive tract should be visually observed for abnormalities or defects in penis, prepuce, testes and epididymides.

Penis and Prepuce. When examining the penis look for a tied penis (nonextension of penis), limp penis (unable to achieve or maintain an adequate erection), and bite wounds. Irritation and abscesses on the penis may also be observed. A preputial prolapse is fairly uncommon, but when it occurs the boar should be culled. Another problem sometimes observed in boars is a tendency to insert the penis into the preputial diverticular pouch. Boars with large, loose prepuces have an increased tendency for this problem. This bad habit may cause ulceration and inflammation of the diverticular lining and accompanying soreness. Irritation and infection of the prepuce will cause hesitancy to breed.

Testes, Epididymides and Scrotum. The testes and epididymides should be palpated through the scrotum for firmness and resiliency (recover in size after compression). The testes and epididymides should be similar in size and free of any soft or firm modules or masses that indicate pathologic problems. Traumatic injuries of the scrotum (such as frostbite), testes or epididymal region may cause temporary or permanent fertility problems. How long fertility is impaired depends on the extent of the injury, the level of degeneration of injured structure or whether adhesions develop.

Testes size is related to a boar's sperm production capability. Although standards to adjust for breed and age differences have not been developed, visual appraisal of boar testes size should be considered.

Semen Evaluation

Semen collection by the gloved-hand method is the next step of the breeding soundness examination. A laboratory evaluation of semen does not provide a means of determining absolute fertility. It only provides an estimate of sperm number (concentration), motility, morphology, and semen volume. Boars less than 10 months of age should not be culled based on marginal semen characteristics. Sperm concentration continues to increase until the boars are two years old. Since semen traits change from day to day, information on two or more ejaculates is needed before a culling decision can be made. Semen volume varies with breed, age and ejaculation frequency. Table 1 shows semen characteristics of young boars (7 to 10 months of age) when ejaculating every 72 hours. A detailed procedure for collecting and evaluating boar semen can be found in the University of Nebraska publication EC 89-264, "Artificial Insemination of Swine".

Table 1. Semen characteristics of young boars (7 to 10 months of age) ejaculating every 72 hours.

Characteristic	*Range*
Gel-free volume (ml.)	190 to 240
Sperm concentration (million/ml.)	151 to 241
Total sperm/ejac (billion)	20 to 40
Motile sperm (%)	70 to 80
Morphologically normal sperm (%)	70 to 80

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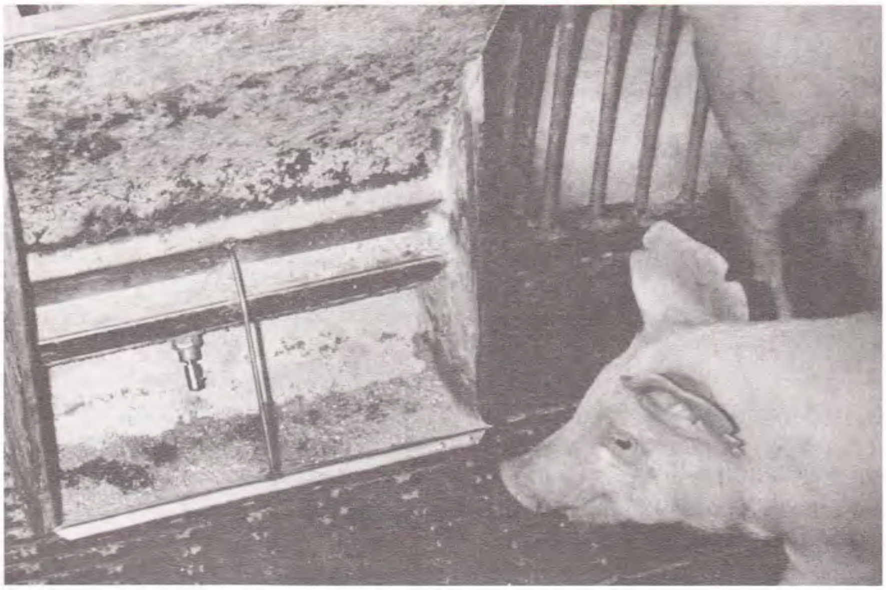
Wet/Dry vs.Dry Feeders forWeanling Pigs

by
Duane Reese
Luis Gama
Clyde Naber
Terry Radke[1]



Some equipment manufacturers have recently introduced "wet/dry" feeders from which pigs can consume either dry or wet feed or both. Proponents suggest that wet/dry feeders improve pig performance compared to conventional feeding systems where feed and water are offered in separate areas of the pen. This study was designed to compare the performance of weanling pigs using a wet/dry feeder to those on a conventional dry feeding system.

Procedures

A total of 120 crossbred pigs were used in two trials averaging 38 days in duration. Pigs were weaned when they were 16 to 33 days of age and randomly assigned to two feeder types according to weight, sex and litter.

In each trial pigs were placed in totally slotted pens containing either a Crystal Spring[a] (wet/dry) or Smidley 304[b] (dry) single-sided, stainless steel feeder. Each wet/dry feeder was 16" wide with two feeding spaces and one nipple waterer in the trough. A water pressure regulator was installed in the water line supplying each wet/dry feeder. The regulator was set to supply 7 to 8 psi of water pressure to the nipple waterers in the feeders. The dry feeders were 22" wide with four feeding spaces. All feeders were opened about 1/2". A standard nipple waterer, supplied by a separate water line, was provided in each pen.

A 1.2% lysine, corn-soybean meal-dried whey diet in crumble form was offered to the weaned pigs until they averaged 25 lb. A 1.0% lysine, corn-soybean meal diet in meal form was provided until the study was terminated. Feed was available free- choice during the duration of both trials except to those using the wet/dry feeders in trial 2. During the first 6 days of trial 2 pigs using the wet/dry feeders were limit-fed to encourage consumption of wet feed that may accumulate in the bottom of the feeders. Pig weights and feed disappearance data were recorded weekly. Feed waste from the feeders was not determined.

Results

The combined results from both trials are presented in Table 1. No significant differences in daily gain, daily feed and feed/gain were observed between pigs using the wet/dry and the dry feeders during any period of the study. The trend toward increased feed disappearance and poorer feed/gain by pigs using the wet/dry feeders during the initial 21 days was possibly due to feed spoilage in the bottom of those feeders. During the initial six days of trial 1 wet feed accumulated in the bottom of two of the three wet/dry feeders and appeared to spoil. This feed was removed from the feeders and discarded. Thereafter, spoiled feed did not appear to accumulate in the bottom of the wet/dry feeders. In the second trial wet feed accumulation in the bottom of the wet/dry feeders was reduced apparently as a result of limit feeding during the first 6 days following weaning.

Table 1. Comparisons of Two Feeder Types for Weanling Pigs[a]

	Feeder	
	Wet/Dry	*Dry*
Day 0 to 21		
Daily gain, lb	.61	.59
Daily feed, lb	.93	.81
Feed /gain, lb	1.53	1.39
Day 22 to 38		
Daily gain, lb	1.29	1.33
Daily feed, lb	2.48	2.46
Feed /gain, lb	1.92	1.85
Day 0 to 38		
Daily gain, lb	.91	.91
Daily feed, lb	1.63	1.57
Feed /gain, lb	1.80	1.72

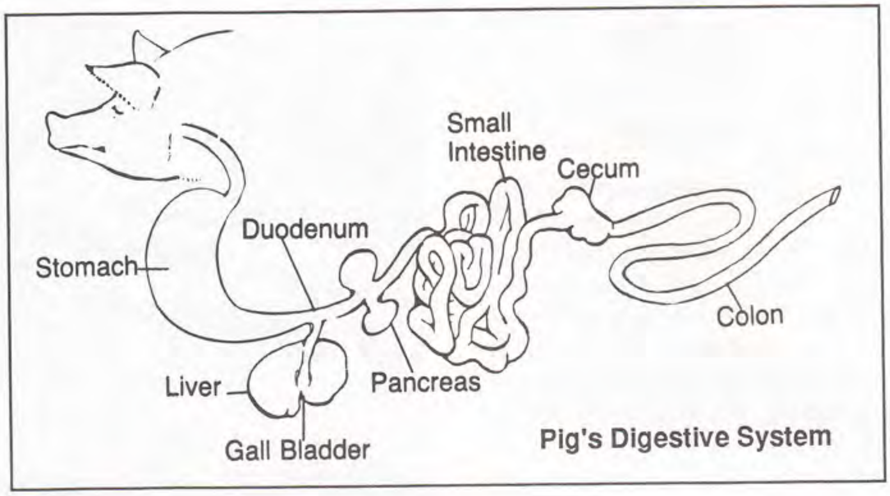
[a]Combined results from two trials; 13.2 to 47.7 lb beginning and final pig weights; 6 pens of 10 pigs/pen/feeder type.

Under the conditions in this study, a wet/dry feeder where weanling pigs had the opportunity to consume either dry or wet feed or both offered no advantage over a conventional feeding system where feed and water were offered in separate areas of the pen.

[a]Gro Master, Inc., Omaha, NE 68164
[b]Marting Mfg. Inc, Britt, IA 50423
[1]Duane Reese is Extension Swine Specialist, Luis Gama is Graduate Student; Clyde Naber is Research Technologist, Terry Radke former Graduate Student in the Department of Animal Science, respectively.

Casein, Soyprotein and Swine Digestive Disorders

by
Edd Clemens
Alycia Zalesky[1]



Physiologists, nutritionists and pathologists fully agree that the small intestine is the primary digestive organ. Over 80 percent of nutrient digestion and absorption occurs within the stomach and small bowel. Infectious and non-infectious disorders of the stomach and small intestine have been easily recognized, and often have devastating results upon the pig. On the other hand, the large bowel (cecum and colon) plays a much smaller role in nutrient assimilation. Like the stomach and small intestine, major infectious and non-infectious disorders of the large bowel are easily recognized (diarrhea, constipation, flatulence, etc.). However, there are a number of non-infectious mechanical disorders of the large bowel which may escape the watchful eye of the producer.

Reports from this laboratory (Nebraska Swine Report, 1988) suggest that the level of dietary protein markedly alters the mucosal layer of the pig's large intestine. These structural alterations are associated with significant changes in the ability of the colon to absorb and secrete fluids and electrolytes. In addition, we have learned that the large intestine may become a "protein sink", which stores protein during periods of abundance and releasing this protein during dietary shortfall. Comparative studies in dogs have also shown that the large intestine undergoes periods of nutritional adaptation, and requires seven to ten days to convert from one nutritionally adapted structure to the next. More recently it has become evident that the large intestine also responds to the source of protein.

This study was conducted to determine the effects of protein source on the colon. Two groups of pigs (65-95 lb) were fed one of two nutritionally balanced diets (16% protein) differing only in the source of dietary protein (casein versus soybean meal). Colonic fluids and tissue samples were collected from both the proximal (descending) and distal (ascending) portions of the colon. Comparisons were made between dietary protein sources and between the two segments of colon.

From this study we observed that the large bowel of these animals exhibits structural modifications due to source of protein (Table 1). We also noticed that a greater proportion of the dietary proteins were deposited in the large bowel when pigs were fed the casein diet. This was also reflected in the enhanced colonic surface area and slight increase in tissue activity.

Not only does the structure of these tissues change when the animal is fed various sources of protein, but also the ability of these tissues to absorb and secrete nutrients is markedly altered. Preliminary studies suggest that colonic absorption of sodium and organic acids is markedly altered and that chloride secretion is less in the casein fed pigs than those fed soybean meal (-0.13 vs -1.42 mmol/hr, respectively). Such absorption and secretion mechanics are critical in maintaining both the buffering capacity and the fluid movement of colonic contents. Comparison of soybean meal and casein fed pigs indicated differences in the bicarbonate (HCO3) and carbon dioxide (CO2) concentrations and acidity (pH) of colonic fluids (Table 2).

Our earlier studies (Nebraska Swine Report, 1988) clearly show that the level of dietary protein influenced both the structural and functional characteristics of the pigs large bowel. That data also indicated that the distal colon segment (ascending colon) exhibited a greater response to protein deprivation.

Table 1. Percent colonic protein deposition, surface area to volume ratio, and tissue energetics (0_2 consumption) for pigs fed soybean meal and casein and for the proximal and distal segments of colon.

	Source of Dietary Protein		Segment of Colon	
	Soybean Meal	Casein	Proximal	Distal
Colonic Protein Content (%)	12.5	13.9	13.3	13.2
Tissue Energetics (um 0_2/gm/min)	0.654	0.685	0.712	0.629
Surface Area to Volume Ratio	4.76	6.43		

Table 2. **Net composition of colonic effluent as observed in pigs fed soybean meal and casein and for the proximal and distal segment of colon.**

	Source of Dietary Protein		*Segment of Colon*	
	Soybean meal	*Casein*	*Proximal*	*Distal*
Colonic pH	7.79	7.85	7.82	7.81
Osmolality	224	228	224	226
Carbon dioxide	19.7	17.1	17.7	18.9
Bicarbonate	27.1	25.9	26.9	26.9
Base Excess	13.6	14.8	14.6	14.0

The present data suggest that the source of dietary protein (soybean meal and casein) do not selectively influence the proximal or distal colon of pigs.

Clearly, protein source has a marked effect both on gut structure and function. These data suggest that a seemingly modest change in diet, such as substituting soybean meal for casein, would necessitate a period of readjustment in the pigs' colon. Previous studies indicate this readjustment period may be seven to ten days, during which time less than optimal feed utilization may be realized. These results reinforce the need for consistency in diet composition in order to achieve optimal performance. Unavoidable diet changes should be made gradually in an attempt to minimize digestive disorders. In less dramatic nutritional alterations, such as converting from one protein source to another, gradual diet transitions are generally not a practical management practice. Recommendations are to simply be aware that the source, and transition, of dietary protein can markedly alter the pigs digestive functions.

[1]Edd Clemens is Professor and Alyce Zalesky is Research Technologist both in the department of Animal Science.

Nipple Waterers — Which Is Best?

by
Dennis D. Schulte
Gerald R. Bodman
Marcus Milanuk[1]

Water is essential for animal growth and feed efficiency. The popular press attests to producer concerns about the availability of water for pigs. Although many studies address water consumption of pigs under various conditions, little is reported on the mechanics of various watering devices. Ideally, nipple waterer designhn should be such that water pressure does not affect the water capacity of the nipple nor the force required to operate the valve. The objective of the work reported here was to quantify the effect of pressure on flow rate from nipple waterers used for nursery-aged pigs in the U.S.

Materials and Methods

Three nipple waterers of each of eleven brands were obtained from the shelves of local suppliers. Each was stated to be for nursery-age pigs. All were 1/2-inch diameter waterers. The nipple waterers fell into one of three categories: a single orifice (Godro, Mark, Stingy), a choice of three orifices (BHD, BPN, GL2000, Lixit, Monoflo, Trojan) or an adjustable orifice (Edstrom, Omega-EX).

The flowrate from each waterer was measured at pressures ranging from 10 to 80 psi. Those devices with adjustable or interchangeable orifices were tested for a minimum of three flowrates at each pressure. Flowrate was determined by weighing the water collected for a period of time. All flows were measured with the valve of the waterer clamped in the full open position. Pressure was measured upstream from the waterer. Pressure was controlled by manually adjusting a gate valve upstream from the waterer. Water was filtered in-line to prevent clogging of the waterers. Water weights and pressures were electronically determined and recorded with microcomputer based equipment.

Results

Ideally, a uniform flow rate results at varying pressures from a well-designed nipple waterer so that various farm water systems may be accommodated. As shown in Figure 1, all waterers provided at least 0.03 gpm (1 cup is 0.0625 gallon) and most provided in excess of 0.25 gpm depending on line pressure. The commonly suggested minimum flow rate of 0.06 to 0.12 gpm appears to be exceeded by nearly all the waterers tested at all pressures.

It is evident from Figure 1 that, although pressure substantially affects flow rates, the effect was relatively small for most nipples with small orifices. In general, flow rate varied from a minimum of 0.03 to a maximum of 0.35 gpm for waterers having small orifices. However, for the larger orifice waterers, flowrate ranged from 0.1 to 1.2 gpm depending on the brand and the orifice settings. A pressure regulator may be warranted for such circumstances.

Ideally, flow rate would change little as water pressure increases. A fairly stable flow rate allows pigs to drink comfortably even as water pressure fluctuates. A few brands came close to meeting that criteria (Edstrom had the least fluctuation).

According to orifice theory, flow rate should increase steadily as water pressure rises. But some of the nipples produced unstable or extremely high flows with the largest orifices and high water pressures (BPN, Godro and BND). High rates contribute to water waste and discourage pigs from drinking.

Water pressure on most farms ranges from 30 to 60 psi, but can be as high as

80 psi, particularly on some rural water systems. Twenty psi at the nipple is often suggested for small pigs. Without some help from a pressure regulator, water pressure will vary widely depending on how many other pigs are drinking, pressure loss along the water line, and where the nipple is located within the building. Most producers choose an orifice plate or adjust the orifice openings when they install the nipples, few check them later. Often, product literature is not detailed enough to show which orifice is best suited for a particular range of water pressures to provide optimum flow rate for nursery pigs.

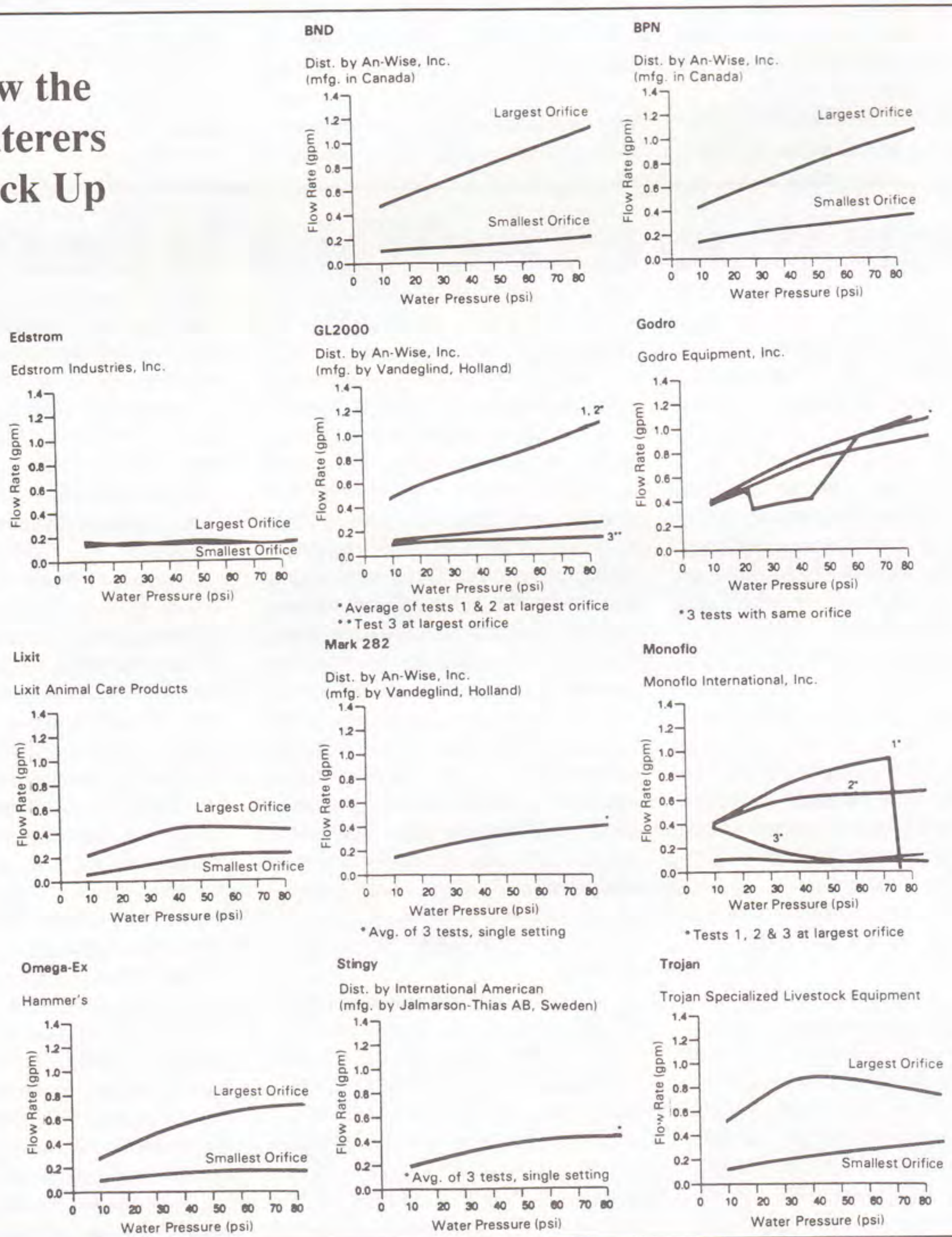
Quality control appeared to be a problem with several of the nipples tested. Flow rates dropped severely in two cases (Monoflow) and was unstable in another (Godro). Thus, lack of pressure may not always cause low water flows.

Conclusions

All of the nipple waterers tested were capable of supplying water at adequate flowrates for nursery pigs. Flow rates varied widely among brands of waterers and with water pressure. The performance of some of the waterers would be enhanced through use of a pressure regulator or flow restrictor.

[1]Dennis Schulte is professor, Gerald R. Bodman is extension agricultural engineer—Livestock Systems and Marcus Milanuk is Energy Integrated Farm System Manager in the Department of Agricultural Engineering at the University of Nebraska-Lincoln.

How the Waterers Stack Up



Cooler Nights for Growing-Finishing Pigs

by
Michael C. Brumm
David P. Shelton[1]

Previous research with weaned pigs has shown that a controlled regimen of reduced night temperatures in nurseries can stimulate feed intake and daily gain with no adverse effect on feed conversion or pig mortality. In research conducted at the Northeast Research and Extension Center with newly arrived feeder pigs, a consistent problem has been the relatively low feed intake for the first weeks post-arrival. Recent efforts have been centered on methods to increase the intake of nutrients by the newly arrived pig. A regimen of reduced nocturnal temperatures was proposed as one method to enhance intake.

To explore this possibility, an experiment was conducted with a total of 488 commingled feeder pigs during the winters of 1987-1988 and 1988-1989. Two identical grower-finisher units at the Northeast Research and Extension Center at Concord were used. Each partially slatted unit consisted of 12 pens (6x16 ft) with comparable ventilation, heating and manure handling systems. Temperature treatments were rotated between the facilities. Pigs were housed 12 per pen from purchase to market. Feed access was provided from a three-hole self feeder with one nipple drinker provided in the dunging area.

Pigs were fed various experimental feeder pig receiving diets during the first three weeks post-arrival. They were then offered a common 16% grower diet until 125 pounds followed by a 14% finisher. All diets contained 50g/T Mecadox until 75 pounds body weight at which time the diets were supplemented with 100g/T chlortetracycline until 125 pounds body weight.

For the first week after arrival, the temperatures in both facilities were maintained at 77°F 5 ft above the pig zone. Beginning one week after arrival, the temperature in the control (CON) facility was lowered 1.8°F per week for eight weeks. In the facility with reduced night temperatures (RNT), the thermostat was set to the same temperature as the control treatment during the day (7 am to 7 pm). Beginning one week after arrival, during night hours (7 pm to 7 am) the thermostat setting was lowered 18°F from the day time setting. Dual thermostats, controlled by a time clock, were used. Temperature reduction was achieved by turning on summer ventilation fans until the desired temperature reduction was achieved. Incoming ventilation air was directed down the wall and over the slatted portion of each pen.

Results

Figure 1 is a plot of the hourly temperatures by week at 5 ft above the floor and outside averaged across both trials. The rate of cool down was rapid for the RNT treatments, with target temperatures generally reached within two hours after cool down began, especially in the first weeks. Near the end of both trials,

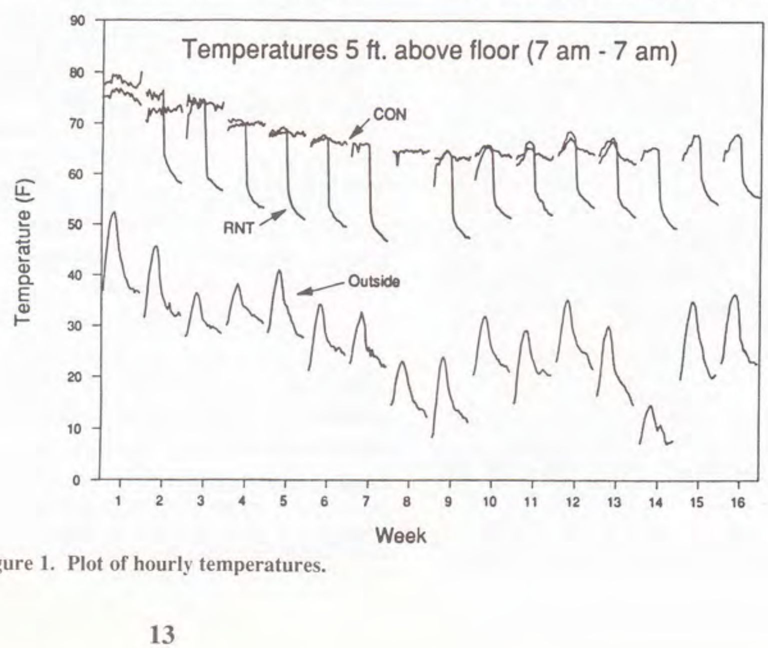


Figure 1. Plot of hourly temperatures.

Table 1. Summary of Pig Performance.

Item	*Control Temp-erature*	*Reduced Nighttime Temp-erature*
No. Pigs	244	244
Pig Weight, lb		
Initial	43.2	43.1
Final	215.5	208.9
ADG, lb	1.49	1.44
ADF, lb	4.91	4.71
F/G	3.29	3.28
Dead and Removed No.	9	10

sufficient heat was generated by the increasingly large pigs that desired cool down was seldom achieved.

Unlike previous results with weaned pigs, the feeder pigs utilized in these trials did not increase their feed intake in response to the RNT treatment (Table 1). In fact, the decrease in feed intake resulted in a decreased rate of gain and lighter final weight with no difference in feed conversion.

It was noted throughout both trials that there was considerably more dust in the RNT facility, indicating a lower relative humidity as a result of the increased ventilation during the nighttime hours.

The depression in feed intake for RNT pigs occurred in both trials and was evident at 56 days. For whatever reason, the RNT pigs decreased their feed intake in response to RNT. However, the RNT regime imposed did not subject the pigs to a temperature for a sufficient time period to cause a worsening in feed conversion.

In this experiment, a RNT regime for feeder pigs imposed one week after purchase and continued for 16 weeks did not stimulate feed intake or daily gain.

Mike Brumm is Extension Swine Specialist, David Shelton is Extension Ag Engineer both at the Northeast Research and Extension Center.

Ethanol Extraction of Soybeans: Another Boost for Nebraska's Ethanol Industry?

by
Joe D. Hancock
Ernest R. Peo, Jr.
Austin J. Lewis[1]

Ethanol production in the U.S. has increased markedly during the past fifteen years, largely due to the need for an economical alternative to petroleum fuels. The use of corn to produce this fuel-grade ethanol is of great interest to commodity groups and farmers in Nebraska and the midwestern United States. As industry works to establish ethanol as a legitimate fuel source, other commercial applications of ethanol should help maintain the viability of this fledgling industry. At the University of Nebraska we have conducted three experiments to investigate the use of ethanol extraction to improve the nutritional value of soybean protein for young pigs.

Procedures

Soybean flakes from which the oil had been extracted, but had not been toasted, were autoclaved (steam heated at 250F) for 5, 20 or 60 minutes to yield heat treatments designated as under-, intermediate- and over-processing. The heat treatments were administered without, before and after extraction with a 55 percent ethanol-water mixture. The extraction process consisted of repeated soakings with clean ethanol-water mixture during a 4-day period. The extracted soybean flakes were dried at room temperature before being ground and added to the basal diet presented in Table 1.

In the first experiment, 45 pigs (average initial weight of 20 lb) were given the dietary treatments for 24 days. Feed and water were supplied ad libitum to the individually-penned pigs. Response criteria were average daily gain, average daily feed intake and feed to gain ratio.

Table 1. Composition of Basal Diets

Ingredient	*Experiments 1 & 2*
Soybean flakes[a]	15.17
Corn	76.60
Corn starch	.90
Salt	.30
Tallow	3.00
Limestone[a]	.80
Dicalcium phosphate[a]	2.08
Vitamins and minerals	1.15

[a]Soybean flakes, limestone,dicalcium phosphate and corn starch were adjusted to bring other diets to 15% crude protein, .8% calcium and .7% phosphorus.

The second experiment was a nitrogen metabolism experiment using the same diets. Fifty-four barrows (average initial weight of 30 lb) were fed the diets for a 3-day adjustment period followed by a 5-day period during which feces and urine were collected. Response criteria were nitrogen digestibility and biological value (the proportion of the nitrogen digested and absorbed, that was retained for tissue growth).

In the third experiment, one pig from each treatment in experiment 1 was killed, and tissue samples were collected from the first section of the small intestine. The tissue samples were evaluated under a microscope for physical changes that might help explain any differences in growth performance and nitrogen metabolism of pigs fed the soybean flake preparations. The physical characteristics measured were villus height (longer villi would indicate increased absorptive surface area) and crypt depth (increased crypt depth would indicate more cell proliferation, generally associated with irritation of the intestinal mucosa).

Table 2. Laboratory Analyses of Soybean Flakes

	Heated Without Extraction			*Heated Before Extraction*			*Heated After Extraction*		
	(Minutes Heat)			*(Minutes Heat)*			*(Minutes Heat)*		
Item	*5*	*20*	*60*	*5*	*20*	*60*	*5*	*20*	*60*
Crude protein, %	50.8	50.9	51.1	65.6	67.1	65.7	66.0	67.2	66.9
Lysine, % of protein	7.1	7.1	5.5	6.9	6.7	5.5	7.1	6.8	6.4
Trypsin inhibitor, mg/g	27.8	4.4	.3	14.5	2.1	.6	11.2	3.1	.4

Table 3. Soybean Flake Treatments Affect Pig Performances

	Heated Without Extraction			*Heated Before Extraction*			*Heated After Extraction*		
	(Minutes Heat)			*(Minutes Heat)*			*(Minutes Heat)*		
Item	*5*	*20*	*60*	*5*	*20*	*60*	*5*	*20*	*60*
Av. daily gain, lb	.14	.70	.39	.41	.70	.44	.50	.83	.75
Avg. daily feed intake, lb	.71	1.41	1.02	.99	1.42	1.13	1.05	1.57	1.57
Feed/gain	5.07	2.01	2.62	2.41	2.03	2.57	2.10	1.89	2.09
Nitrogen digestibility, %	72.6	80.9	80.0	79.6	83.1	80.8	80.7	84.7	82.3
Biological value, %	58.7	60.3	53.6	62.8	64.8	54.8	61.6	65.0	62.0

Table 4. Soybean Flake Treatments Affect Small Intestine Morphology

	Heated Without Extraction			*Heated Before Extraction*			*Heated After Extraction*		
	(Minutes Heat)			*(Minutes Heat)*			*(Minutes Heat)*		
Item	*5*	*20*	*60*	*5*	*20*	*60*	*5*	*20*	*60*
Villus height, *um*	370	493	461	437	474	379	454	539	520
Crypt depth, *um*	445	508	520	540	511	556	528	530	488
Height/depth	.83	.97	.89	.81	.93	.68	.86	1.02	1.07

Results

Laboratory analyses of the soybean flakes are listed in Table 2. Heat treatment of the soybean flakes had little effect on protein content, but extraction with ethanol increased the crude protein content from about 51 percent to 66 percent. Previous research has shown that extraction of soybean flakes with an alcohol-water mixture removes carbohydrates and sugars and increases the protein content. An increase in protein content does not necessarily indicate an improvement in the soybean flakes as a protein source. Because corn-soybean meal diets are first limiting in the amino acid lysine, an increase in lysine as a percentage of protein content would be a better "chemically determined" indicator of increased protein quality. When the soybean flakes were exposed to under- and intermediate-processing, lysine:protein percentage was similar regardless of ethanol extraction. Yet, when the soybean flakes were exposed to over-processing, the lysine:protein percentage was greatest when heat treatment came after extraction with ethanol. This response was expected, because heating proteins in the presence of sugars eventually results in destruction of heat-sensitive amino acids such as lysine. Removing the soybean carbohydrates by extraction with ethanol before the highest level of heat treatment, protected the protein quality (i.e., higher lysine:protein percentage) of the soybean flakes.

Extraction with ethanol reduced the trypsin inhibitor content to about half of that of the under-processed soybean flakes. However, increasing heat treatment had an even greater effect on trypsin inhibitor content, and at the intermediate and over-processing levels of heat treatment, extraction with ethanol did little to reduce trypsin inhibitor content of the soybean flakes.

Growth performance and nitrogen metabolism of pigs fed the soybean flake preparations are presented in Table 3. Average daily gain, average daily feed intake, feed/gain, nitrogen digestibility and biological value were greatest at the intermediate level of heat treatment, and were improved when pigs were fed soybean flakes extracted with ethanol. The beneficial effect of extraction was most pronounced for the under-processed soybean flakes, an effect that corresponds well with the trypsin inhibitor-lowering effect of extraction with ethanol. Over-processing of the soybean flakes reduced performance, especially for pigs fed soybean flakes heated without, or before extraction. When over-heated after extraction, the nutritional value (especially biological value) was reduced less than when over-heated before extraction. This corresponds with the protection of the lysine:protein percentage in soybean flakes that were heated after extraction.

Measurements of villus height, crypt depth, and height:depth ratio are presented in Table 4. Villus height was greater in pigs fed the soybean flakes heated after extraction with ethanol than in pigs fed the soybean flakes that were heated without or before extraction with ethanol. No consistent response was observed for crypt depth. A few reports from Europe and the U.S. have indicated that feeding soybean meal to newly-weaned pigs can result in alterations in the small intestine (i.e., short, blunt villi and increased crypt depth) that result from a mild allergic reaction.

Those alterations are presumably one of the causes of the diarrhea and "post-weaning lag" that commonly begins 7 to 10 days after weaning. The maintenance in villus height, without a corresponding increase in crypt depth, for pigs fed the soybean flakes heated after extraction with ethanol, suggests an improved nutritional status of the villi rather than prevention of a mild allergic reaction in this experiment.

Although further research is needed to define the mechanism by which extraction with ethanol affects the nutritional characteristics of soybean flakes, it does appear that the use of ethanol to improve the nutritional value of soybean proteins can benefit both pork producers and the ethanol industry.

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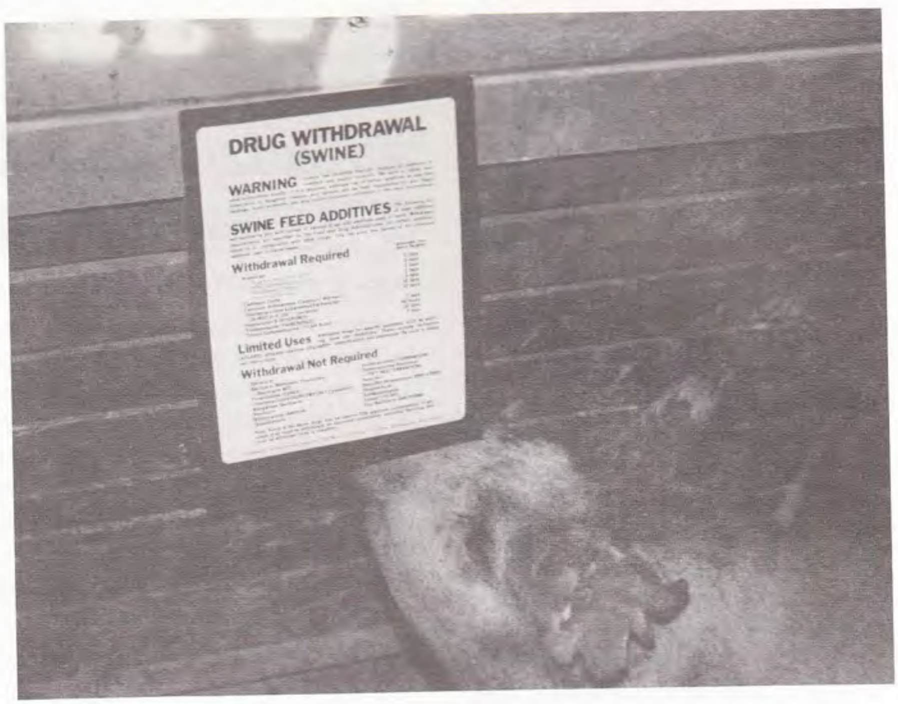
Salinomycin Improves Growth Rate and Feed Efficiency

by
Austin J. Lewis
Mark A. Giesemann[1]



Salinomycin is a new antibiotic that is classified as an ionophore. Other antibiotics in this class include monensin (Rumensin) and lasalocid (Bovatec), which are used to increase feed efficiency in ruminants. Like monensin and lasalocid, salinomycin is also an effective coccidiostat, and has been approved by the Food and Drug Administration (FDA) for the prevention of coccidiosis in broilers. Salinomycin has not been approved by the FDA for use in diets on pigs, but its approval for use in the US is anticipated in the near future. We have conducted an experiment at the University of Nebraska to evaluate the effectiveness of this new antibiotic in improving pig growth under Midwestern US conditions.

Experimental Procedures

Two hundred and fifty weanling pigs were fed nursery diets (20% protein) containing either ASP-250 (chlortetracycline, sulfamethazine and penicillin) or salinomycin (25 g/ton) or without any antibiotics. The initial weight of the pigs was 16 lb and the nursery period lasted 28 days. There were 25 pens with 10 pigs (5 barrows and 5 gilts) in each pen.

At the end of the nursery period the pigs were moved to a modified-open-front (MOF) building for the growing-finishing period. The pigs were penned in the same groups of 10 as they were for the nursery. Ten pens of pigs were fed diets without antibiotics, five pens were fed diets with 50 g/ton of chlortetracycline, and ten pens were fed diets with 25 g/ton of salinomycin. A 16 percent protein corn-soybean meal diet was fed during the growing period (33 to 120 lb). Protein content was reduced to 14 percent during the finishing period (120 to 194 lb). Pigs were allowed *ad libitum* access to feed and water throughout the experiment.

Results

During the nursery period pigs fed diets containing ASP-250 grew 12 percent faster and with a 7 percent better feed efficiency than pigs fed diets with no antibiotics. These improvements are typical of the normal response to antibiotics in the nursery. Salinomycin fed at 25 g/ton was ineffective and did not improve either growth rate or feed efficiency.

Salinomycin was, however, effective during the growing-finishing period. As shown in Table 1, pigs fed salinomycin during the growing period had distinctly better growth and feed efficiency than pigs fed the diets without antibiotics or with chlortetracycline. A

Table 1. Performance of Growing-Finishing Pigs (Nebraska Experiment 88406)

	Treatments		
Item	*No antibiotics*	*Chlortetracycline*	*Salinomycin*
No. of pens	10	5	10
No. pigs/pen	10	10	10
No. pigs[a]	96	48	96
Growing Period:			
Avg. initial weight, lb	32.8	33.3	32.6
Avg. final weight, lb	116.7	116.2	125.4
Avg. daily gain, lb	1.40	1.38	1.55
Feed/gain	2.55	2.56	2.41
Finishing Period:			
Avg. initial weight, lb	116.7	116.2	125.4
Avg. final weight, lb	189.4	190.0	202.2
Avg. daily gain, lb	1.73	1.76	1.83
Feed/gain	3.43	3.42	3.40
Growing and Finishing Periods:			
Avg. daily gain, lb	1.54	1.54	1.66
Feed/gain	2.96	2.96	2.85

[a]A few pigs removed from each treatment for various reasons.

similar pattern was observed during the finishing period, although the response to salinomycin was not quite as large. When data from the growing and finishing periods were combined, salinomycin increased weight gain by 8% and feed efficiency by 4% compared to the other diets.

Chlortetracycline was ineffective in this experiment. In some previous experiments we have obtained a beneficial response from chlortetracycline fed at 50 g/ton (see 1981 Nebraska Swine Report). Chlortetracycline is approved for the promotion of growth and improvement of feed efficiency at levels up to 50 g/ton, and is also approved for enteritis and leptospirosis control at levels up to 200 g/ton.

Awaiting Approval

Salinomycin proved very effective in increasing gain and feed efficiency of finishing pigs in this experiment. However, the FDA has not yet approved this antibiotic as a commercial feed additive for pigs. As with all new animal drugs, salinomycin must be shown to be both safe and effective. The manufacturer hopes to obtain approval during 1990 or 1991.

[1]Austin J. Lewis is Professor and Mark A. Giesemann is Research Technologist, Department of Animal Science.

Low-Inhibitor Soybeans as a Feedstuff for Pigs

by
Austin J. Lewis
Mark A. Giesemann
Joe D. Hancock[1]

Anti-nutritional factors in raw soybeans depress growth of young pigs. As a pig matures it is better able to withstand the negative effects of these factors, but uncooked (raw) soybeans are not an acceptable protein source for nursery-age, growing or finishing pigs. Heating raw soybeans destroys these harmful factors. This is the primary reason soybean meal is toasted after solvent extraction.

Among the anti-nutritional factors of soybeans is a compound known as Kunitz trypsin inhibitor. This inhibitor interferes with the ability of the pig to digest protein. The Kunitz inhibitor generally accounts for about half of the total trypsin inhibitor activity. New strains of soybeans have been developed that do not contain the Kunitz trypsin inhibitor. These soybeans yield similarly to conventional soybeans. Because these new varieties have less growth-inhibiting effect they may require less heating. With that in mind, the University of Nebraska and Kansas State University have conducted cooperative research to determine the nutritional value of these new soybeans. Our objective was to measure the effect of time of roasting on the nutritional value of conventional soybeans and soybeans without the Kunitz inhibitor for nursery-age, growing and finishing pigs.

Soybeans of the Williams 82 variety with (+K) and without (-K) Kunitz trypsin inhibitor were either half or fully roasted. Other samples of the beans were left unroasted (raw). This resulted in six dietary treatments. Different roasting times were accomplished by varying the speed at which the soybeans moved through a Roast-A-Tron roaster.

Soybeans for the experiments at both universities were grown at a single location and processed together. The lysine content and trypsin inhibitor activity of the soybeans is given in Table 1. Researchers at Kansas State University studied the effects of these treatments for nursery-age pigs. Their results indicated that when soybeans were raw or half roasted the soybeans without Kunitz trypsin inhibitor (-K) clearly supported superior performance (Table 2). However, when the soybeans were fully roasted there were no differences in performance among soybean types. Full roasting of the +K and -K soybeans was necessary to achieve optimum performance. A more detailed report of the nursery study may be found in the 1989 Kansas Swine Day Report.

Two separate experiments were conducted at the University of Nebraska; one for growing pigs and one for finishing pigs. Sixty-six crossbred pigs were used in each experiment. The growing pigs (30 gilts and 36 barrows) weighed 49 lb at the beginning of the experiment and 104 lb at the end. The finishing pigs (24 gilts and 42 barrows) averaged 112 lb initially, and 227 lb at termination. Six diets were balanced to contain only 80% of the 1988 NRC requirements for lysine, but to meet requirements for vitamins and minerals (Table 3). This was done so that differences in amino acid utilization would be reflected in growth performance. The contribution of lysine from the soybeans and corn was the same for all six diets. During the course of the experiment, pigs were penned individually and allowed *ad libitum* access to feed and water. At the end of the experiments all pigs were scanned ultrasonically for backfat depth at the last rib. Response criteria were rate of gain, feed conversion and last rib fat thickness.

Feeding -K soybeans resulted in improvement in average daily gain and feed/gain of growing pigs (Table 4). Furthermore growing pigs consuming -K soybeans had lower last rib fat depths. The growth-inhibiting effects of soybeans fed raw or half roasted were much more pronounced for pigs consuming the +K soybeans. Growing pigs consuming raw -K soybeans performed comparably to pigs consuming half-roasted +K soybeans. However -K soybeans required full roasting to support optimal performance of growing pigs.

Finishing pigs fed -K soybeans also gained more efficiently and had lower last rib fat depths than pigs fed +K soybeans (Table 4). Full roasting was required to optimize performance of finishing pigs for both soybean types. However, the finishing pigs fed the half-roasted -K soybeans were as efficient as those consuming fully roasted +K soybeans. Thus, for finishing pigs, only half the roasting time may be necessary with -K soybeans to achieve similar efficiency of growth as fully-roasted conventional soybeans.

Table 1. Effect of Roasting Time of Soybeans With (+K) and Without (-K) Kunitz Trypsin Inhibitor on Lysine Content and Trypsin Inhibitor Activity

	+K Roasting time			*-K Roasting time*		
	None	*Half*	*Full*	*None*	*Half*	*Full*
Lysine, %	2.40	2.40	2.30	2.30	2.30	2.20
Trypsin inhibitor activity, mg/g	24.11	18.50	6.95	13.32	5.29	0.64

Table 2. Performance of Nursery-Age Pigs Fed Soybeans With (+K) and Without (-K) Kunitz Trypsin Inhibitor[a]

	+K Roasting time			*-K Roasting time*		
	None	*Half*	*Full*	*None*	*Half*	*Full*
Average daily gain, lb[a]	0.39	0.45	0.90	0.52	0.67	0.91
Feed/gain	2.85	2.63	1.89	2.38	2.13	1.92

[a]240 pigs; init. wt. 12.8 lb; fed corn-soybean meal diet, lysine = .88%.

Roasting of soybeans is one of the costs to consider when choosing between soybean meal or soybeans as a protein source for pigs. The economic feasibility of feeding soybeans may be calculated using the following equation:

$$A = .86M + .17F - (S + P)$$ where:

A = cost advantage of soybeans
M = cost of one ton of 44% protein soybean meal
F = value of one ton of feed grade fat
S = value of one ton of raw soybeans
P = cost of processing one ton of soybeans.

Thus if the cost of processing raw soybeans can be reduced, their value in relation to soybean meal can be in-

Table 3. Diet Composition, %

Ingredients	*Growing*	*Finishing*
Soybeans[a]	17.2	11.6
Corn	77.9	84.2
Corn starch[a]	1.5	1.0
Dicalcium phosphate	1.2	1.0
Limestone	0.8	0.8
Vit. and min.	1.1	1.1
	100.0	100.0
Nutrient composition		
Lysine	.60	.48
Ca	.65	.60
P	.55	.50

[a]Ratios of soybeans and corn starch adjusted so that the lysine contributed by the different soybean treatments was the same in all diets.

Table 4. Performance of Growing and Finishing Pigs Fed Soybeans With (+K) and Without (-K) Kunitz Trypsin Inhibitor[a]

	+K Roasting time			*-K Roasting time*		
	None	*Half*	*Full*	*None*	*Half*	*Full*
Growing pigs:						
Average daily gain, lb	0.89	0.97	1.40	1.16	1.12	1.32
Feed/gain	3.66	3.37	2.79	3.11	3.00	2.75
Last rib fat, in	0.47	0.45	0.31	0.38	0.40	0.30
Finishing pigs:						
Average daily gain, lb	1.54	1.70	1.75	1.68	1.66	1.86
Feed/gain	3.85	3.70	3.53	3.71	3.50	3.24
Last rib fat, in	0.96	0.99	1.00	0.92	0.94	0.79

[a]66 pigs in each study: corn-soybean meal diets, lysine = .60 and .48% for growing and finishing respectively.

creased. Our research findings suggest that the lower inhibitor content of -K soybeans does not reduce the extent to which soybeans must be roasted for nursery-age or growing pigs, but may in the case of finishing pigs. Further research is in progress to measure the effects of heating +K and -K soybeans on their value as a protein source for finishing pigs.

[1]Austin J. Lewis is Professor and Mark A. Giesemann is Research Technologist, Department of Animal Science. Joe D. Hancock is Assistant Professor, Animal Science and Industry, Kansas State University.

Amino Acids and Energy for Growing Pigs

by
Lee I. Chiba
Austin J. Lewis[1]

Pigs are expected to perform best when all nutrients are supplied in the diet in just the proportions needed to meet their requirements. Vitamins, minerals and water are important nutrients, but their requirements can be met with relatively little cost. On the other hand, amino acids and energy together account for more than 90 percent of total feed costs. Efficient use of these nutrients is important for commercial pig production.

Importance of Feed Intake

Variations in feed intake, which influence the amounts of amino acids and energy consumed, are a major cause of differences in pig performance. Feed intake is especially important for pigs weighing up to approximately 110 lb because there is evidence that young pigs' potential for lean tissue growth lies beyond the upper limit of their appetites.

Energy Content of Diets

Many factors that influence feed intake. It is generally *assumed* that pigs adjust their intake to achieve a certain energy intake. Pigs consume less feed when energy content of the diet is increased. Unless some adjustment of amino acid concentration is made, then amino acid intakes decrease also. For this reason, it is usually assumed that dietary amino acid levels should be related to energy content. However, information on the need to adjust amino acids (or protein) according to changes in energy content of the diets has been conflicting.

Although possible causes of conflicting responses are numerous, one of the main reasons might be differences in body composition. Determination of the rate and efficiency of deposition of body components (i.e., water, protein and fat) that account for the increase in body weight is likely to enhance the understanding of amino acid and energy nutrition in pigs.

Adjust Amino Acids?

An experiment was conducted to investigate the effects of diets, in which lysine and other amino acids were either adjusted or unadjusted for differences in digestible energy (DE) concentrations. Dietary treatments consisted of three lysine:DE ratios (1.50, 2.35 and 3.20 g/Mcal) at each of five DE levels (3.00 to 4.00 Mcal/kg) for the adjusted diets, and three lysine levels (.45, .71 and .96%) at each of three DE levels (3.50, 3.75 and 4.00 Mcal/kg) for the unadjusted diets.

Twenty-four diets were assigned within sex to 72 gilts and 72 barrows weighing approximately 44 lb. To maintain constant proportions among amino acids, a mixture of 45.5% corn and 54.5% soybean meal (basal mix) was used to formulate all diets. The differences in lysine and energy concentrations were achieved by adjusting the proportions of the basal mix, tallow, corn starch and sand (Table 1). Pigs were housed and fed individually. Feed and water were available ad libitum. When pigs weighed approximately 110 lb, empty body composition was determined.

Table 1. Composition of Diets (Experiments 1 and 2)

	Ranges of dietary composition					
Item	*Experiment 1*			*Experiment 2*		
Ingredients			%			
Basal mix[a]	26.35	to	75.00	36.18	to	85.68
Tallow	0	to	15.00	2.00	to	10.00
Corn starch	1.42	to	57.24	.19	to	50.35
Sand	.28	to	12.35	1.24	to	7.82
Dextrose	0	to	5.00			
Vitamins and minerals[b]	3.05	to	3.80	2.89	to	3.65
Chemical analysis						
Crude protein, %	7.33	to	20.50	9.83	to	22.91
Lysine, %[c]	.46	to	1.33			
Calcium, %	.69	to	.77	.71	to	.77
Phosphorus, %	.61	to	.64	.60	to	.65

[a]Basal mix: 45.46% corn and 54.54% soybean meal (44% crude protein).

[b]Provided to meet or exceed the National Research Council (1979) requirements; all diets were formulated to contain .75% calcium and .65% phosphorus.

[c]Only the basal mix was analyzed for amino acids in experiment 2.

As expected, feed intake of pigs decreased linearly as energy content of the diets increased. Energy intake was independent of DE concentration of the diets in both the adjusted and unadjusted diets. Similarly, intakes of lysine and other amino acids were not affected by energy content in the adjusted diets. However, pigs consumed progressively less lysine as DE concentrations increased from 3.00 to 4.00 Mcal/kg when lysine content was not adjusted.

The results (Table 2) were a reflection of the way pigs consumed energy and lysine. When lysine levels were adjusted, the rates of water and protein deposition and the efficiency of energy utilization for protein deposition were relatively consistent or increased slightly as energy content of the diets increased. These criteria, however, decreased linearly toward high energy diets when lysine:DE ratios were not maintained. Similar results were obtained for weight gain and the efficiency of energy use for weight gain. There was no effect of energy content in the adjusted diets, but the rate of fat deposition appeared to increase when DE concentration increased in the unadjusted diets. These results emphasize the need to adjust amino acid concentrations in concert with changes in energy content of the diets. Otherwise, lean (protein and its associated water) deposition rate is likely to decrease, and fat deposition rate may increase.

Higher Amino Acid Levels?

The results of the first experiment (Table 2) also indicated that pigs responded to increases in lysine:DE ratio up to 3.20 g/Mcal. The rate of fat deposition also decreased linearly with increases in lysine:DE ratio. Therefore, another experiment was conducted to determine the effects of six lysine:DE ratios (1.90 to 3.90 g/Mcal) at two DE levels (3.25 and 3.75 Mcal/kg) on the performance of pigs weighing 44 to 110 lb. Lysine and other amino acid levels were adjusted for dietary DE concentrations in all 12 diets. Empty body composition was estimated when pigs weighed approximately 110 lb.

As in the first experiment, energy content of the diets had no effect on the rates of water and protein deposition or the efficiency of energy use for protein deposition when lysine:DE ratios were maintained (Table 3). Pigs fed diets high in energy deposited more fat than those fed diets low in energy content. Lean deposition and protein deposition to DE intake ratios increased with increases in lysine:DE ratio up to 3.40 g/Mcal, and showed little or no response with further increases. However, responses were small when lysine:DE ratio increased from 3.00 to 3.40 g/Mcal. Likewise, the rate of fat deposition decreased sharply up to 3.00 g lysine/Mcal DE, and changed little with further increases. Similar results were obtained for weight gain and the efficiency of energy utilization for weight gain.

Amino Acid:Energy Ratio

Adequate daily intakes of amino

Table 2. Effect of Adjusted and Unadjusted Diets on Water (WD), Protein (PD), Fat Deposition (FD) and PD to Digestible Energy Intake (PD:DEI) in Pigs Weighing 44 to 110 pounds (Experiment 1)[a]

	Adjusted diets					*Unadjusted diets*				
		Least-squares means[b]					*Least-squares means[b]*			
DE, Mcal/kg	*Lys:DE, g/Mcal*	*WD, g/d*	*PD, g/d*	*FD, g/d*	*PD:DEI, g/Mcal*	*Lys, %*	*WD, g/d*	*PD, g/d*	*FD, g/d*	*PD:DEI, g/Mcal*
Low lysine										
3.00	1.50	214	64	250	8.9	.45	214	64	250	8.9
3.25[c]		219	67	216	9.6					
3.50		248	75	252	10.6		185	57	205	9.4
3.75		244	72	255	11.5		183	55	244	8.1
4.00		229	68	255	10.8		124	37	228	6.6
Medium lysine										
3.00	2.35	310	94	214	14.9	.71	310	94	214	14.9
3.25		344	105	218	15.2					
3.50		342	103	221	15.4		300	89	258	13.2
3.75		323	97	225	15.8		297	90	256	13.1
4.00		364	109	235	16.7		252	74	280	11.5
High lysine										
3.00	3.20	372	112	206	18.4	.96	372	112	206	18.4
3.25		369	113	193	18.3					
3.50		395	121	209	18.8		340	102	237	16.0
3.75		403	122	217	18.8		350	107	225	16.8
4.00[d]		384	117	190	19.8		360	109	239	16.7

[a]Empty body composition was estimated by the urea dilution technique; DE = digestible energy and Lys:DE = lysine (Lys) to DE ratio.

[b]Six individually fed pigs/diet.

[c]One pig died from unknown cause.

[d]Body composition of one pig was not estimated in the unadjusted diets.

Table 3. Effect of Two Digestible Energy (DE) Levels and Six Lysine (LYS) to DE Ratios (LYS:DE) on Water (WD), Protein (PD), Fat Deposition (FD) and PD to DE Intake (PD:DEI) in Pigs Weighing 44 to 110 Pounds (Experiment 2)[a]

		Least-squares means[b]			
DE, Mcal/kg	*Lys:DE, g/Mcal*	*WD, g/d*	*PD, g/d*	*FD, g/d*	*PD:DEI, g/Mcal*
3.25	1.90	301	89	223	13.7
3.75		302	91	262	13.7
3.25	2.50	359	107	201	17.2
3.75		389	115	235	17.8
3.25	3.00	423	129	178	20.6
3.75		422	126	201	20.1
3.25	3.40	458	138	144	21.9
3.75		440	132	209	19.9
3.25	3.70	449	138	164	21.4
3.75		435	132	188	20.7
3.25	3.90	422	127	166	20.6
3.75		432	131	175	21.5

[a]Empty body composition was estimated by prediction equations based on mean of backfat measured at the three positions using an ultrasonic instrument.

[b]Eight individually fed pigs/diet.

acids and energy are essential for optimum pig performance. It may not be important whether those intakes are achieved by a concentrated or diluted feed. If the ratio of amino acid to energy that allows pigs to consume a proper balance of those nutrients at various energy concentrations can be established, then feeding this ratio should result in a relatively constant rate of lean deposition.

The use of a constant amino acid to energy ratio is valid only if the relationship between energy intake and protein deposition is linear, provided that amino acid intake is not limiting. A number of investigators have demonstrated that the relationship is linear for pigs weighing up to approximately 110 lb. In addition, the relationship between the rate of lean deposition and body weight of pigs appears to be linear up to 110 lb, implying that daily amino acid and energy requirements of pigs can be met by feeding increasing amounts of a properly balanced, single diet during this phase. These and the relatively consistent lean deposition rate observed at the various dietary energy contents (Tables 2 and 3) indicate that the concept of using a constant amino acid to energy ratio is appropriate for growing pigs.

The optimum amino acid to energy ratio might be described as the ratio that allows consumption of amino acids and energy that complement each other for maximal lean deposition with low fat deposition. The results of the second experiment indicated that the performance of pigs was optimized at 3.00 g lysine/Mcal DE. Further increases in lysine:DE ratio resulted in slight or no improvement in the rate and the efficiency of the deposition of the empty body components.

Regression Analyses

To describe amino acid and energy interrelationships, various regression analyses were conducted. The regressions of weight gain and protein deposition on lysine:DE ratios are presented in Figures 1 and 2, respectively. The regression analyses for protein deposition were conducted within each experiment.

Weight gain of pigs increased as lysine:DE ratio increased up to 3.00 g/Mcal, followed by a plateau and slight reduction (Figure 1). For protein deposition, although the patterns of response between sexes were slightly different in the first experiment, both gilts and barrows responded to increases in lysine:DE ratio up to 3.20 g/Mcal (Figure 2). In the second experiment, there was a positive response to increases in lysine:DE ratio up to 3.40 g/Mcal. However, pigs' response was small when lysine:DE ratio increased from 3.00 to 3.40 g/Mcal. These results indicate that the pigs used in the present experiments responded to a higher lysine:DE ratio than that currently suggested by the National Research Council for pigs weighing 44 to 110 lb (.75% or 2.21 g/Mcal DE).

Conclusion

The results emphasize the need to adjust amino acid concentrations ac-

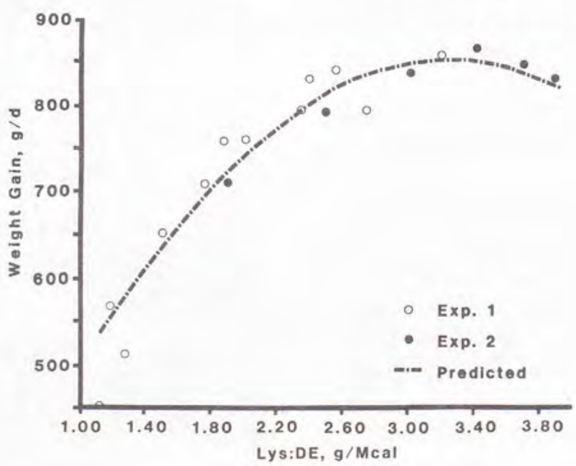


Figure 1. The relationship between weight gain and lysine (Lys) to digestible energy (DE) ratio (Lys:DE) in pigs weighing 44 to 110 lb. Each point represents the mean of individually fed pigs (n = 6 to 30). The prediction equation was:

$$Y = -1012.1 + 453.2(Lys:DE) - 69.5(Lys:DE)^2 + 14.9(IWT) + 16.2(FWT)$$

$$(n = 239; S_{y.x} = 83.8; R^2 = .62)$$

where Y = weight gain (g/d), Lys:DE (g/Mcal), IWT = initial weight (kg) and FWT = final weight (kg). Both IWT and FWT were included in the model as covariates, and their means were used for the regression line.

cording to changes in energy content of diets. Performance was relatively consistent at various dietary energy contents when amino acid to energy ratios were maintained, implying that a constant amino acid to energy ratio is appropriate for pigs weighing 44 to 110 lb. In addition, the results also indicate that the performance of pigs was optimized at 3.00 g lysine/Mcal DE, which is considerably higher than that currently recommended by the National Research Council (2.21 g/Mcal). The choice of a lysine:DE ratio to feed in a commercial pork producing operation will depend on several economic factors. The most economical ratio may differ from the optimal ratio determined in this research.

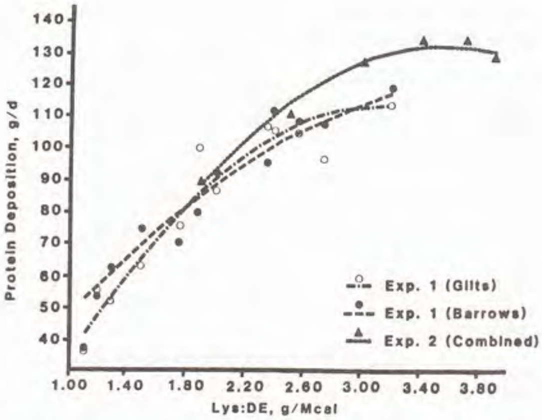


Figure 2. The relationship between the rate of protein deposition and lysine (Lys) to digestible energy (DE) ratio (Lys:DE) in pigs weighing 44 to 110 lb. Each point represents the mean of individually fed pigs (n = 3 to 16). The prediction equations were:

Gilts (Experiment 1):

$$Y = -187.82 + 110.66(\text{Lys:DE}) - 17.54(\text{Lys:DE})^2 + 1.32(\text{IWT}) + 2.01(\text{FWT})$$
$$(n = 71;\ S_{y.x} = 11.8;\ R^2 = .82)$$

Barrows (Experiment 1):

$$Y = -148.15 + 67.28(\text{Lys:DE}) - 8.33(\text{Lys:DE})^2 + 1.07(\text{IWT}) + 2.27(\text{FWT})$$
$$(n = 71;\ S_{y.x} = 12.0;\ R^2 = .79)$$

Combined (Experiment 2):

$$Y = -122.25 + 116.89(\text{Lys:DE}) - 16.48(\text{Lys:DE})^2 + 4.31(\text{IWT}) - .89(\text{FWT})$$
$$(n = 96;\ S_{y.x} = 14.9;\ R^2 = .58)$$

where Y = protein deposition (g/d), Lys:DE (g/Mcal), IWT = initial weight (kg) and FWT = final weight (kg). Both IWT and FWT were included in the model as covariates, and their means were used for the regression lines.

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Grain Sorghum vs. Corn for Gestating and Lactating Sows

by
Gary F. Louis
Austin J. Lewis
Ernest R. Peo, Jr.[1]

In Nebraska for the last 10 years, the average price of grain sorghum has been 12 percent less than corn. Using the "rule of thumb" that grain sorghum has a feeding value equal to 95 to 97 percent of corn (see University of Nebraska Swine Diet Suggestions) means that there are often economic benefits to be gained by feeding grain sorghum to pigs. Many producers have taken advantage of this situation for growing and finishing pigs, but have been reluctant to feed grain sorghum to sows during lactation when corn is available. As no information was available which refutes or supports this practice, we conducted an experiment to compare the performance of lactating sows fed corn or sorghum based diets during gestation and lactation.

The corn-soybean meal (C-SBM) gestation and lactation diets were formulated to contain 12 and 14% crude protein, respectively. A non bird-resistant, bronze sorghum replaced yellow dent corn on an equal weight basis in the sorghum-soybean meal (S-SBM) diets (Table 1). The sorghum was rolled and the corn was ground to obtain equal particle sizes for the two grain sources.

Seventy-five (39 first parity; 36 second parity) sows were allotted to the gestation diets at breeding. They were fed 4.4 lb/day from breeding to day 54. They were then moved from outside lots to an environmentally-controlled room and fed 4 lb/day for the remainder of gestation. On day 109 of gestation the sows were moved to raised farrowing crates in environmentally controlled rooms (70°F and 50% relative humidity). The sows were then switched to the lactation diets. Half of the sows from each gestation dietary treatment were assigned to lactation diets containing the opposite grain source. That is half of the sows fed corn in gestation were switched to sorghum diets and half of the sows fed sorghum in gestation were fed corn diets during lactation. Sows were allowed *ad libitum* (free choice) access to feed throughout lactation. No creep feed was provided during the 21-day lactation. To prevent masking of the grain effects, there was no crossfostering of pigs between litters. Starting on day 2 postweaning, sows were checked daily with a boar to determine the weaning to estrus interval.

Sows consuming the S-SBM diet gained slightly more weight during gestation than sows consuming the C-SBM diet (Table 2). As the grain source fed in gestation did not affect lactation performance, only the main effects due to the lactation grain source will be reported. The number of pigs born live and the birth weights were slightly different between treatments, but this was not attributed to the grain source fed.

During lactation, sows fed the C-SBM diet consumed more feed (an average of 1.4 lb/day more) than the sows fed the S-SBM diet (Table 3). Individual pig weight gains were more than 1 lb/hd greater for pigs from sows fed the C-SBM diet than from those fed the S-SBM diet (Table 4). Litter weight gains of sows fed the C-SBM diets were also greater than litter weight gains of sows consuming the S-SBM diet. A statistical adjustment (covariance) to equalize the litter size at birth did not affect the conclusions about lactation effects.

In addition to differences in feed intake, nutrient use must be considered as factor contributing to the reduced performance of the litters of sows consuming the S-SBM diet. A metabolism study involving twelve lactating, first parity sows indicated a difference in nutrient utilization between the C-SBM and the S-SBM diets. Energy use from the two diets was similar but sows used 20 percent more of the protein in the C-SBM diet than the S-SBM diet for maintenance and milk production.

Despite the 12 percent difference in lactation feed intake and the depression in protein use, weight loss from farrowing to day 21 of lactation was similar for the sows fed the two diets (Table 5). A similar weaning to estrus interval was also observed among the sows fed the different diets. Sows consuming the C-SBM and S-SBM diets during lactation had average weaning to estrus intervals of 5.1 and 5.4 days, respectively. All sows expressed estrus by day 10 postweaning.

This research indicates that both corn and sorghum based diets, when fed during gestation and lactation, will support acceptable levels of reproductive performance. However, sows fed a corn based diet during lactation consumed more feed and utilized a greater proportion of the dietary protein than those fed grain sorghum. This probably explains why sows consuming C-SBM diets had litters with greater weight gains. Further research is needed to understand why sows fed the S-SBM diet consumed less feed than sows fed the C-SBM.

Table 1. Diet Composition (%)

	Gestation diets		*Lactation diets*	
Ingredient	*CSBM*	*S-SBM*	*C-SBM*	*S-SBM*
Ground corn	84.80		69.05	
Rolled sorghum		84.80		69.05
Soybean meal, 44%	10.40	10.40	16.10	16.10
Beet pulp			10.00	10.00
Minerals	3.80	3.80	3.85	3.85
Vitamins	1.00	1.00	1.00	1.00
Calculated composition (as-fed basis):				
ME, kcal/lb	1467	1414	1429	1385
CP, %	11.78	12.12	13.83	14.11
Lysine, %	.51	.50	.70	.69
Calcium, %	.90	.90	.90	.90
Phosphorus, %	.80	.80	.80	.80

Table 2. Sow Weights and Weight Changes during Gestation.

	Gestation Diet	
	C-SBM	*S-SBM*
Sow weight, lb		
at breeding	355.8	354.3
54 day	387.5	387.6
109 day	424.8	430.2
Gestation weight change[1]	69.0	75.9

[1]Gestation weight change = 109 day weight - breeding weight.

Table 3. Lactation Feed Intake.

	Lactation diet	
	C-SBM	*S-SBM*
Lactation feed intake, lb/day		
d 1	10.52	8.84
d 2	8.58	8.84
d 3	9.57	7.83
d 4 - d 7	11.27	10.25
d 8 - d 14	14.15	12.43
d 15 - d 21	14.51	13.18
d 1 - d 21	13.07	11.68

Table 4. Litter Performance.

	Lactation diet	
	C-SBM	*S-SBM*
Litter performance		
No. litters farrowed	38	37
Pigs farrowed live	10.25	11.11
Pigs farrowed dead	0.31	0.55
Pigs farrowed mummies	0.68	0.68
Pigs at 7 days	9.48	9.64
Pigs at 14 days	9.19	9.45
Pigs at 21 days	9.11	9.40
Pig survival, %	88.88	84.61
Weight gain over 21-day lactation, lb		
Individual pig	10.14	9.00
Total litter	92.38	85.45

Table 5. Sow Weights and Weight Changes during Lactation.

	Lactation diet	
	C-SBM	*S-SBM*
Sow weight ,lb		
109 day	425.9	429.1
Postpartum (24 hr)	402.4	407.9
At weaning (21 day)	378.2	385.9
Postpartum wt. change[1]	-23.5	-21.2
Lactation wt. change[2]	-22.0	-24.2

[1]Postpartum weight change = postpartum weight - 109 day weight.

[2]Lactation weight change = weaning weight - postpartum weight.

[1]Gary F. Louis is graduate student, Austin J. Lewis is Professor and Ernest R. Peo, Jr. is Professor Emeritus at the Department of Animal Science.

How Much Will Sows Eat?

by
William C. Weldon
Austin J. Lewis[1]

The amount of feed that sows eat during lactation is one of the major determinants of their reproductive performance. Inadequate feed intakes during lactation reduce milk production and can lead to poor rebreeding performance after weaning. Therefore, it is important to understand the factors that control feed intake during lactation. Otherwise, reproductive performance may be limited by voluntary intake of nutrients during this critical period of production.

During lactation the nutrient requirements of sows increase dramatically. Sows often don't consume enough feed to meet their requirements for milk production, maintenance and growth (if first litter sows). This results in large losses of weight during lactation. It is interesting, however, that if sows are allowed to eat *ad libitum* (free choice access to feed) during gestation they will consume more feed during gestation than during the early periods of lactation.

We have conducted an experiment to measure the feed intake of sows allowed feed *ad libitum* during gestation, and to compare feed intake during lactation of these sows with similar sows fed 4 lb of feed daily during gestation. To accomplish these goals 9 sows received *ad libitum* access to feed and 9 sows received 4 lb of feed daily during the last 45 days of gestation. The sows were in individual gestation stalls in an environmentally regulated facility. Upon farrowing all sows were allowed to eat *ad libitum.* Litters were adjusted to 10 pigs by 3 days after farrowing. Feed intakes were measured daily. Sows were weighed weekly throughout gestation and lactation. Feed wasted was collected and weighed so that the actual amount of feed consumed by the sow could be calculated.

Three sows were removed from the study during its course. Two sows were removed from the *ad libitum*-fed group and one was removed from the restricted fed group. Of the sows removed from the *ad libitum* group one was removed because she failed to farrow and one sow died. The restricted fed sow that was taken off test due to complications involved with insertion of an ear vein catheter. Therefore, there were 7 sows fed *ad libitum* and 8 fed restricted amounts of feed during the gestation period.

Feed intakes of sows during gestation are shown in Figure 1. When sows were allowed to eat ad libitum they consumed a large quantity of feed on the first day. Thereafter, sows adjusted their intake to a level that declined gradually as gestation progressed. As the day of farrowing approached, voluntary feed intake decreased dramatically (Figure 2).

After farrowing, sows allowed to eat *ad libitum* during gestation consumed less feed than sows fed 4 lb of feed/day. Feed intakes of both groups increased during the course of the lactation period. Sows fed restricted amounts of feed during gestation ate nearly twice

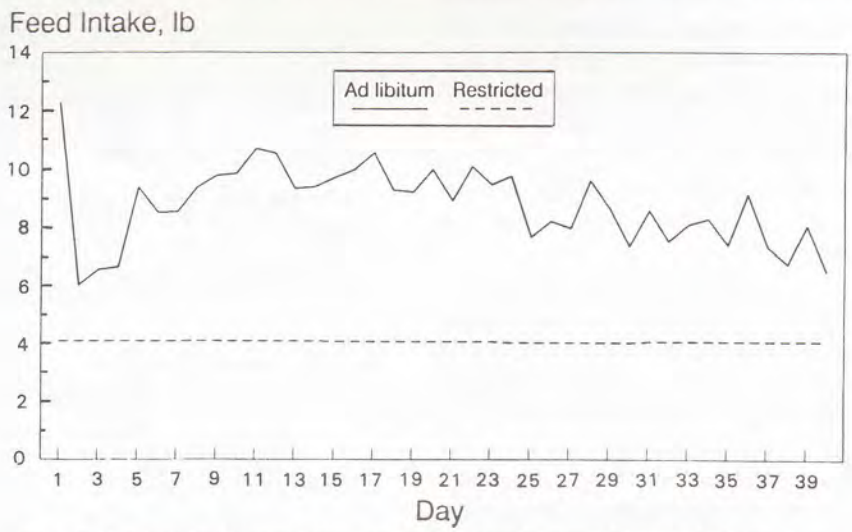
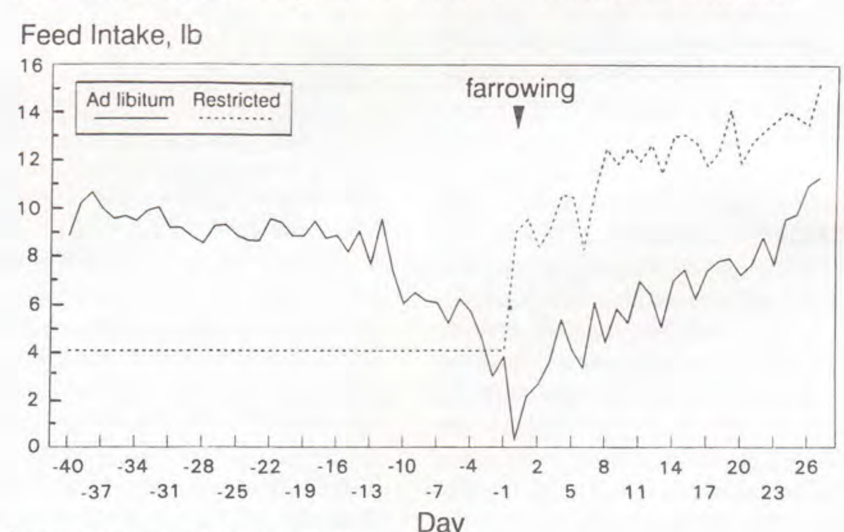


Figure 1. Feed Intake of Gestating Sows after Release from Restricted Gestation Feed Intake



[a]All sows fed *ad libitum* during lactation

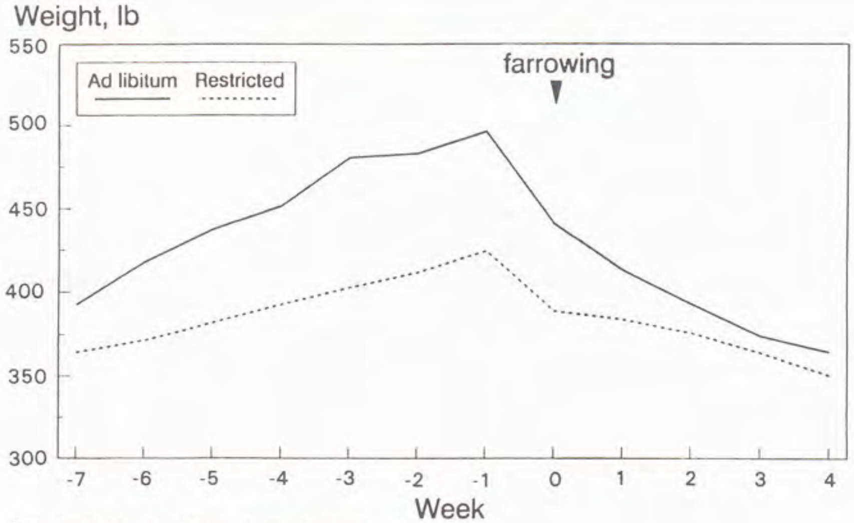
Figure 2. Feed Intake of Sows During the Final 30 days of Gestation and During Lactation[a]

as much at any given time during lactation as sows fed *ad libitum* during gestation. The greatest difference in intake was during first 3 days of lactation. Sows previously fed *ad libitum* ate less than 4 lb of feed daily while sows fed restricted amounts of feed during gestation ate more than 8 lb of feed daily during the first 3 days of lactation. We saw no adverse affects on the sow or litter when sows were full fed immediately after farrowing.

As expected, sows allowed *ad libitum* access to feed during gestation gained more weight during gestation, and lost more weight during lactation (Figure 3). The greater lactation weight losses of the sows fed *ad libitum* during gestation resulted in similar weaning weights among sows on the study.

The practical significance of this research is that to maximize feed intake during lactation sows must receive restricted quantities of feed (normally 4 to 5 lb of a grain-soybean meal diet) during gestation. High levels of feed during gestation result in large weight gains during gestation, and depressed feed intakes and large weight losses during lactation.

In future research we plan to investigate the factors that are responsible for control of feed intake in sows during lactation.



[a]all sows fed *ad libitum* during lactation

Figure 3. Weights of Sows During Gestation and Lactation[a]

[1]William C. Weldon is a Graduate Student and Austin J. Lewis is Professor at the Department of Animal Science.

Importance of Follicle Stimulating Hormone Concentrations for Follicle Development During the Estrous Cycle

by
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Clyde Naber
Dwane R. Zimmerman[1]

Ovulation rate (number of ova released) is important because it determines the upper limit for number of pigs born per litter. Ova (eggs) are released from ovarian follicles (fluid filled structures) that develop to mature size and rupture approximately 30 to 40 hours after onset of estrus. The number of large follicles at or near estrus is indicative of ovulation rate since essentially all large follicles present on the ovaries at estrus do ovulate.

Large follicles (>7 mm) originate from a pool of growing medium size (3 to 6.9 mm) follicles. Medium follicles first appear on the ovaries about 4 days after estrus. They increase in number until day 14 of the cycle and then begin to decline. Large follicles first appear on the ovaries a few days before estrus, usually between days 16 and 18 of the estrous cycle.

Follicular development is thought to be under the control of follicle stimulating hormone (FSH). Research with rodents and sheep has demonstrated the importance of elevated FSH concentrations during the periovulatory (immediately before and after ovulation) and proestrous (4 to 5 days preceding onset of estrus) periods of the estrous cycle. Suppression of FSH during these two periods of the estrous cycle reduced the development of large follicles which led to reduced ovulation rate and delayed onset of next estrus. Though direct evidence for circulating concentrations of FSH influencing follicular development has not been reported for the pig, positive relationships have been observed between FSH concentrations and ovulation rate. Gilts selected for high ovulation rate at the University of Nebraska were reported to have higher concentrations of FSH during the periovulatory period than Control line gilts. British researchers similarly reported that sows having higher concentrations of FSH during the postweaning period expressed higher ovulation rates at the first postweaning estrus. The research reported here was designed to determine the importance of circulating concentrations of FSH for follicular development during the proestrous period.

Materials and Methods

Forty gilts from the University of Nebraska Gene Pool population (14 breed composite) were used in the experiment. All gilts had expressed two or more estrous cycles prior to use. The experimental approach involved suppression of FSH concentrations during the proestrous period and measurement of changes in follicular development. To facilitate treatment of gilts at a precise stage of the estrous cycle, the start of the proestrous period was induced in all gilts by administering prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) to each gilt on day 12 of the estrous cycle.

Gilts were randomly assigned in equal numbers to receive twice daily intravenous administration of 10 ml of porcine follicular fluid (pFF) or saline (S). Treatment started on day 12 and ended after 48 hours, 96 hours or at onset of estrus (approximately 144 hours after pFF or S). Ovaries were removed and characterized for number of large (>7 mm), medium (3 to 6.9 mm) and small (<3 mm) surface follicles when treatment ended. Porcine follicular fluid has been shown to contain high concentrations of an FSH inhibiting hormone known as "inhibin". Inhibin is produced by ovarian follicles and signals anterior pituitary gland to decrease release of FSH. The dose and injection regimen were demonstrated in a previous experiment to suppress and maintain FSH concentrations at baseline.

Gilts were maintained in an environmentally regulated room beginning on day 13 of the estrous cycle prior to treatment. They were girth-tethered in stalls and fitted with an indwelling jugular cannula on day 6 after estrus. Gilts were fed 3.5 lb of a 14 percent protein, corn-soybean meal diet twice daily. Blood samples were collected and estrous checks made twice daily at 6 a.m. and 6 p.m. Plasma samples were assayed for concentrations of FSH and progesterone.

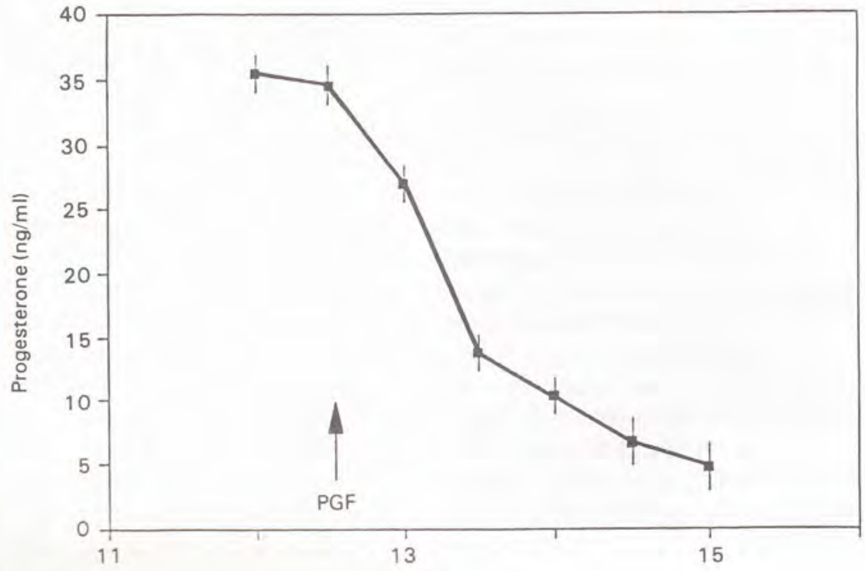

Figure 1

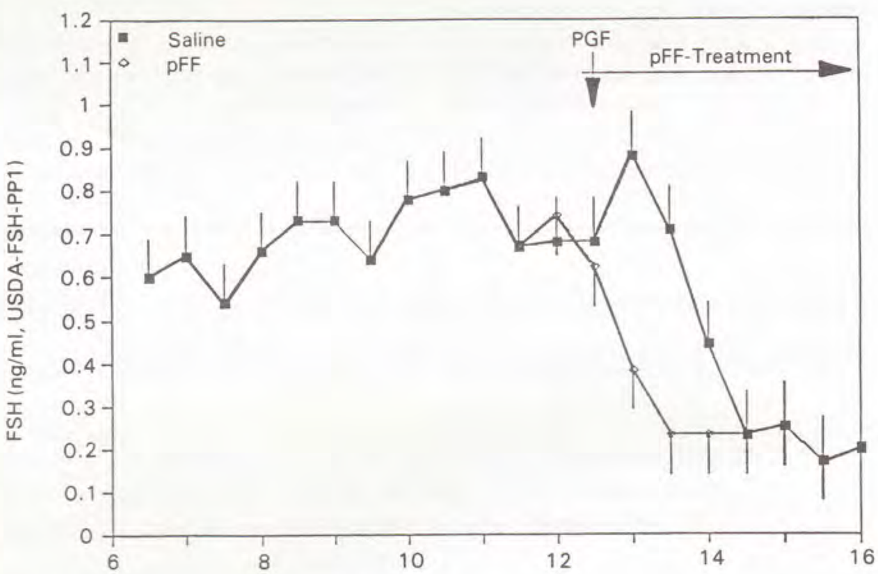

Figure 2

Results

Based on the decline in circulating progesterone during the 48 hour period following $PGF_{2\alpha}$ treatment, 39 of 40 gilts responded with corpora lutea regression and entered the proestrous stage of the estrous cycle (Figure 1). pFF treatment rapidly suppressed FSH concentrations when compared to controls (Figure 2). Concentrations of FSH were decreased substantially at 12 hours (pFF, .37 vs S, .89 ng/ml) and at 24 hours (pFF, .23 vs S, .71 ng/ml) after the initiation of pFF injections. FSH concentration was also lower in pFF treated gilts at 36 hours, but after 36 hours FSH concentrations were low in both treated and control gilts.

The pattern of follicular development in saline treated control gilts is shown in Figure 3. Numbers of small follicles declined sharply between 48 hours and 96 hours (57.1 vs 23.9) and then exhibited no further decline. Numbers of medium follicles declined between 48 hours and 96 hours (39.2 vs 8.2) and then decreased to zero at estrus. In contrast, numbers of large follicles increased from virtually none at 48 hours to maximum numbers at onset of estrus.

The pattern of follicular development was altered by suppression of FSH for 36 hours with pFF. Numbers of small and medium follicles were substantially reduced at 48 hours by treatment with pFF (small, 33.3 vs 57.2; medium, 24.8 vs 39.2). However, numbers of small and medium follicles

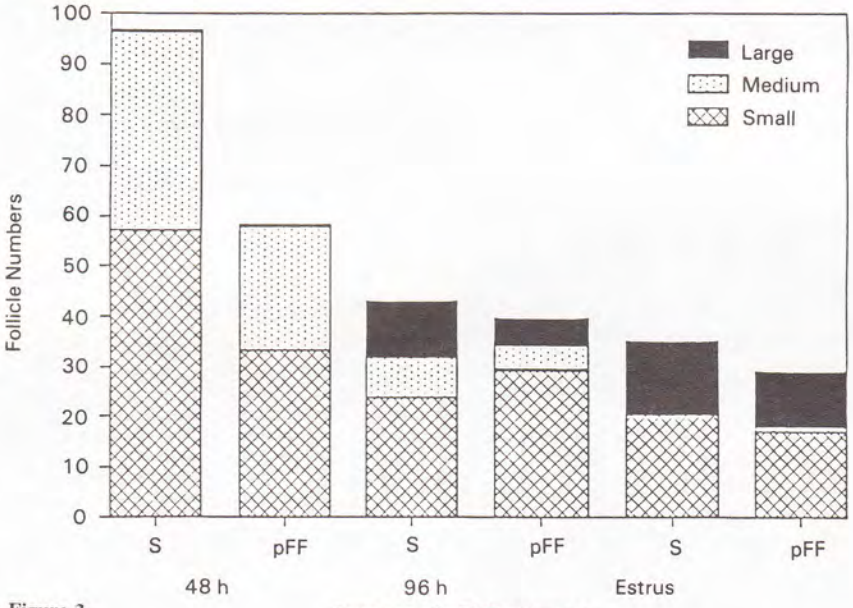

Figure 3

did not differ in pFF and S treated gilts at 96 hours or at estrus (Figure 3). In contrast, numbers of large follicles were markedly reduced by pFF treatment both at 96 hours (S, 11.0 vs pFF, 5.5) and at estrus (S, 14.5 vs pFF, 11.1). The interval to the onset of estrus after the $PGF_{2\alpha}$ injection ranged between 120 and 168 hours and was not delayed by pFF treatment (147 hours) compared to saline controls (138.5 hours).

Data from the present experiment suggest that small and medium follicle populations require elevated concentrations of FSH for maintenance and further development during the early proestrous period. Further research using replacement therapy with highly purified FSH is needed to prove that the detrimental effect on follicle populations is due specifically to lowered concentrations of FSH. The dramatic decline in large follicles after pFF treatment during the mid to late proestrous period suggests that many of the medium follicles that remained after 36 hours of FSH suppression were unable to respond to the hormonal signals that stimulate further development of medium follicles into large preovulatory follicles. Since number of large follicles at onset of estrus is indicative of ovulation rate in pigs, it appears that FSH concentration during the follicular phase has an important influence on ovulation rate. Whether the effect of pFF treatment on follicular selection and maturation is due to lowered FSH concentration or to a change in the ratio of FSH to luteinizing hormone (ovulating hormone) cannot be determined from the present investigation. Future research will be designed to address these and other questions regarding hormonal regulation of follicle development and ovulation rate in pigs.

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Starter and Feeding Strategies for Early Weaned Pigs

by
Murray Danielson[1]

Early weaned pigs can be expected to improve performance when fed a highly digestible postweaning diet. Determination of the proper time to reduce diet nutrient density is not only an economic factor, but also involves the adaptation of the pig's digestive system. Adaptation to reduction in diet nutrient density of the pig is like the development of the root system of a tree. The sooner the adaptation or root system development occurs, the sooner increased performance or growth will normally take place. A trial conducted at the West Central Research and Extension Center compared the feeding of a high nutrient density diet (HNDD) for 10 days and 20 days postweaning, followed by a reduced nutrient density diet (RNDD) for the balance of the 35 day nursery period.

Table 2. Effect of length of time when feeding a high nutrient density diet in early weaning pig programs.

	Light		*Heavy*	
	Days fed high nutrient density diet			
Item	*10 days*	*20 days*	*10 days*	*20 days*
No. of pigs	32	32	32	32
Average pig wt (lb)				
Initial	11.8	11.7	14.4	14.5
35 days	30.8	28.8	37.4	35.5
Average daily gain (lb)				
0-10 days	.11	.08	.15	.09
0-20 days	.25	.19	.30	.23
0-35 days	.54	.49	.66	.61
Feed/gain				
0-10 days	2.81	6.04	2.31	5.65
0-20 days	2.09	1.98	1.98	1.95
0-35 days	1.56	1.52	1.57	1.53

Procedure

A total of 128 crossbred pigs weaned at 21 days were used in the 35-day trial. The pigs were split into a light-weight group and a heavy-weight group. The trial was conducted in environmentally controlled rooms in raised decks, eight pigs (4 female and 4 male) per pen. The pigs were not creep fed during lactation and were not allowed an adaptation period prior to being placed on study.

The diet formulations (A and B) fed the pigs during the trial appear in Table 1. The meal diets were fed ad libitum. Diet A, the HNDD was fed to 32 light pigs and to 32 heavy pigs for 10 days. These pigs were then fed diet B (RNDD) for the remaining 25 days of the 35-day trial. Diet A was fed to 32 light pigs and 32 heavy pigs for 20 days. These pigs were then fed diet B for the remaining 15 days of the 35-day trial. Individual pig weights and pen feed intake was recorded at 10, 20 and 35 days.

Table 1. Composition of starter diets.

	Diet	
Ingredient	*A-HNDD*[a]	*B-RNDD*[b]
Yellow corn	20	48
Roasted soybeans	6.4	39
Alfalfa hay	1.8	2.26
Dried whey	10	5.2
Dried skim milk	40	—
Dried fresh solubles	5	—
Dried brewers yeast	1	—
Sugar	10	—
Lard	3	—
Calcium carbonate	—	.58
Dicalcium phosphate	.4	1.8
Iodized salt	.3	.3
Trace minerals[c]	.1	.1
Selenium premix	.15	.15
L-lysine•Hcl	—	.15
Vitamin antibiotic mix[d]	1.85	2.46
	100.00	100.00
Calculated Analysis, %		
Protein	21	19.45
Calcium	.75	.84
Phosphorus	.7	.75
Lysine	1.44	1.18

[a]HNDD - High nutrient density diet.

[b]RNDD - Reduced nutrient density diet.

[c]Calcium Carbonate Company, Swine, 20% zinc.

[d]Provided each lb of diet the following: vitamin A, 2400 IU; vitamin D, 306 IU; riboflavin, 2 mg; calcium pantothenate, 5.4 mg; niacin, 12 mg; choline, 120 mg; vitamin B_{12}, 12.07 mcg; CSP-250, 1136 mg.

Results

As shown in Table 2, average daily gain (ADG) of the pigs for the 35-day trial was greater for pigs fed diet A for 10 days than for the pigs fed diet A for 20 days. The heavy pigs had a greater ADG than the light pigs as would be expected under normal conditions. However minimal, feed required per pound of gain (F/G) was improved for all pigs that were fed diet A for 20 days as compared to pigs fed diet A for 10 days.

In all studies of this type, it must not be overlooked that the differences in genetic background, feed source, buildings and equipment and management can influence pig performance. Defining the conditions of research studies of this type are pertinent with the thought of employing the results to on the farm production.

Summary

The results of this study indicate no need for a prolonged high nutrient density diet feeding program for early weaned pigs. Further the study indicates high nutrient density diets may reduce pig performance when fed over a prolonged feeding period. There is a need for further research in the feeding and management strategies of early pig weaning programs.

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Prospects for the Chinese Pigs in the USA

by
William T. Ahlschwede*[1]

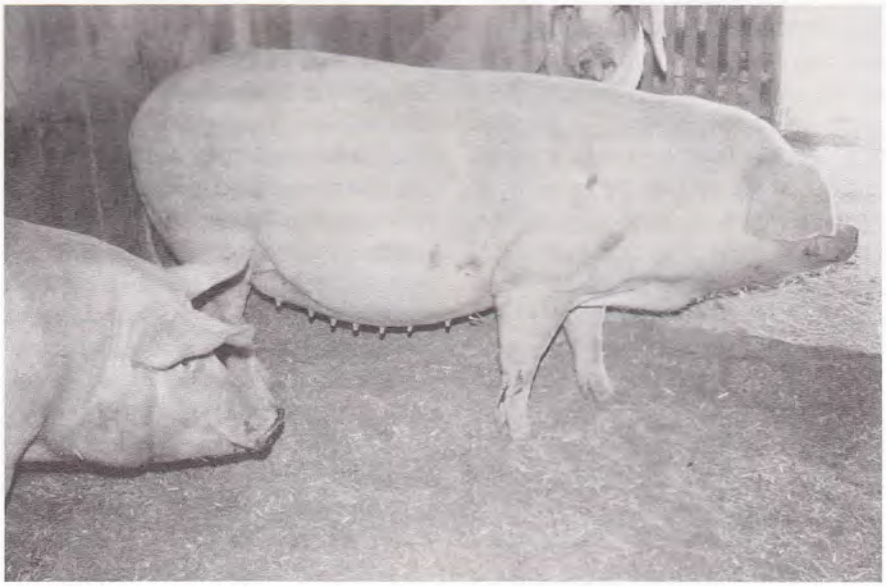
The importation of three breeds of Chinese pigs to US research stations in 1989 captured the attention of the pork producing industry. Reports of their arrival featured the large litter sizes of the breeds and pictures of these strange looking pigs, with suggestions of possible disease resistance and the ability to digest fiber. While we have no prior experience with these Chinese breeds in the USA on which to predict their performance here, several European research centers and breeding companies have results which can help shape our expectations.

The National Institute of Agricultural Research in France imported three breeds of Chinese pigs in 1979, the Meishan, Jiaxing and Jinhau. In 1987, the Agricultural University in Wageningen, Netherlands, acquired 16 males and 13 females of the Meishan breed from France. In Great Britain, a consortium of five British breeding companies and the Institute for Animal Physiology and Genetics Research, at Edinburgh, Scotland, imported eleven Meishan boars and 21 gilts from China in 1987. The Meishan population is being maintained at Edinburgh.

Because they started sooner, the French researchers have reported more results than others. Each of the three breeds was represented by three pigs, with semen available from three additional Meishan boars. Initial results of reproduction studies with the three breeds and crosses with Large White and Landrace were reported in 1983. Growth and carcass results were reported in 1985. Later studies have been primarily based upon the Meishan. A summary of the most recent study is shown in Table 1. Two French breeding companies have initiated development projects using the Chinese breeds.

In the Netherlands, crossbreeding studies are being initiated in cooperation with breeding companies. The matings are being designed to expose major gene effects on littersize, if they are present. Such a major gene would be a candidate for isolation and insertion into other breeds. Initial studies have been made to quantify maternal and genetic effects in the Meishan relative to the Landrace. The response of the Meishan to exogenous somatatrophin has also been studied.

Meishan sows



Half Meishan crossbred sow

Initial studies in Great Britain have involved crosses with the Large White. As in the Netherlands, researchers are looking for major genes affecting littersize. The cooperating breeding companies have received allocations of Meishan, and are initiating development studies.

In Europe, the research and development emphasis has gravitated to the Meishan breed, one of the three breeds

Table 1. Summary of Meishan performance in France

	Littersize		*Daily Gain*
	alive	*wean*	*21-154 days*
MEISHAN	13.5	12.0	1.01
M x LW	14.3	13.2	1.47
Large White	9.3	8.2	1.34
	Age at 220 lb	*F/G*	*Carcass Lean %*
Pietrain X Meishan	180 days	3.20	47.8
Pietrain X (MxLW)	179	3.08	51.5
Pietrain X Large White	176	3.01	55.4

imported in the USA. In all three countries, the Meishan has been found to have large litters, both as purebreds and as crosses. Heterosis appears similar to that experienced with European and American breeds. The Meishan is slower growing than the Large White and Landrace breeds, is much fatter and reaches puberty quite early. The behavior of the Meishan is different than the European breeds. Sows do not take easily to farrowing crates, would rather eat from the floor than from pans or feeders, are quite docile and gentle, are hard to move and consequently difficult to heat check. Meishan boars have high levels of libido. Once they reach puberty, often by three months of age, they tend to rant, rather than eat. Researchers have observed a higher incidence of abscesses under the skin with the Meishan, than with European breeds. With mature animals, there is a tendency for the skin folds on the face to close over the eyes, obscuring vision.

Studies in France completed in 1989 suggest that the Meishan can be an economical inclusion in commercial breeding programs, provided that selection against fat is practiced. They suggest that synthetic breeds, with half Meishan genes be established. Intense selection for rate of lean gain would be practiced in the synthetic. This is the approach being used by one of the French breeding companies. The synthetic breed would be used as a maternal grandparent for terminal crossbreeding programs. An increase of 1.5 pigs per litter would be expected at the final cross.

A second strategy suggested by the French is to select for lean gain in the Meishan breed, and use it as a maternal grandparent. This approach would be more expensive during the development stages (poor performance of the purebred Meishan) and would take longer to reach acceptable lean content levels, but would yield larger increases in littersize-about 2.5 or 3 pigs per litter.

In 1985, we reported in the Nebraska Swine Report that inclusion of a prolific breed, such as the Meishan in commercial crossbreeding systems looked promising from an economic point of view. Advantages of $30 to $40 per litter produced were indicated. That report was based on a computerized evaluation of crossbreeding systems, including a "prolific" breed. The prolific breed was patterned after the early results from France with the Meishan. The reproduction data was available at that time. However, the growth, feed efficiency and carcass evaluation was not available, and estimates were used for those traits. The French data now available indicate that the performance of the Meishan is not as bad as the estimates used for gain, feed and fat thickness.

Studies being initiated at the University of Illinois, Iowa State University and the US Meat Animal Research Center with the Meishan, Minzhu and Fengjing breeds from China will in a matter of time tell us how these breeds respond to American conditions and to crosses with American breeds. The results of the French studies encourage us to be optimistic that increased sow productivity is possible with the new germ plasm. But the French experience also suggests that we be patient. Seven to ten years of development may be needed before a commercial product is feasible.

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*During the summer of 1989, the author visited the three European research centers studying the Chinese pigs. This report includes his personal observations and those of the researchers visited.

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Responses to Selection for Weight of Testes

by
Rodger K. Johnson
Gregg R. Eckardt[1]

More output per breeding female is a desirable genetic goal. However, genetic improvement of reproductive traits is not easy. Reproductive traits are sex limited and often are not expressed until after animals are chosen to be breeders. This complicates the process of accurately selecting genetically superior animals. For reproductive traits, young boars and gilts must be selected on records of dam and sibs.

Because fewer breeding males than females are needed, most genetic change comes from high selection intensity of males. For this reason, breeders have been searching for traits measurable in males at a young age that are good predictors of reproductive performance of daughters. Selection for such a trait could substantially increase rate of genetic change over direct selection for reproductive traits. Size of testes might be such a trait for pigs.

Why Testes Size?

Hormones controlling ovarian function in females that lead to expression of puberty and ovulation of eggs also control rate of development of testes. In mice and sheep, lines and breeds superior in ovulation rate, litter size or age at puberty are often above average in size of testes, libido and sperm output.

Evidence for a genetic relationship between rate of testicular growth and ovulation rate in pigs was found in comparisons of boars from the Nebraska high ovulation rate and control lines. Boars from the high line had larger testes up to about 160 days of age.

Indirect evidence suggests selection for size of testes will improve female reproduction. We cannot be sure of the relationship between size of testes and female reproductive traits until we select directly for size of testes and observe correlated changes in reproductive traits. An experiment was initiated in 1981 in which boars were selected for size of testes at 150 days of age. Six generations of selection have been completed.

Experiment

Large White and Landrace breeds were crossed in 1979 to form the experimental population. Selection and matings were random for two generations. Pigs of the F_3 generation were assigned randomly within litter to a line selected for predicted weight of testes (line TS) or a randomly selected control line (C).

Line TS averaged 43 litters by 15 sires per generation and line C averaged 42 litters by 15 sires. Litters were weaned at 28 days of age and moved from nursery to finishing facilities at about 60 days of age. Boars and gilts were grown in separate houses with about 10 pigs per pen.

All line TS males were left intact, but in line C only 30 boars were left intact each generation. These 30 boars were two randomly selected sons of each sire. One boar was used as a breeder and one was an alternate. A total of 1,095 boars, about 156 per generation (base generation plus 6 generations of selection), were evaluated in line TS. A total of 218 boars were evaluated in line C (about 31 per generation). Width and length of paired testes measured with a caliper and body weight were recorded at approximately 140 days and 160 days of age. Sonoray measurements of backfat were also taken at 160 days of age. Measurements of testes were adjusted to 140 and 160 days of age, and backfat was adjusted to 200 lbs liveweight.

Boars were ranked each generation on predicted weight of paired testes. In line TS the 30 highest ranking boars were retained, the top 15 were designated as breeders and the others were alternates to be used only if primary boars failed to breed.

Boars from the F_1 and F_2 generations were measured and castrated. The data were used to develop an equation to predict weight of testes at 150 days from measurements of length and width. The equation is:

$$PWT = 12.5(W140) + 20.0(L140) + 16.0(W160) + 32.0(L160) - 508.3$$

where,

PWT = predicted weight (g) of paired testes at 150 days,

W & L = width and length of testes, cm, and

140 & 160 = age in days when measured.

The multiple correlation between predicted weight of testes and weight of excised testes was calculated to be .92.

Selection of females was random in both lines. A total of 55 gilts per line were retained at weaning each generation. These represented at least one and not more than two per litter. Age at puberty was determined by daily exposure to boars beginning when gilts reached 130 days of age. Fifty gilts from each line were mated each generation. Farrowing rate averaged 86% in line TS and 84% in line C. Sixty three additional gilts (32 TS and 31 C) were retained in generation 5. These were slaughtered after their second estrous period and ovulation sites on ovaries were counted. All gilts were weighed at 135 days of age and again when they were probed for backfat at about 200 lbs.

Results

Average weight of testes in the base generation was 412 g. Each generation, the 15 selected boars in line TS averaged 60.9 g heavier testes than average boars of this line. Total selection applied over 6 generations was 365.6 g. Response to selection measured as the difference between line averages is shown in Figure 1. Significant response occurred. Lines differed by 139.6 g at generation 6. Genetic change was estimated to be 23.3 g per generation, 5.6 percent of the base generation mean. Realized heritability of predicted weight of testes was .32.

Faster growth and somewhat fatter

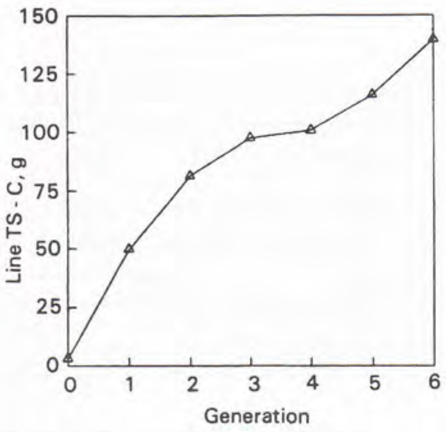

Figure 1. Predicted Weight of Testes

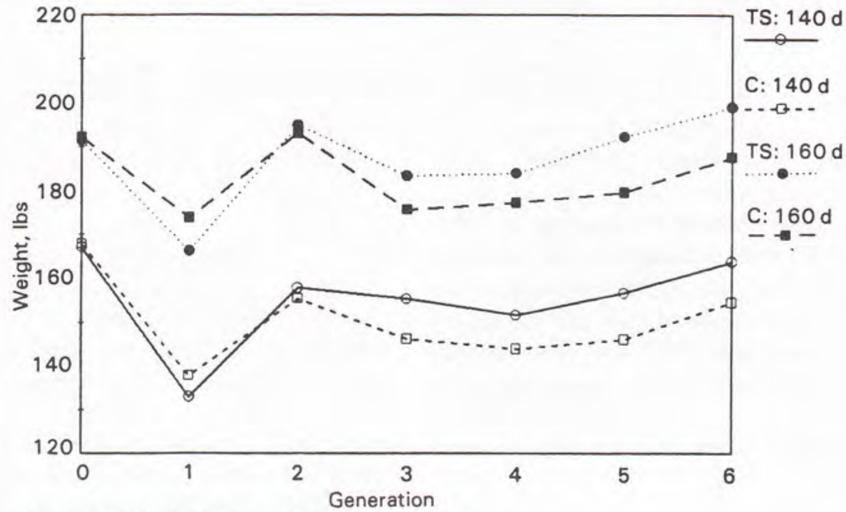

Figure 2. Weight of Boars at 140 and 160 Days

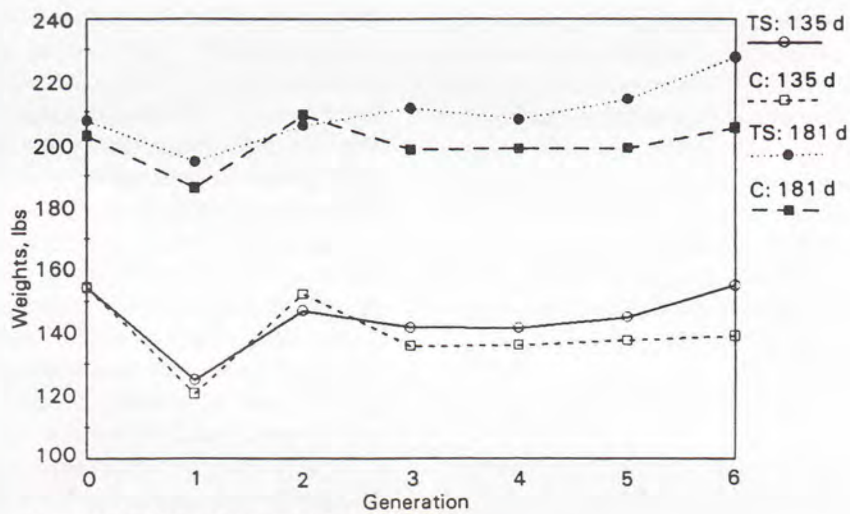

Figure 3. Weight of Gilts at 135 and 181 Days

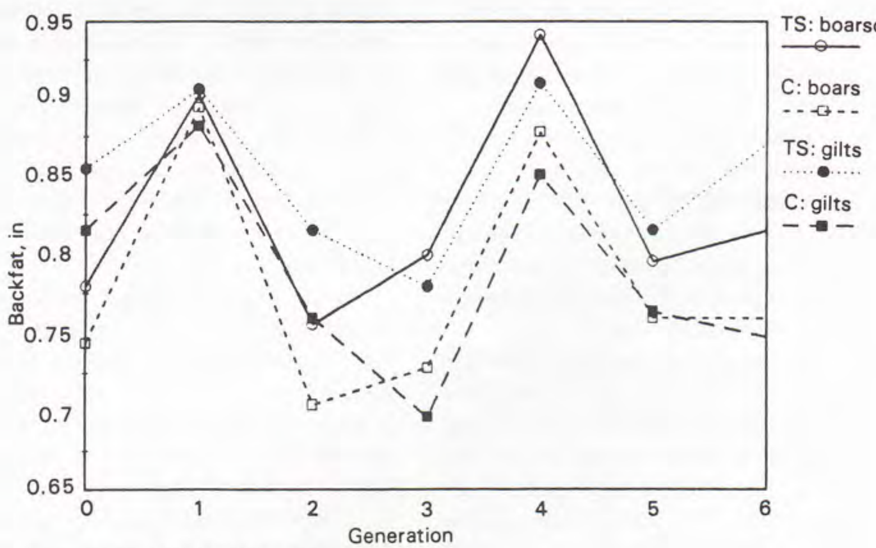

Figure 4. Backfat at 200 lbs Boars and Gilts

pigs accompanied changes in weight of testes (Figures 2, 3 and 4). Responses were statistically significant in gilts, but not in boars. However, similar changes for both sexes in body weight and probed backfat thickness indicate size of testes at 150 days is correlated genetically with both rate of growth and backfat thickness.

Genetic associations of rate of growth and backfat with size of testes are not high. Total change in each trait was measured as average change per generation times 6. For predicted weight of testes, total change was estimated to be about 34% of the base generation mean. In comparison, total changes in weight and backfat of boars were 13.4 lbs (8% of the base generation mean) at 140 days, 19.4 lbs (10%) at 160 days and .0 in (.1%) backfat. Changes in body weight of gilts were similar, 15.4 lbs (10% of the base generation mean) at 135 days and 15.7 lbs (7.7%) at 181 days, but the increase in backfat was estimated to be .064 in (8.1 %) in line TS gilts after 6 generations.

Body weight and weight of testes are genetically associated, but considerable variation in weight of testes is independent of body weight. This is in agreement with moderate correlations between size of testes and body weight found in several other species.

Figure 5 shows average age at puberty for gilts of each generation. In early generations, it appeared age at puberty in gilts in line TS was improving

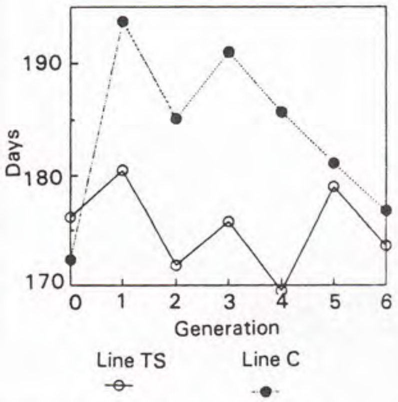

Figure 5. Age at Puberty for Gilts

compared to line C gilts. In generation 5 and 6 lines differed very little.

Further, gilts from lines TS and C were not different in ovulation rate in generation 5. Average ovulation rate was 13.2 for line TS and 12.8 for line C. Results are not what was expected based on relationships of differences among lines and breeds of sheep and mice.

Conclusions and Application

Size of testes in boars at 150 days of age is moderately heritable (32%) and quite variable (coefficient of variation of about 25%). Thus, direct selection will cause relatively large genetic changes. Increased body weight and somewhat fatter pigs at 200 lb are expected to accompany genetic changes from selection only for size of testes.

Selection in this experiment will continue for several more generations to accurately assess genetic relationships among male and female reproductive traits. However, it does not appear that size of testes at 150 days will be a useful selection trait in males to improve ovulation rate and age at puberty of gilts. Thus, genetic relationships observed among lines and breeds of mice and sheep were not found within this population of pigs.

Size of testes is related to sperm output and possibly to sexual aggressiveness of boars. Therefore, some attention probably should be given to size of testes in selection of boars. However, heavy emphasis on size of testes is not justified because it would dilute selection pressure for other economically important traits. Practically, breeders probably should not select boars with obviously small testes; but measurement of testes with the goal of selecting to improve reproductive performance of daughters is not recommended.

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[1]Rodger K. Johnson is Professor, and Gregg Eckardt is a former Graduate Student both with the department of Animal Science.

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B-K Ladenburg, Inc., Simi Valley, CA
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