EC85-219 1985 Nebraska Swine Report

Roger J. Kittok
University of Nebraska-Lincoln, rkittok1@aol.com

James E. Kinder
University of Nebraska-Lincoln, kinder.15@osu.edu

Rodger K. Johnson
University of Nebraska-Lincoln, rjohnson5@unl.edu

Donald G. Levis
University of Nebraska-Lincoln, donlevis@hotmail.com

R. K. Christenson
USDA, Agricultural Research Service, US Meat Animal Research Center

See next page for additional authors

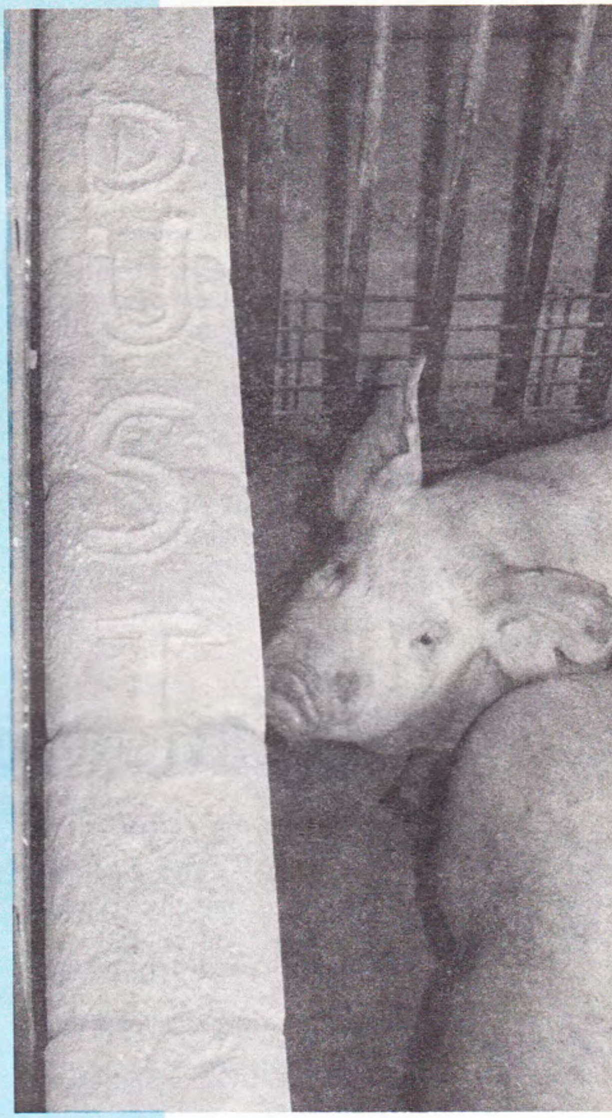
Authors

Roger J. Kittok, James E. Kinder, Rodger K. Johnson, Donald G. Levis, R. K. Christenson, Casey B. Frye, Chris R. Calkins, Roger W. Mandigo, Robert M. Timm, Daryl D. Fisher, Roy Carlson, E.R. Peo Jr., William R. Schneider, Martin L. Wiernusz, Alex Hogg, R. D. Fritschen, Lee I. Chiba, William Ahlschwede, M. C. Brumm, D. Carlson, G.W. Jesse, H.F. Mayes, G.M. Zinn, J.A. DeShazer, Jerry D. Plessing, Dennis D. Schulte, Marcus J. Milanuk, Gerald Bodman, LaVerne E. Stetson, and Jack L. Schinstock

Nebraska Cooperative Extension Service EC 85-219
Nebraska Agricultural Experiment Station

1985

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

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Leo E. Lucas, Director of Cooperative Extension Service, University of Nebraska, Institute of Agriculture and Natural Resources.

TEACHING RESEARCH EXTENSION

Institute of Agriculture and Natural Resources

Acknowledgments

Agriculture Laboratories, State of Nebraska, Lincoln, NE

A. H. Robins Co., Richmond, VA

Allflex Tag Company, Harbor City, CA

Ajinomoto USA, Inc., New York, NY

American Cyanamid Company, Princeton, NJ

Armour Food Company, Madison, NE

Bettcher Industries, Inc., Vermillion, OH

Blevins Popcorn Co., North Bend, NE

Custom Feed Blenders, Omaha, NE

Distributors Processing Inc., Porterville, CA

Efficiency Resources Inc., Kalona, IA

Eli Lilly and Company, Indianapolis, IN

Farmland Foods, Crete, NE

Fats and Protein Research Foundation, Inc., Des Plaines, IL

Geo. Hormel Packing Company, Fremont, NE

John Morrell Packing Company, Sioux Falls, SD

National Pork Producers Council, Des Moines, IA

Nebraska Farmer, Lincoln, NE

Nebraska Inter-Industry Electric Council, Columbus, NE

Nebraska Pork Producers Association

Nebraska SPF Accrediting Agency, Lincoln, NE

Nebraska Soybean Utilization and Marketing Board, Lincoln, NE

Nebraska Sorghum Utilization and Marketing Board, Lincoln, NE

Norden Laboratories, Lincoln, NE

Pfizer, Inc., Terre Haute, IN

The Upjohn Co., Kalamazoo, MI

Union Pacific, Omaha, NE

Urschel Laboratories, Inc., Valparaiso, IN

U.S. Meat Animal Research Center, Clay Center, NE

Waldo Farms, Dewitt, NE

Wimmer Meat Products, Inc., West Point, NE

Contents

Issued December 1984, 7,000

The 1985 Nebraska Swine Report was compiled by William T. Ahlschwede, Extension Swine Specialist, Department of Animal Science.

What Do The Testes Do?

Roger J. Kittok
James E. Kinder
Rodger K. Johnson[1]

The testes of the boar, in addition to sperm production, are a source of the steroid hormones, testosterone and estrogen. These hormones are involved in libido. They also play a part in the regulation of release of other hormones called gonadotropins from the pituitary.

Gonadotropins increase the release of steroid hormones from the testes. An increase in steroid hormones will act to decrease concentrations of the gonadotropin, luteinizing hormone (LH). This control is referred to as negative feedback and results in pulses of LH being released into the blood. The present study is part of continuing research to determine the mechanisms that regulate the reproductive hormones of swine (see "Select Boars for Litter Size?", 1983 Nebraska Swine Report).

Hormone Regulation

The components of a potentially beneficial pattern of hormone regulation are not well known. This study was conducted to determine the effect of complete removal of negative feedback regulation on LH secretion.

In the experiment, LH secretion of boars was monitored before and after castration. Multiple blood samples were taken to determine the concentration of LH in the blood (plasma LH). Determinations were made of average plasma LH, number and amplitude of pulsatile releases of LH and the amount of LH released following an injection of gonadotropin releasing hormone (GnRH; 170 ng/lb. body weight). Plasma LH response to GnRH injection was used to estimate the amount of releaseable LH stores present in the pituitary.

Ten crossbred boars (13 to 14 months old; 350 lb) were used. Blood samples were collected at 12-minute intervals for 7 hours through indwelling jugular catheters.

Figure 1 illustrates the results collected from one representative boar (arrow indicates when GnRH was given). Blood samples were collected one day before and seven days after castration. In the intact boars (before castration), there were few pulsatile releases of LH (1.6 pulses/6 hours) and LH averaged 568 pg/ml. During the sampling period before castration, the representative boar (Figure 1) had only one increase in LH that was considered a pulse of LH.

The graph of data collected seven days after castration illustrates the increase in the number of LH pulses (5.6 pulses/6 hours) and LH response to GnRH injection. After castration, LH averaged 820 pg/ml. Pulse amplitude did not change after castration (234 vs 290 pg/ml).

Plasma LH Increases

The conclusions from this study are that removal of testicular steroids from intact boars caused an increase in average plasma LH concentration and allowed LH to be released more frequently but in pulses that were no larger than those released from intact boars. The increase in the amount of LH release stimulated by GnRH injection after castration and the fact that pulse amplitude did not change after castration may reflect that the amount of releasable LH increases in the absence of steroid hormones.

In the normal intact boar, steroid concentrations vary throughout the day. As a result, LH is released in pulses (1.6 pulses/6 hours in this study). The number of LH pulses in individual boars is not always well correlated with the level and(or) fluctuations of steroid hormones. The best pulsatile pattern and level of sensitivity of negative feedback regulation for boars will be the subject of future research.

[1]Roger J. Kittok is Associate Professor, Physiology. James E. Kinder is Associate Professor, Beef Physiology. Rodger K. Johnson is Professor, Swine Breeding.

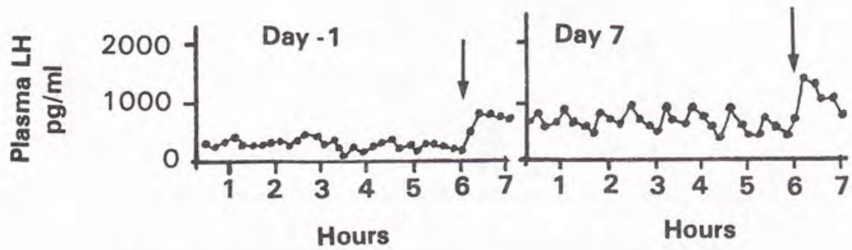


Figure 1. LH before and after castration in a representative boar.

Evaluating Replacement Boars for Sexual Behavior

Donald G. Levis
Ronald K. Christenson[1]

The swine industry does not have a standardized procedure to evaluate sexual behavior of replacement boars. Many complaints are heard when young boars do not appear to be working. Sometimes the complaints are valid, other times they are not because of poor mangement. To reduce conflicts between buyer and seller, we need a standardized system for evaluating boar sexual behavior and fertility. Our research results have shown that the following factors must be considered when evaluating boars for sexual behavior.

Evaluation Pen

It is best to use a small pen (12′ x 12′) that provides excellent footing. Build and locate the evaluation pen so the boar is not easily distracted by other animals during the evaluation.

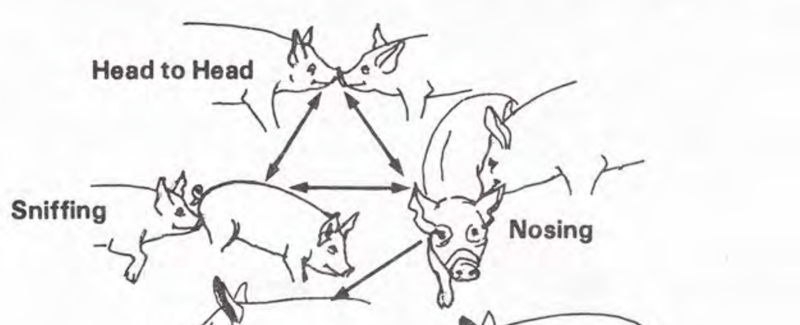


Figure 1. Diagram of sexual behavior in swine (Signoret, 1970).

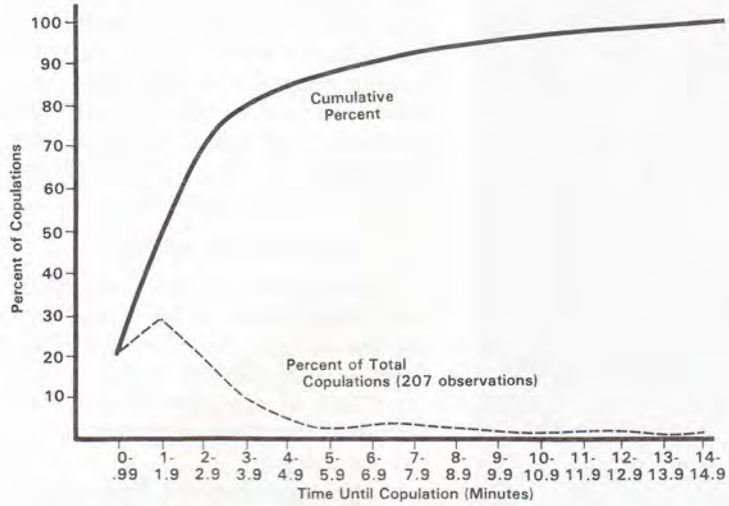


Figure 2. Copulation rate as related to copulation time.

Females to Use

When evaluating young, inexperienced boars, the boar and sow should be about the same height. A substantial difference in height between male and female can be associated with observed differences in sexual behavior.

Although a **group situation** (2-4 females) may provide a good environment to evaluate boar sexual behavior (eagerness and willingness to mount and attempt service), it may prevent a true evaluation of his mating dexterity (skill at copulating) as a result of all the distractions and interference of other females.

A young boar attempts to interact with all the females and many times persistently pursues a nonreceptive female. This behavior results because a boar uses a trial and error method of locating females in estrus and has trouble discriminating between receptive and nonreceptive females. The response of individual females to his investigative courtship rituals of chanting, chomping, salivating, nosing the female's side and flank, sniffing the ano-genital area and mounting attempts does influence his sexual behavior. The sequence of events which occur in precopulatory activity is shown in Figure 1.

Both sexual behavior and mating dexterity are more satisfactorily evaluated when only **one receptive female** is in the evaluation pen. Boars that have adequate sexual behavior and excellent mating dexterity will quickly mount and copulate.

Evaluation Procedure

Evaluate young boars at least two weeks before the breeding period when they are 7 to 7½ months of age. Some boars show signs of sexual development at five months of age. However, sexual development is a gradual process with age being a better indicator of sexual maturity than body size. There is not enough time to buy, isolate and evaluate a replacement boar for the breeding period if a boar with poor sexual behavior is not identified until one week before the breeding

Table 1. Variation between boars for mounting and copulatory behavior.

Study A			Study B		
Boar no.	Avg. no. mounts/eval.[a]	Copulation %	Boar no.	Avg. no. mounts/eval.[b]	Copulation %
A1	3.1	25.0	B1	1.0	33.3
A2	5.3	50.0	B2	1.8	100.0
A3	8.4	75.0	B3	2.2	100.0
A4	8.6	50.0	B4	2.7	100.0
A5	8.9	25.0	B5	3.8	100.0
A6	9.8	37.5	B6	9.0	100.0
A7	11.0	25.0	B7	9.0	50.0
A8	11.6	87.5	B8	10.8	66.7
A9	11.8	50.0	B9	12.7	50.0
A10	12.4	12.5	B10	13.0	16.7
A11	12.9	50.0	B11	14.0	16.7
A12	19.6	00.0	B12	14.5	66.7

[a,b]Number of evaluations per boar were 8 and 6, respectively.

period. This problem could be prevented if boars were evaluated at six months of age, but research has not been conducted to determine whether boars can be successfully evaluated for sexual behavior at six months of age.

Pre-test Familiarization. A young, inexperienced boar will exhibit sexual behavior more satisfactorily if given a 2-minute period to become familiar with the surroundings of the evaluation pen before the estrous female (gilt or sow in heat) enters the pen.

Time in Evaluation Pen. Upon access to an estrous female, a young boar should be allowed 15-20 minutes for expressing sexual behavior. Figure 2 shows that 99% of the copulations will occur within the first 13 minutes of the evaluation.

Behavior Traits to Observe. Two traits to evaluate are mounting behavior and mating dexterity. Mating dexterity is the more important. Some boars have a willingness and eagerness to mount and attempt intromission, but have low rates of successful matings (Table 1). The results of two studies are listed in Table 1. Boars are numbered in order by mounting frequency. Boar A12 was sexually aggressive, but after a short period of time became physically aggressive. This boar could not copulate because he thrust in a wild manner and overextended his penis. Boar A8 was sexually aggressive but due to his mating dexterity, was able to obtain an 87.5% copulation rate. One boar in each of the studies (A1 and B1) showed very little interest in females. These two boars spent most of their time standing or walking around in the evaluation pen. In study B, boars 7 through 12 were sexually aggressive but had lower percentage copulation than boars 2 through 6 as a result of poor mating dexterity.

Young boars should be evaluated for abnormal sexual behavior. In a third study, 9 of 12 boars performed at least one rectal ejaculation. The repeated incidence for most of the boars was low, except for two boars who showed a high incidence of rectal ejaculation (3 of 16 matings; 7 of 16 matings). The incidence of coitus interruptus (penis becoming limp and falling out) was observed in one boar during 7 of his 12 evaluations. The frequency of boars having these abnormal sexual behaviors is not known, but it can be and has been devastating to producers only using 1-3 boars.

Number of Evaluations. Data presented in Figure 3 indicate that boars should be evaluated at least four times. It should be noted that the percent improvement in the average sexual behavior score is small after four evaluations. To accomplish the four evaluations, the boars should be evaluated twice per week on consecutive days for two weeks.

Mating Assistance. Little research has been conducted which shows the value of mating assistance. Our research has shown that helping 8-month-old boars with their first four matings does not improve their mating success or time to copulation later in life (1984 Nebraska Swine Report).

Summary

Boars should be evaluated for sexual behavior two times per week for two weeks when they are 7 to $7^1/_2$ months of age. The objective is to identify boars that exhibit adequate sexual behavior and good to excellent mating dexterity during a series of four 15-minute evaluations.

[1]Donald G. Levis is Associate Professor, South Central Center, Clay Center. Ronald K. Christenson is Research Physiologist, U.S. Meat Animal Research Center.

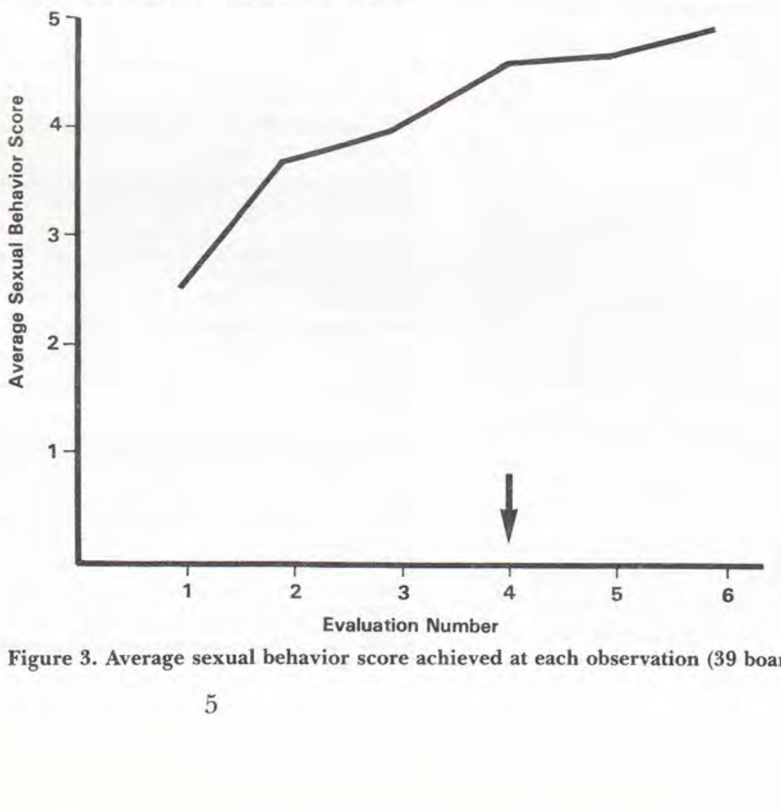


Figure 3. Average sexual behavior score achieved at each observation (39 boars).

A Fresh Pork Processing System

Chris R. Calkins
Casey B. Frye[1]

Mechanical portioning of pork loins into uniformly shaped and sized chops can reduce labor costs and may enhance yield. Additional savings in pork processing can be obtained by fabricating the carcass before chilling since energy is not used to chill excess fat and bone.

Previous research has focused on brine chilling as a method of rapidly cooling the hot pork muscle to facilitate mechanical portioning. While this approach of linking the two systems appears feasible, studies indicate potentially severe toughening when the muscle is cooled too rapidly. This occurs because the muscle pH is high, indicating that the muscle is still metabolically active. By delaying the time between slaughter and rapid chilling, metabolic activity should stop and muscle shortening (toughening) might be avoided.

Objectives of this research were to evaluate delay times between slaughtering and rapid chilling as a means of preventing muscle toughness.

Experimental Design

Loins removed from pork carcasses after a 1, 3, or 5 hour post-slaughter delay period were used to compare three rapid chilling methods (brine chilling by immersion in a sub-freezing salt solution; packing in dry ice; holding in a sub-freezing, carbon dioxide-chilled cabinet) to a conventionally chilled control (24 hours at 32°F). After crust freezing by one of the rapid chilling methods (or blast freezing the control), all loins were allowed 1 hour for temperature equilibration, pressed and cleaved into uniformly sized chops.

The time required to crust-freeze each loin was recorded and muscle pH at start of rapid chilling was observed. Frozen chops were evaluated for muscle shortening (sarcomere length) or cooked for tenderness assessment by a trained, sensory evaluation panel or shear force on an Instron Universal Testing machine.

Delay Time Important

Tables 1, 2 and 3 present the results of rapid chilling by brine chilling, dry ice packing, or in a carbon dioxide-chilled cabinet, respectively. In almost every case, a one hour time delay between slaughter and rapid chilling was not sufficient to prevent detrimental changes to the product. Chops from this treatment were higher in pH, had shorter sarcomeres and were generally less tender than the controls. However, when a delay time of three hours was imposed, chops compared favorably with chops from conventionally chilled loins.

These results suggest that by delaying at least three hours before rapidly chilling hot pork muscle, metabolic activity has stopped or slowed to the point where only minimal shortening and toughening may have occurred. This treatment did not take any longer to chill.

Rapid Chilling Methods

The response of pork muscle to any of the rapid chilling methods was similar. Each method reflects undesirable changes with only a one hour delay time while desirable results are obtained after three hours delay. Thus, from the product standpoint, brine chilling, dry ice packing, and chilling in a carbon dioxide-cooled chamber are acceptable techniques.

From our experience, however, the logistics of chilling with these methods should be examined. Brine chilled loins tended to float in the brine and had to be weighted down. Also, these loins had to be packaged before chilling to prevent salt from coming in contact with the fresh meat. Unless a showering system is used, use the other rapid chilling treatments.

Conclusions

Hot pork processing can be linked with mechanical portioning by several rapid chilling methods. It is imperative that a three or more hour delay period occur between slaughter and start of the rapid chilling technique.

[1]Chris R. Calkins is Assistant Professor, Meats. Casey B. Frye is a graduate student. The National Pork Producers Council partially funded this project.

Table 1. Results of brine chilling hot pork loins.

	Delay time (hour)			
Trait	1	3	5	Control
Chilling time (min)	100.9	114.9	113.6	168.2
Initial pH	6.58	5.87	5.80	5.53
Sarcomere length (μm)	1.17	1.70	1.79	1.98
Shear force value (Kg)	4.21	3.73	3.49	3.42
Tenderness rating[a]	8.13	9.15	7.41	8.20

[a]1 = tough; 15 = tender.

Table 2. Results of packing hot pork loins in dry ice.

	Delay time (hour)			
Trait	1	3	5	Control
Chilling time (min)	95.4	98.0	88.3	168.2
Initial pH	6.50	5.78	6.01	5.53
Sarcomere length (μm)	1.38	1.88	1.46	1.98
Shear force value (Kg)	4.16	3.55	3.15	3.42
Tenderness rating[a]	9.11	9.51	10.15	8.20

[a]1 = tough; 15 = tender.

Table 3. Results of carbon dioxide chilling of hot pork loins.

	Delay time (hour)			
Trait	1	3	5	Control
Chilling time (min)	91.7	84.8	79.6	168.2
Initial pH	6.49	6.07	5.89	5.53
Sarcomere length (μm)	1.26	1.70	1.72	1.98
Shear force value (Kg)	3.94	3.75	3.60	3.42
Tenderness rating[a]	8.06	8.16	9.34	8.20

[a]1 = tough; 15 = tender.

Reduction or Replacement of Sodium in a Pork Product

Chris R. Calkins
Roger W. Mandigo
Casey B. Frye[1]

Concern that excess sodium in the diet may cause hypertension and coronary heart disease has led many individuals to reduce sodium intake. While sodium, commonly eaten as salt (sodium chloride), can be ingested from many sources, attention has been focused on processed and manufactured meats. These products require some salt in the formulation to achieve sufficient bind and textural development in the product.

Table 1. Instrumental evaluations of tumbled, boneless ham manufactured with different chloride salts.

Treatment[a]	Break force (Kg)	Adhesion (g)
Na	1.80	22.4
K/Na	1.99	22.9
K	1.38	16.1
Mg/Na	0.62	3.6
Mg	0.56	2.4

[a]Na = sodium chloride (100%); K/Na = 50% potassium chloride/50% sodium chloride; K = potassium chloride (100%); Mg/Na = 50% magnesium chloride/50% sodium chloride; Mg = magnesium chloride (100%).

Several projects have been conducted to assess the feasibility of reducing or replacing sodium chloride with other chloride salts in highly emulsified products where mechanical action has aided protein extraction. It is not known if the same relationships exist in tumbled pork products. The objective of this study was to determine the feasibility of reducing or replacing sodium chloride in tumbled pork products by using other chloride salts.

Experimental Design

Lean, boneless ham pieces were used to manufacture 10 batches (20 lb each) of boneless, tumbled ham. The meat was pumped with one of five pickling brines formulated to be equivalent to 2% sodium chloride in the final product. The chloride salt treatments consisted of 100% sodium chloride (Na); partial replacement (50%) with potassium chloride (K/Na) or magnesium chloride (Mg/Na); or total replacement (100%) with potassium chloride (K) or magnesium chloride (Mg). The meat pieces were then ground through a kidney plate and vacuum tumbled for three hours, followed by a two hour equilibration time and an additional three hours of tumbling. The product was then stuffed into a no. 11 casing ($6^1/_8''$ diameter), pressed in smokehouse racks, cooked to 150°F and smoked. The hams were stored in a cooler for later evaluation.

Samples from the boneless, tumbled ham were served to an untrained sensory panel for evaluation of flavor, texture, juiciness, overall acceptability and aftertaste on 7-point scales (1 = extremely undesirable; 7 = extremely desirable). In addition, the strength of the bind between meat pieces was evaluated on an Instron Universal Testing Machine by breaking a 1 in. section of ham in half (break strength) or by pulling apart a ham slice (adhesion).

Sodium or Sodium/Potassium Best

Results of instrumental analyses are given in Table 1. In both tests (break strength and adhesion) no differences were found between the Na and the K/Na treatments. These were superior to all other chloride salt treatments in the development of bind and texture between ham pieces. This suggests that adequate solubilization of protein needed for texture development cannot be achieved unless Na or K/Na is used.

Table 2 presents results of the sensory evaluation panel. For every trait, the control (100% Na) was more desirable than any other chloride treatment. The ratings for the K/Na treatment, while lower than the control, were also in the desirable end of the rating scale. This probably means that either treatment would be accepted by the consumer. The K and Mg salts revealed an unacceptable flavor which was moderately enhanced by addition of Na.

Table 2. Consumer panel sensory evaluations of tumbled, boneless ham manufactured with different chloride salts.

Treatment[a]	Flavor[b]	Texture[b]	Juiciness[b]	Overall acceptability[b]	Aftertaste[b]
Na	5.41	5.51	5.16	5.37	5.34
K/Na	4.30	4.80	4.29	4.14	3.79
K	2.81	3.82	3.21	2.73	2.68
Mg/Na	3.54	4.06	3.42	3.46	3.59
Mg	1.75	2.33	2.30	1.83	1.90

[a]Na = sodium chloride (100%); K/Na = 50% potassium chloride/50% sodium chloride; K = potassium chloride (100%); Mg/Na = 50% magnesium chloride/50% sodium chloride; Mg = magnesium chloride (100%0.
[b]1 = extremely undesirable; 7 = extremely desirable.

Summary

It appears that an acceptable tumbled pork product can be created by replacing the ionic equivalent of 50% sodium chloride with potassium chloride. Other salts and salt combinations were unacceptable.

[1]Chris Calkins is Assistant Professor, meats. Roger W. Mandigo is Professor, meats. Casey B. Frye is a graduate student.

Figure 1. House mice damaged the insulation in this wall panel in a laboratory experiment at the University of Nebraska–Lincoln. The damage occurred in 6 months.

House Mice Damage Insulation

Robert M. Timm
Daryl D. Fisher[1]

Pork producers have reported increasing problems with rodents (Norway rats and house mice) in confinement buildings. These buildings often provide an ideal environment for rodents to feed, nest, and reproduce. The gnawing, nesting, and tunneling activities of these rodents often result in severe damage to insulation inside walls and attics.

From earlier surveys of Nebraska pork producers, we knew that few producers could give us precise estimates of economic losses caused by rats or mice in their confinement buildings. We decided to conduct a laboratory experiment to measure the amount of destruction that could be caused to different types of insulation by house mice.

We constructed "mouse pens" into which we placed 4 x 4-foot insulated wall sections. Into each pen, we placed three adult female and two male house mice. We provided them as much food and water as they would use. The mice were able to enter the wall panels through holes in the bottom of each panel.

We tested four different types of wall panels, each containing a different combination of insulation: (1) $3\frac{1}{2}''$ fiberglass batt; (2) $3\frac{1}{2}''$ fiberglass batt plus 1-inch extruded polystyrene (Styrofoam); (3) $3\frac{1}{2}''$ fiberglass batt plus 25/32-inch fiberboard sheathing; and (4) $3\frac{1}{2}''$ of loose-fill cellulose fiber. We wanted to see if some types of insulation were damaged by mice more quickly than others.

The mice lived and reproduced in the wall panels for six months. Although some mice survived the entire experiment, many present at the conclusion were ones which had been born during the test. On the average, there were 8.8 mice per wall panel at the end of the experiment.

Table 1. Reduction in insulating ability and resulting increase in heating costs as a result of house mouse damage. Values represent a hypothetical confinement building, 50 x 24 ft, maintained at 75° F at Lincoln, Nebraska.

Insulation	Average reduction in R value	Increased heating costs/ winter
Fiberglass	51%	$112
Fiberglass + Styrofoam	33%	$ 77
Cellulose Fiber	81%	$182
Fiberglass + Fiberboard	49%	$110

Damage Heavy

All insulation types were heavily damaged by mice (Figure 1). In fact, the mice actively removed insulation from all of the panels at such a rapid rate that two of the panels filled with cellulose fiber were essentially empty after $4\frac{1}{2}$ months. At the experiment's conclusion, we measured the insulating ability of the wall panels by cooling one side of each panel and taking measurements on the opposite side using a heat flow probe. This allowed us to quantify the damage in terms of a reduction in "R value" that was caused by the mice.

Table 1 summarizes the reduction in R value and the calculated additional heat loss from a hypothetical building which had suffered that degree of mouse damage. It is apparent that rodent damage in swine confinement buildings can be expensive for pork producers. Not only may the cost of heating such buildings be increased, but it would be expensive to re-insulate the building to repair the rodent damage.

The best way of preventing rodent damage is to keep very low numbers of rats or mice on the premises. Rodent-proof construction techniques can be used to exclude these pests from buildings, or at least exclude them from wall spaces. Conscientious use of appropriate rodenticides may help keep rodent populations in check.

For additional information on rodent control, the NebGuides "Rodent Proof Construction," "Controlling Rats," and "Controlling House Mice" are available from Nebraska Cooperative Extension Service offices.

---

[1]Robert M. Timm is Extension Vertebrate Pest Specialist, and Daryl D. Fisher is Graduate Assistant, Department of Forestry, Fisheries & Wildlife. This work was funded by Integrated Pest Management, USDA.

Alternate Feed Grains for Weanling Pigs

Roy Carlson
E. R. Peo, Jr.[1]

Although corn and grain sorghum will continue to make up the lion's share of the feed grains used in swine diets, every so often an economic opportunity surfaces for the use of "alternate" feed grains. For example, during 1984 wheat became cost-competitive with corn as a feed grain. As a result, many questions were raised as to whether or not wheat could be fed to swine and if so, how much? A similar economic situation developed as regards "popcorn." The "PIK" program and the diversion of acres from regular corn to popcorn raised questions as to the feeding value of popcorn for swine.

There is considerable information on the feeding value of wheat for swine but little on popcorn. Since feeding programs have changed over the years and nutrient requirements have been refined, we felt it was a good time to reevaluate the feeding value of wheat and to obtain some information on how to feed unpopped popcorn to pigs.

Wheat, Popcorn

Two experiments were conducted, one with wheat replacing 33%, 67% and 100% of the corn on a pound for pound basis in the grain portion of the diet and a similar study in which popcorn replaced 33%, 67% and 100% of the corn on a pound for pound basis.

Studies were conducted with weanling pigs since they often respond more quickly and more dramatically to dietary changes in nutrient composition or availability. Thus, we feel that the results obtained with young pigs are probably a direct reflection on what to expect with growing-finishing swine.

The results of the study with wheat are shown in Table 1. Pigs fed diets containing wheat gained faster and more efficiently than those fed the 100% corn (grain portion) diet. The best gain was made by pigs fed the diet where the grain portion of the diet was 2/3 corn and 1/3 wheat. The gains of the young pigs were good on all of the wheat diets. Compared to those fed the 1/3 wheat diet, gains decreased 13% when the grain portion of the diet was 1/3 corn and 2/3 wheat and 15% when the grain was 100% wheat. The wheat was ground to a medium consistency but feed intake decreased when the diets contained more than 1/3 wheat. Finely ground wheat will cause palatability problems in diets containing large amounts of wheat.

In the popcorn study, pigs fed regular corn gained 20% faster on 9% less feed than those fed popcorn (Table 2). It appears that the pigs did not prefer the popcorn diets because they consumed 12% less feed on the average than those

(Continued on next page)

Table 1. Comparison of corn and wheat ratios for weanling pigs[a] (Nebr. Experiment 84406).

	100% corn	67% corn 33% wheat	33% corn 67% wheat	100% wheat
ADG (lb)	.68	.86	.75	.73
ADFI (lb)	1.10	1.30	1.12	1.08
F/G	1.60	1.50	1.49	1.49

[a]Data based on 4 pigs/pen; 3 pens/treatment; int. wt 17.0 lb. Length of test 27 days.

Table 2. Comparison of regular corn and popcorn ratios for weanling pigs[a,b] (Nebr. Experiment 84407).

	100% regular corn	67% reg. corn 33% popcorn	33% reg. corn 67% popcorn	100% popcorn
ADG (lb)	.70	.59	.55	.59
ADFI (lb)	1.12	.97	.92	1.10
F/G	1.61	1.74	1.66	1.85

[a]Popcorn was graciously supplied by Blevins Popcorn Co., North Bend, Nebraska.
[b]Data based on 4 pigs/pen; 3 pens/treatment; int. wt 13.0 lb. Length of test 28 days.

Table 3. Nutrient composition of popcorn and regular corn.

Nutrient, %[a]	Popcorn	Regular corn
Dry matter	88.3	87.0
Protein	10.5	8.7
Calcium	0.01	0.02
Phosphorus	0.29	0.28
Amino acids		
Lysine	0.29	0.25
Methionine	0.25	0.20
Threonine	0.38	0.36

[a]Analyzed values, as-fed basis. Source of popcorn was Blevins Popcorn Co., North Bend, Nebraska.

Alternate Feed Grains . . .

(continued from page 9)

fed the regular corn diets. Surprisingly, when popcorn made up 100% of the grain portion of the diet, the pigs consumed nearly as much feed per head per day as those fed the diet with 100% regular corn. The popcorn used was a very clean, yellow variety and was ground through the same screen size (1/4") as normal corn.

Performance Lower on Popcorn

The reason for the reduced performance of the pigs fed popcorn is not known. Popcorn is higher in crude protein than regular corn but this was not considered in this study since the substitution of popcorn for regular corn was made on a pound for pound basis. The reduced performance of pigs fed popcorn should not have been due to protein or amino acid deficiency since the basal diet calculated 19.6% crude protein and 1.1% lysine, more than adequate for pigs of the starting weight used in the study. As indicated, popcorn was substituted for regular corn on a pound for pound basis. Thus the popcorn diets had to be higher in crude protein and lysine than the regular corn diet since the popcorn fed analyzed nearly 2% higher in crude protein and .04% higher in lysine than regular corn (Table 3). Further research is planned to determine how to make better use of popcorn in swine feeding programs.

At the moment there are few alternate markets for non-salable popcorn. While pig performance may be reduced somewhat, until we know more about it, if you have popcorn, feed it. If wheat is available and price-competitive with corn it can be used to great economic advantage in swine diets. Further savings can be realized if the diet is reformulated on a lysine basis. Remember in calculating cost comparison that good quality wheat is 60 lb/bushel; #2 corn is 56 lb.

---

[1]Roy Carlson is Research Technician. E. R. Peo, Jr. is Professor, Swine Nutrition.

Ergot sclerotia (black) in grains can be toxic.

Ergot and Swine Reproduction

Norman R. Schneider
Martin L. Wiernusz
Alex Hogg
Robert D. Fritschen[1]

Ergot infections of rye and other cereal grains are often reported, especially under damp growing conditions. Epidemics of ergotism in both domestic animals and humans have occurred during the last 2,000 years, and still occur when ergot-contaminated grain or grain based foods or feedstuffs are ingested.

Ergot sclerotia, fungal fruiting bodies of *Claviceps* spp., may contain 10 or more biologically active alkaloids. Sclerotia displace whole kernels in developing grain heads, and often exceeds 5-10% of the weight of the harvested grain. Cereal grains are prohibited in interstate commerce when sclerotia concentrations exceed 0.3%.

Classic toxic manifestations of ergot alkaloid ingestion are convulsions, reduced blood circulation to extremities, and abortion. Ergotism was called St. Anthony's fire, in reference to the medieval saint whose help was sought in relieving the buring pain in extremities deprived of blood supply.

Consumption of ergot by pregnant sows may cause a number of adverse effects. The most common are decreased piglet birth weight,

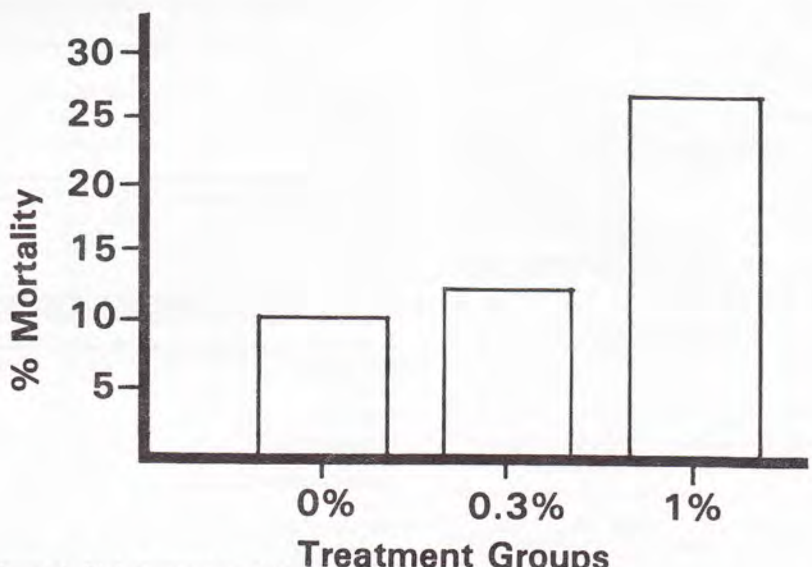


Figure 1. Piglet mortality at birth.

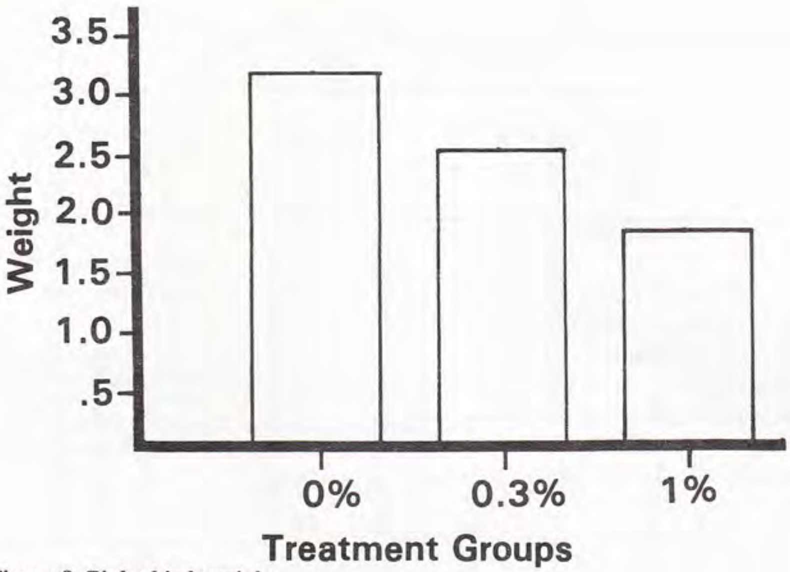


Figure 2. Piglet birth weight.

increased neonatal mortality and lack of milk production (agalactia).

The present research was designed to characterize effects of rye ergot alkaloids in swine during gestation and lactation. Results from these studies may lead to improved management of alkaloid toxicosis in swine. Knowledge of dosage-related biological responses in swine ergotism will permit better evaluation of exposure, minimize economic impact and ultimately help in the development of effective preventive and therapeutic measures.

Materials and Methods

Three treatment groups, each consisting of six pregnant gilts, were fed diets containing 0, 0.3 and 1% ergot sclerotia. Experimental diets were fed from 30 days after breeding to 21 days after farrowing. Ergot sclerotia used in the experimental diets were obtained from contaminated rye grown in north-central Nebraska. Sclerotia were separated from grain by density flotation and incorporated in diets at specified concentrations. Basal diets are listed in Table 1.

Bred gilts were purchased from a SPF farm in northeast Nebraska. Ultrasonic diagnosis and vaginal biopsies were performed on each sow to confirm pregnancy approximately 35 days after breeding. With breeding date considered day 0, feeding trials were started on day 30 of gestation. Each gilt was fed about 4 lb of feed daily until farrowing, then was fed *ad libitum* during lactation.

Health of each gilt was evaluated, pens were examined for aborted fetuses and visual evaluation of external genitalia was performed daily until farrowing. The following measurements were evaluated during feeding trials: litter size, piglet mortality at birth, birth weight, milk production, piglet survival and weight gain to weaning.

Results

One gilt in the 0.3% treatment group aborted. In addition, one gilt confirmed pregnant in the 0.3% treatment group failed to farrow. No abortions or complete fetal resorption occurred in either the 0% and 1% treatment groups.

Litter sizes for the three treatments averaged 7.8, 5.3 and 8.8 for 0, 0.3 and 1% groups, respectively. Piglets born dead comprised 10.25, 12.5 and 26.4% of the 0, 0.3 and 1% treatment groups (Figure 1). Piglet mortality was more than twice as great in the 1% treatment group as in the control group.

Table 1. Composition of basal diets.

	Percent of diet	
Ingredient	Gestation	Lactation
Ground rye	50.0%	50.0%
Ground corn	38.8	33.4
Soybean meal	6.3	11.8
Dicalcium phosphate	2.3	2.8
Ground limestone	0.8	0.5
Salt	0.7	0.5
Trace mineral mix	0.05	0.05
Vitamin premix	1.0	1.0

Table 2. Percent of total living piglets per treatment.

Pig age	Group		
in days	0%	0.3%	1.0%
1	100	96	79
2	100	75	15
3	97	64	0
7	91	64	0
21	86	61	0

An inverse relationship between piglet birth weight and sclerotia concentration was observed. Average piglet birth weight for 0, 0.3 and 1% groups were 3.18, 2.5 and 1.83 lb, respectively (Figure 2).

Milk production varied considerably between the three treatment groups. Two gilts in the 0.3% treatment group were agalactic, and all gilts in the 1% treatment group were agalactic.

Piglet survival rate during the 21-day lactation period also varied greatly between treatment groups (Table 2). During the first day after farrowing, 21% of piglets in the 1% treatment group died, as compared to 4 and 0% for the 0.3 and 0% groups, respectively. Neonatal mortality on the second day after farrowing was 85, 25 and 0% for 1, 0.3 and 0% groups, respectively. By the seventh day, all piglets (100%) in the 1% group had died, compared to 36 and 9%, respectively, in the 0.3 and 0% control groups.

Piglet weight gains were compared at various intervals throughout the trial (Table 3). Control group piglets had trends for higher weight gains and higher weaning weights than the 0.3% group. No 1% group piglets survived to weaning.

Discussion

Ingestion of ergot-contaminated feed by pregnant gilts had detrimental effects on pregnancy, reproductive performance, and lactation. One of the most obvious

(Continued on next page)

Ergot . . .

(continued from page 11)

effects was agalactia. Another apparent effect was that of abortion and fetal death.

Effects of ergot alkaloids on reproductive performance were manifested by increased piglet mortality at birth, decreased birth weight, and decreased weight gain to weaning. These effects were more obvious in the 1% treatment group and appear to be dosage related.

These data indicate that dietary concentrations of ergot sclerotia greater than 0.3% in swine feed have potentially detrimental effects on overall reproductive performance of swine. Severity of effects is directly related to dietary concentration. Utilization of ergot-contaminated feed is not recommended for pregnant or lactating sows, and could severely compromise the success of a swine farrowing operation. Effects of feeding swine ergot-contaminated feed with less than 0.3% ergot sclerotia are unknown, but could adversely affect reproductive performance.

Table 3. Average weights of piglets.[a]

Pig age in days	Group 0%		Group 0.3%		Group 1.0%	
1	3.18	n=5	2.51	n=5	1.83	n=6
4	3.66	n=5	3.77	n=3	0.00	n=6
7	4.54	n=5	4.14	n=2	0.00	n=6
14	6.35	n=4	5.84	n=2	0.00	n=6
21	13.32	n=4	12.43	n=2	0.00	n=6

[a]Means were calculated from average litter weights for all surviving litters per treatment.
n=litters per group.

[1]Norman R. Schneider is Associate Professor, Veterinary Toxicologist, Veterinary Science. Martin L. Wiernusz is Graduate Research Assistant, Veterinary Science. Alex Hogg is Extension Verterinarian and Professor, Veterinary Science. Robert D. Fritschen is District Director, Panhandle Center, Scottsbluff. Supported in part by Union Pacific Foundation and Nebraska Agricultural Research Division Project 14-024.

Hog-house Dust Reduced With Fat in Diet

Lee I. Chiba
E. R. Peo, Jr.[1]

The results of a recent University of Nebraska survey indicated that 47.5% of producers surveyed said they were bothered by hog-house dust or odor. This number could have been higher if the survey included only those who used total confinement facilities.

Hog-house dust is potentially dangerous, not only as a carrier of pathogenic microorganisms and harmful gases, but because of its direct adverse effect on the respiratory tract of pigs and people. In humans, dust can induce acute or chronic malfunction of the respiratory tract which is often associated with symptoms such as coughing, chest tightness, wheezing, stuffy nose, short breath, eye irritation or watering, headache, and dizziness. Raising swine in a dusty condition may predispose animals to respiratory disorders.

Also, the hog-house dust has adverse effects on buildings, equipment and is an obnoxious odor, as most producers realize.

Pneumonia

Pneumonia is unquestionably one of the most frequently encountered pathological conditions in pigs, and hog-house dust has been blamed for the incidence and aggravation of pneumonia. Chronic pneumonia, characterized by low mortality and high morbidity, has been assessed as between 35 and 60% in Iowa. It has been reported that 50 to 70% of pigs passing through bacon factories in England have shown signs of pneumonia. The reduction of body weight gain attributed to the presence of chronic pneumonia has been reported from negligible to 16%. One researcher indicated that the respiratory disease may cause two dollars per hog loss nationally, and even mild pneumonia can reduce rate of gain as much as 10%.

Animal Fat Energy Source

Inedible animal fat such as tallow and lard is an excellent energy source, being about 2.25 times that of grain. Many researchers, at the Nebraska Station and elsewhere, have shown that as the energy density of growing-finishing swine diets increase, feed intake will decrease without adversely affecting gain, thus resulting in an improvement in feed efficiency. Therefore, the use of animal fat in growing-finishing diets is largely determined by economical considerations, i.e., to use animal fat when the price of fat is less than 2.25 times the price of grain.

Table 1. Composition of experimental diets (Neb. Exp. 82417, 83302 and 84403).

	Trial 1[a] MOF		Trial 2[a] MOF		Trial 3 and 4[b] ER	
Diet[c]	1 (W/T)	2 (WO/T)	1 (W/T)	2 (WO/T)	1 (W/T)	2 (WO/T)
Ingredients						
Corn	71.70	77.95	74.32	77.07	74.50	80.74
SBM	20.05	18.85	19.71	19.48	17.25	16.04
Tallow	5.00		2.50		5.00	
Limestone	.95	.95	.91	.93	.93	.96
Dicalcium phosphate	.95	.90	1.21	1.17	1.02	.96
Salt (iodized)	.25	.25	.25	.25	.25	.25
Trace mineral mix	.05	.05	.05	.05	.05	.05
Vitamin premix	1.00	1.00	1.00	1.00	1.00	1.00
Selenium premix	.05	.05	.05	.05		
	100.00	100.00	100.00	100.00	100.00	100.00

[a]Diets are formulated to contain 15% crude protein.
[b]Diets are formulated to contain 14% crude protein.
[c]W/T=with tallow; WO/T=without tallow.

ciency of 9.2, 2.8, 8.5 and 10.2% for trials 1, 2, 3 and 4, respectively, compared to those fed diets containing no added tallow.

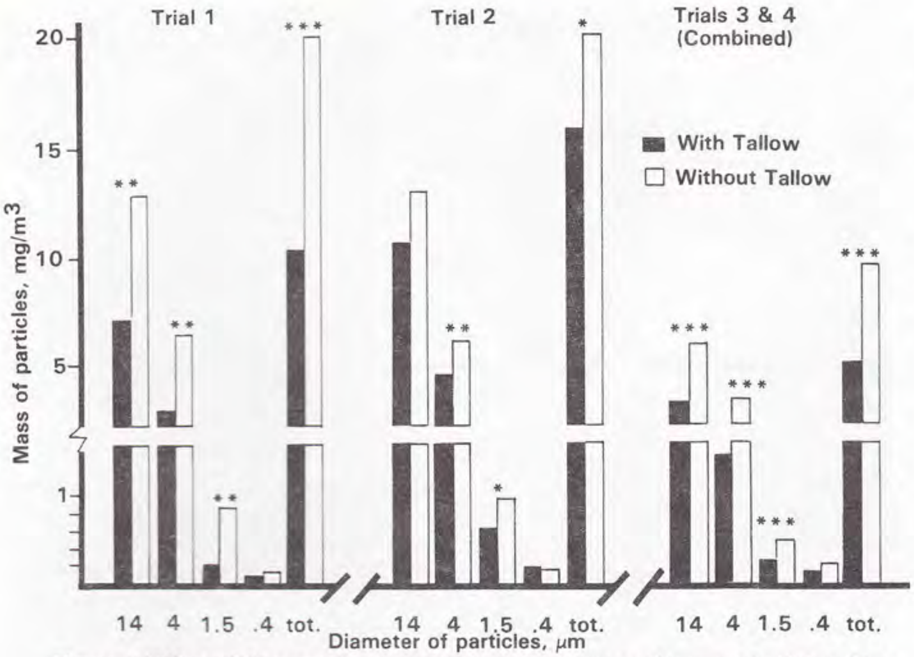


Figure 1. Effect of dietary tallow on aerial-dust levels in confinement facilities. Diets (W/T) contained 5% added tallow in trials 1, 3 and 4, and 2.5% in trial 2. *P<.05; **P<.01; ***P<.002.

Additional Benefits

Adding fat to swine diets has many benefits beyond its high energy value. It may increase palatability of feed, increase vitamin stability, reduce wear on mixing and handling machinery through its lubricating action, and aid in the absorption of other nutrients. Fat also aids in the reduction of dust loss and controls feed dust during the preparation and feeding of diets. This aspect of the use of animal fats in swine diets may have a significant impact on today's production systems. Since hog-house dust is mostly "feed dust," fat can play an important role in improving air quality in swine confinement facilities.

Studies Conducted

Four trials were conducted with a total of 1,480 pigs to determine the effect of dietary fat on pig performance and dust levels in confinement facilities. Two naturally ventilated modified open front (MOF) units were used in trials 1 (November, 1982-February, 1983) and 2 (March-June, 1984) and two totally enclosed environmentally regulated (ER) growing-finishing confinement units were utilized in trials 3 (April-June, 1983) and 4 (September-November, 1983).

The composition of experimental diets used in trials 1, 2, 3 and 4 is presented in Table 1. In trial 1, the 250 pigs (25 pens of 10 pigs/pen) in MOF-1 were fed diet 1 (5% added tallow) whereas those in MOF-2 were fed diet 2 (no added tallow). The diets were reversed for the two MOF units in trial 2. However, in this trial diet 1 contained only 2.5% added tallow. In trials 3 and 4, the 120 pigs (12 pens of 10 pigs/pen) in ER-1 were fed diet 1 (5% added tallow) whereas those in ER-2 were fed the same diet but containing no added tallow (diet 2).

Aerial-dust concentrations were measured weekly using a four-stage cascade type impactor that separates dust particles into size classes (14, 4, 1.5 and .4 μm). Settled dust determinations were made on the basis of the weight of dust which settled on 8 cm diameter petri dishes (12/unit, trials 1 and 2; 10/unit, trials 3 and 4) placed throughout the facilities. The lungs and snouts of a representative sample of pigs from each unit were subjected to complete gross pathological examination at the end of trials.

As expected, pig performance was improved by the addition of tallow to the diet. Pigs fed the diets containing 5 and 2.5% tallow showed an improved feed effi-

Aerial-dust levels reduced by 50%

The effect of dietary tallow on aerial-dust levels is summarized in Figure 1. Addition of 5% tallow to the swine diet reduced aerial-dust concentrations in all size classes in trials 1, 3 and 4. In trial 1, in which a diet containing 5% tallow was used, aerial-dust was reduced 49.1% whereas the reductions were 48.2 and 51.4% in the ER units for trials 3 and 4, respectively.

The concentrations of aerial-dust in the units, where the diet containing no added tallow was used, were similar for both trials 1 and 2. However, the dust levels in the units, in which diet 1 (5 and 2.5% added tallow) were used, were different according to levels of tallow in the diets (49.1% reduction in trial 1 vs 21.4% in trial 2). This may suggest the superiority of 5% added tallow in the diet over 2.5% for reducing hog-house dust.

Overall, aerial-dust levels were lower in the ER units than MOF units. This may suggest that mechanical ventilation systems are an effective and practical way of removing some of the particulate matter from confinement units. Thus, mechanical ventilation, along with addition of fat to swine diets, can contribute to a further reduction in aerial-dust concentrations.

A word of caution! The potential airborne materials are drier with greater ventilation rates and thus may actually increase hog-house dust problems. Furthermore the

(Continued on next page)

Table 2. Effect of dietary tallow on settled dust levels in confinement facilities (Neb. Exp. 82417, 83302 and 84403).

	Settled dust, grams	
	Diet	
	1[a] (W/T)	2 (WO/T)
Trial [b]		
1 (53 and 30 days)[cd]	2.11	3.55
2 (27 days)	.80	.89
3 (49 days)[d]	2.18	2.84
4 (53 days)[d]	1.12	1.87

[a]Contained 5% added tallow in trials 1, 3 and 4; 2.5% in trial 2.
[b]Days in () indicate dust collection period.
[c]Average of two sample sets.
[d]Means are different (P<.001).

Hog-house Dust . . .

(continued from page 13)

lower relative humidity, associated with mechanical ventilation, may interfere with the functions of the lungs to remove foreign intruder from their system. Also, the ventilation systems currently used are designed for controlling temperature and humidity, not for removing particulate matter from the animal's environment. Therefore, increased ventilation capacity and higher ventilation rates will be required for air purity than are desirable for temperature and moisture control.

The results of settled dust determination are presented in Table 2. Addition of tallow to the diet of growing-finishing swine resulted in 41, 10, 23 and 40% reduction of settled dust in trials 1, 2, 3 and 4, respectively. Five percent tallow reduced settled dust quite markedly (trials 1, 3 and 4), but 2.5% tallow had a small effect on reduction of settled dust (trial 2).

Source of Hog-house Dust

Hog-house dust consists of minute particles of solid matter such as soil, feed, hair and skin debris, plant spores, and dried fecal material. If the feed dust was reduced by the addition of fat to the diets, then crude protein value should increase because of increased proportion of hair and skin debris (high in crude protein) in the hog-house dust. Figure 2 illustrates this point. As the aerial-dust concentrations decrease, the crude protein values increase. These results, along with microscopic examinations of collected dust, suggested that hog-house dust is mainly feed dust.

Table 3. Effect of dietary tallow on lung lesions of pigs reared in confinement facilities (Neb. Exp. 82417, 83302 and 84403).

	Trial							
	1		2		3		4	
Diet	1[a]	2	1[b]	2	1[a]	2	1[a]	2
Lung score[c]								
0	8	4	10	5	3	7	6	5
1[de]	18	14	2	3	16	5	1	3
2[e]	4	3	7	4	5	9	5	12
3	0	3	9	10	3	3	10	7
4	0	2	4	6	2	5	4	1
5	0	0	1	0	2	3	0	0
6	0	0	0	2	0	0	0	0
Total	30	26	33	30	31	32	26	28

[a]5% added tallow in a diet.
[b]2.5% added tallow in a diet.
[c]Higher the value greater the degree of lung lesions.
[d]Denotes difference between the treatments in trial 3 (P<.05).
[e]Denotes difference between the treatments in trials 3 and 4 combined (P<.05).

Lung Lesions

Results of the lung examination at the end of trials are summarized in Table 3. Most of the lung samples showed various degrees of lung lesions in all four trials. Although there was no relationship between dietary treatments and lung lesion scores, there was a tendency for pigs fed diet 2 (without fat) to have more severe forms of lung lesions than those fed diet 1 (with fat) in trials 1 and 3. A similar trend was not observed in trials 2 and 4. However, the dust reduction was only 21.4% in trial 2 and aerial-dust levels in trial 4 were substantially lower (2.9 mg for diet 1 and 6.0 mg/m^3 of air for diet 2) than the rest of trials. Therefore, small difference between the two units in trial 2 and lower dust levels in trial 4 may have had some influence on the pattern of incidence of lung lesions.

There was no difference in incidence of abnormal turbinates (snouts) between the two dietary treatments in all four trials.

Conclusion

The advantages of using fat in growing-finishing swine diets have been mentioned previously. The role of fat as a bonding agent of minute particles seems obvious. Therefore, fat can aid in reduction of dust losses and control feed dust during diet preparation and feeding. The fact that simply adding 5% fat to the diet can reduce aerial-dust levels by 50%, regardless of building type and season, might be an additional justification for using fat in the swine diets. These, in turn, may contribute to the reduction of health hazards of swine and animal attendants associated with the hog-house dust.

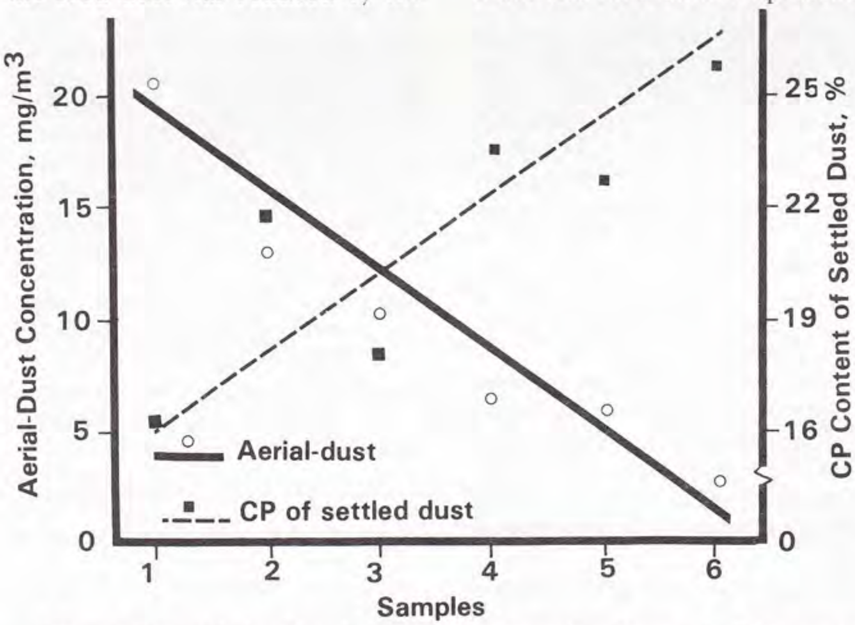
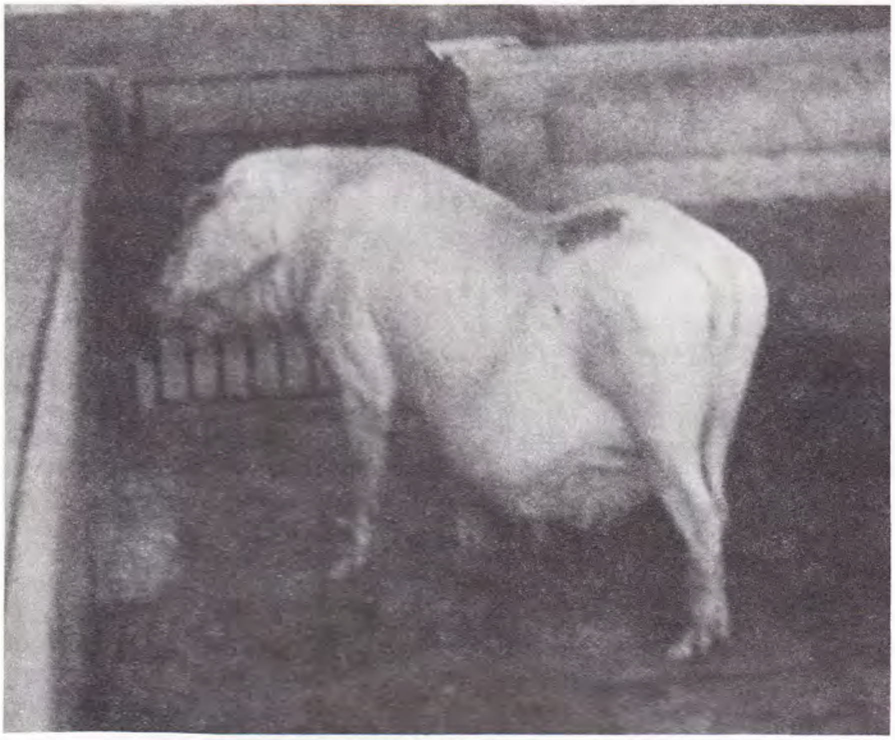


Figure 2. The relationship of aerial-dust levels and crude protein (CP) content of settled dust in swine confinement facilities (Neb. Exp. 83302 and 82417). Mean total aerial-dust concentrations of both treatments and trials are plotted in descending order and CP content of settled dust are plotted against those points (r = −.87; P<.05).

[1]Lee I. Chiba is a graduate student. E. R. Peo, Jr., is Professor, Swine Nutrition.



The Chinese pig.

Try the Chinese Pig

William T. Ahlschwede[1]

Travelers to the Peoples Republic of China have observed large litters in several Chinese breeds. Some have suggested that we immediately import these pigs to enhance productivity levels in the US. However, procedures adopted to protect the health of the US swine herd make importation both costly and lengthy.

Because of the time and expenses we would like reasonable assurances that the germ plasm would be useful. This study evaluated the economic impact of including a highly prolific breed in commercial crossbreeding systems. If reasonably expected production levels in an imported breed led to projections of substantial profit improvement, then importation would be encouraged. If the expected improvement in production led to only small improvement in expected profit, the importation would seem unwise.

Systems Analysis Used

A Crossbreeding Systems Analysis procedure was used to assess the potential profit from the inclusion of a highly prolific breed in crosses. The procedure (see 1982 Nebraska Swine Report) calculates the breed composition and heterosis level in a given crossbreeding system, estimates production levels for each generation in the system and projects an economic outcome. The analysis program relies upon inputted breed averages as the base for expected performance levels. The economic projections are based on a production budget, modified to reflect variable levels of production.

The inclusion of a Chinese breed in the program is somewhat speculative. We have no experience with Chinese pigs in this country. In addition to the reports of returning travelers, which reflect production only under conditions in China, a study has been conducted in France using three of the Chinese breeds. The French study provided estimates of litter size and pig survival for three breeds. Data supporting Chinese breed values for rate of gain, feed efficiency and carcass fatness were not available.

To include a Chinese breed in the analysis system, it was necessary to assign performance data to the breed, rather than basing it upon research data. The reproduction performance was based upon the results of the French study, using one of the most prolific breeds. The pig performance data were assigned to place the "Chinese" breed at a disadvantage. The breed averages for all breeds used in the study are show in Table 1.

In addition to assigning slow inefficient growth and fat carcasses to the Chinese breed, the economic evaluation was adjusted to further discriminate against the exotic breed. The cost of weaning an extra pig per litter was increased to pay for extra sow feed (100 lb extra gestation feed per litter per extra pig). Fat pigs were discriminated against at market by using the NPPC Pork Value System of pricing. An increase of 0.1 in fat reduced market value by 1%.

The economic evaluation system produces a break even situation at $45 per cwt with an 80% conception rate, 7.5 pigs weaned per litter, pigs reaching market weight at six months of age with 1.15 in fat at

(Continued on next page)

Table 1. Breed averages used in crossbreeding systems analysis.[a]

Breed	Con	Born	Surv	Days	Fat	F/G
Yorkshire	72	10.80	72	177	1.20	3.35
Landrace	69	10.00	84	180	1.40	3.60
Hampshire	85	9.00	66	183	1.00	3.30
Duroc	85	9.60	66	172	1.20	3.33
Chinese	85	14.60	90	220	1.60	4.00

[a]Con is conception rate
Surv is piglet survival rate
Days is days to 220 lb or days to market
Fat is backfat thickness at the last rib

The Chinese Pig . . .

(continued from page 15)

the last rib and using 3.5 lb feed per lb gain from 40 to 220 lb. Improvements in performance in any of these traits increases profit. Reduction reduces profit.

The outcomes of the Crossbreeding Systems Analysis evaluations are given in Table 2. Systems A and B do not use the prolific breed. A is a three-breed rotation among Hampshire, Duroc and Yorkshire. System B is a four-breed terminal using F_1 Yorkshire-Landrace females. The matings necessary to produce the replacement gilts are included in the system. The results for these two systems are somewhat different than previously reported due to the changes in the economic evaluation system. System C is a three-breed rotation substituting the "Chinese" breed for Hampshire. The cyclical nature of the rotation crosses is apparent from these results, as is the impact of increased litter size in the "exotic" crosses. Systems D and E are terminal crossbreeding systems, adding the "Chinese" breed on the sow side of System B. In these systems, the sows producing the terminal cross market hogs are 1/4 "Chinese." The difference in these two systems is in the way replacement gilts are produced. In System F, the sow producing the terminal cross is 1/2 Chinese. This system substitutes the Chinese breed for the Landrace in System B.

The productivity differences shown between System A and B are reflective of differences observed by pork producers and verified by enterprize records. The added profit potential projected in systems using the "Chinese" crosses indicates that added increments of sow productivity will yield added increments of profit. This is in the presence of sizable discounts for added fatness and slow inefficient growth. The added $40-50 potential profit due to including the Chinese pig is attractive.

The differences among Systems C, D, E and F reflect breeding system differences. The economic disadvantage for System C is that one of the three generations is much less productive than the other two. The differences between the last three systems is due to the cost of producing replacement gilts.

Table 2. Results of crossbreeding systems analysis using a Chinese breed (100 litters produced).

BoarxSow	Percent in system	Concep-tion %	Pigs raised	Days to market	Backfat	Feedlot F/G	Projected profit on 100 litters: Mating	System
A Hamp, Duroc, Yorkshire rotation								
H x Y,R	33.33	80	856	169	1.07	3.26	7460.53	
D x H,R	33.34	83	796	165	1.12	3.27	5290.60	
Y x D,R	33.33	85	902	166	1.15	3.28	5180.94	5977.31
B four breed terminal cross								
Y x Y	5	72	778	177	1.2	3.35	2286.33	
L x Y	15	72	843	166	1.27	3.41	3572.68	
HD x L,Y	80	87	955	166	1.18	3.33	9372.14	8147.93
C Duroc, Yorkshire, China rotation								
D x C,R	33.33	83	1171	175	1.29	3.46	12165.99	
Y x D,R	33.34	85	984	171	1.24	3.38	8732.62	
C x Y,R	33.33	80	1002	189	1.40	3.65	3085.09	7994.64
D Terminal with China maternal greatgrandsire								
L x L	2	69	840	180	1.4	3.6	−419.36	
C x L	5	69	873	186	1.47	3.72	−1814.85	
Y x C,L	15	80	1211	175	1.32	3.5	12188.19	
HD x Y,CL	78	89	1071	170	1.2	3.38	11969.66	11065.43
E Terminal with China maternal greatgrand-dam								
C x C	2	85	1312	220	1.6	4.00	429.33	
L x C	5	85	1319	186	1.47	3.72	9022.81	
Y x L,C	15	80	1211	175	1.32	3.50	12188.19	
HD x Y,LC	78	89	1071	170	1.2	3.38	11969.66	11624.29
F Terminal with China maternal grandsire								
Y x Y	5	72	778	177	1.2	3.35	2286.33	
C x Y	15	72	855	185	1.37	3.60	166.30	
HD x C,Y	80	91	1189	175	1.23	3.43	14263.81	11550.31

Imports Warranted

The results of this evaluation indicate considerable economic advantage due to the use of a breed more prolific than currently available in the USA. While some of the Chinese breeds are even more prolific in China than the figures used here, it is difficult to predict how those breeds would produce in this country. The French studies give us some confidence that a Chinese breed can be found that will produce well here.

The added economic advantage projected by including a highly prolific breed in crossbreeding systems appears to be large enough to merit further pursuit. A first step would be to import representatives from several of the prolific Chinese breeds and test them and their crosses in our management systems. The results of these tests would serve to verify the potential value of including those breeds in our crosses. These tests would serve to identify which of the Chinese breeds are best candidates for use here.

The advantage predicted from including a highly prolific exotic breed in production systems in this country is large enough to encourage speedy pursuit.

[1]William T. Ahlschwede is Extension Swine Specialist.

Nursery Feeder Space—How Much?

M. C. Brumm
D. Carlson[1]

To maintain low nursery facility costs, pork producers want to provide the least amount of feeder space compatible with adequate weaned pig performance. Currently, producers are confronted with varying claims and recommendations for the number of feeder holes, ranging from one pig per feeder hole up to four pigs per hole. This study was conducted to determine what effect feeder hole availability had on weaned pig performance.

In this study, 3½ to 5-week-old newly weaned pigs were housed in a flat deck nursery. Each 4 ft x 4 ft pen had a woven wire floor, open mesh sides, one feeder, one nipple drinker and held eight pigs (2 ft^2/pig). The feeders utilized had five feed holes, each measuring 5.5 inches x 5.5 inches. Feeder holes were restricted by means of a plywood insert in two or four of the feeder holes to provide one, three, or five feeder holes per pen.

At the start of the 35-day experiment, the newly weaned pigs were assigned to the experimental feeder hole treatments based on weight groups. The pigs were fed a commercial pelleted diet *ad libitum* for the duration of the experiment. Pigs were weighed weekly with feed intake and efficiencies determined at that time.

Table 1. Effect of feeder space on weaned pig performance.

Item	Feeder space 1	3	5
No. of pigs	31	32	32
Weight (lb); initial	15.2	14.8	14.9
final	37.0	36.9	35.5
ADG, lb	.63	.63	.59
ADF, lb	.89	.96	.93
F/G	1.42	1.50	1.57
Dead/removed, no.	2	1	0

Results

To minimize weight variation within each pen, pigs were divided into heavy and light weight groups, with average starting weights of 18.9 and 11.1 pounds, respectively. There was no interaction between initial weight and the number of feeder holes.

Restricting the number of feeder holes had no significant effect on average daily gain, feed intake, or feed conversion (Table 1). During the entire trial, pigs in pens with one feed hole were observed to compete more for the available hole. This aggressive behavior might be an explanation for the greater weight variation observed in these pens (Figure 1). However, this competition also served to slightly restrict daily feed intake, resulting in a 9.5% improvement in feed conversion compared to the pigs in pens with five holes.

In the pens with five feed holes, the pigs formed a habit of dunging in one or two of the feeder corners, causing wasted feed which contributed to a nonsignificant depression in feed efficiency. Pigs in pens with three feed holes made the best apparent use of their space with little aggression observed and the least amount of variation in the weight of pigs within the pen.

After only two weeks in the experiment, pigs in pens with one feeder hole had a 13.3 pound range in weight within a pen as opposed to only a 9.0 pound range for three feed holes and an 8.5 pound range for five holes ($P<.05$). At the termination of the 5-week experiment, the smallest range was 14.5 pounds for three feed holes and the largest was 25.8 pounds for the one feed hole ($P<.05$).

Conclusion

In conclusion, pigs in pens with three feed holes (2.7 pigs per hole) had the best performance with the least amount of weight variation at the end of the experiment. Pigs in pens with one feed hole (8 pigs per hole) had the greatest weight variation while pens with five feed holes (1.6 pigs per hole) had problems with messy feeders and wasted feed. The results support the current recommendation of 2 to 3 pigs per feed hole for newly weaned pigs in flat deck nurseries.

---

[1]M. C. Brumm is Assistant Professor, Animal Science. D. Carlson is a student in Animal Science.

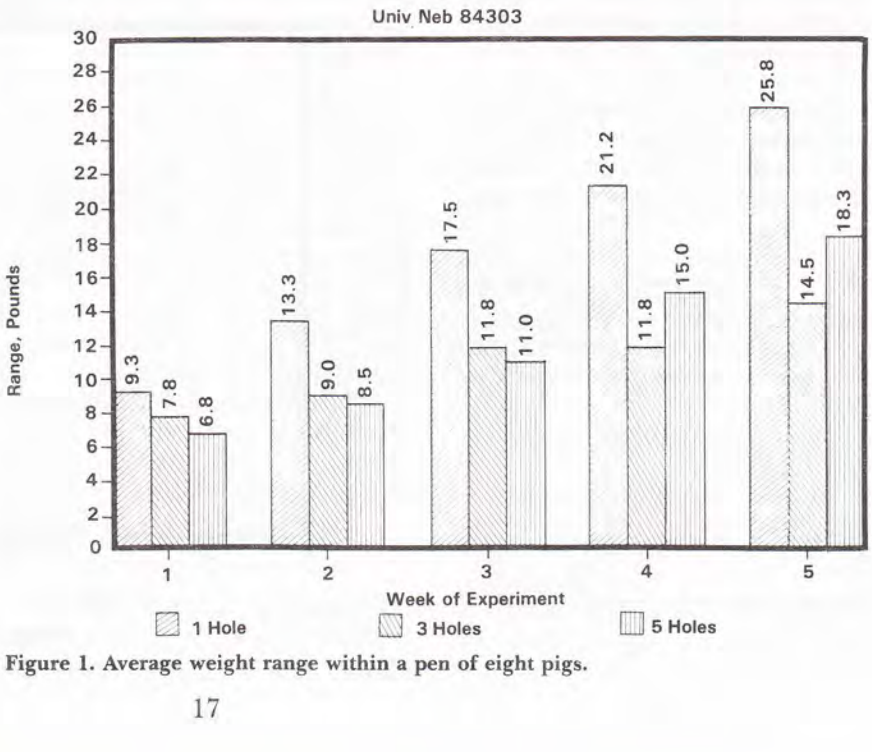


Figure 1. Average weight range within a pen of eight pigs.

To market, to market.

Managing Comingled Feeder Pigs

M. C. Brumm
G. W. Jesse
H. F. Mayes
G. M. Zinn[1]

The comingling, marketing, and transporting of feeder pigs results in considerable weight loss. It is common for pigs given no access to feed or water during the marketing routine to have shrinks of 10% or greater from payweight to arrival weight at a finisher's farm. Producers buying these comingled pigs often resort to feeding receiving diets lower in protein than normal grower diets in an effort to reduce post-arrival scours. An experiment was conducted to determine the effect of market management and receiving diet protein level on the performance of feeder pigs.

In each of two trials, comingled graded feeder pigs were purchased from a southern Missouri auction market and transported 650 miles to the University of Nebraska's Northeast Center. Pigs were individually weighed when they arrived at the market around 8 pm on a Monday evening, and were given either no access to feed or water (N) or two pounds of a 16% commercial crumble and access to water (FW). Following the Tuesday auction, pigs were reweighed and loaded for transport, generally around 7-8 pm.

Upon arrival at the Northeast Center on Wednesday morning, pigs were immediately weighed and assigned to one of three receiving diets; a 12% crude protein diet (12%), a 16% protein corn-diet (16%), and a 20% crude protein diet (20%) (Table 1). All receiving diets were formulated using corn and soybean meal and ASP-250.

The receiving diets were hand-fed to appetite on the solid portion of the floor in the sleeping area of the pen twice daily for the first week. During the second week, receiving diets were fed *ad libitum* from a self feeder. After the two-week receiving period, all pigs were fed a 16% crude protein grower diet containing ASP-250 until 125 lb when they were switched to a 14% crude protein finisher diet containing 50 g/T chlortetracycline.

The pigs were treated for worms on the day following arrival with Tramisol in the drinking water and retreated three weeks later with Atgard in the feed. Pigs were sprayed for lice and mange with a lindane solution 9-12 days after arrival.

Pens of pigs were rated each day for severity of scours by two persons for 16 days after arrival. A scale of 1 to 5 was used, with 1 being a normal firm stool and 5 being extreme diarrhea (scours).

Results

Pigs having access to feed and water gained 2.2 pounds while at the auction market. Pigs with no feed or water lost 2.9 pounds (Table 1). At the end of the feeding trials, pigs given no feed or water access weighed 5.1 pounds more ($P<.02$).

Table 1. Effect of market treatment on feeder pig performance.

Item[a]	Treatment: Feed/water	None
Weight, lb		
Market arrival	47.5	48.4
Market departure[b]	49.7	45.5
Northeast Center arrival[b]	45.4	42.8
Final[c]	207.4	212.5
ADG, lb[d]	1.46	1.51
ADF, lb	4.64	4.85
F/G	3.19	3.23

[a]10 pigs/pen; 12 pens/market treatment.
[b]($P<.0001$).
[c]($P<.02$).
[d]($P<.05$).

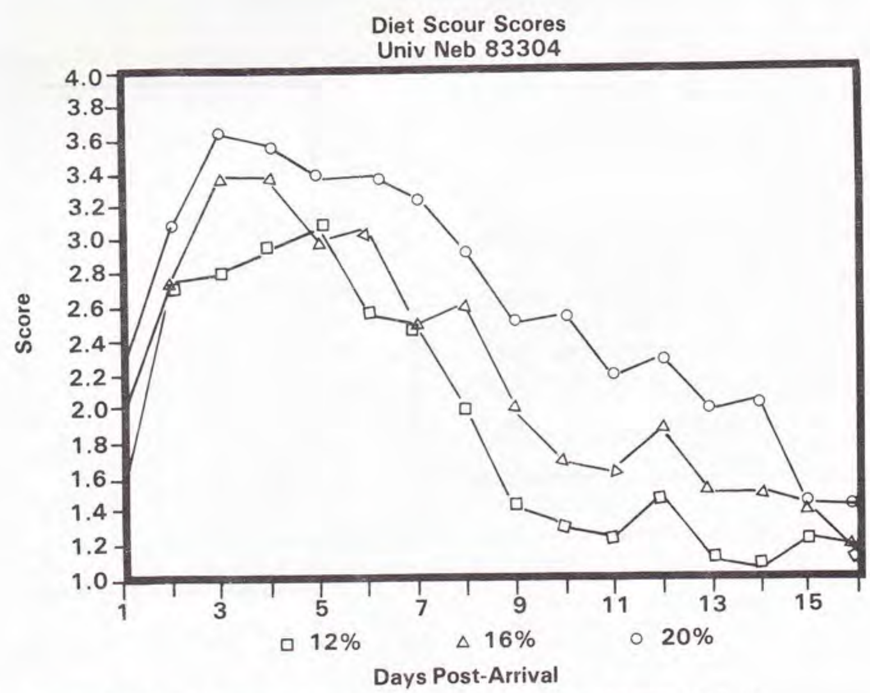


Figure 1. Effect of receiving diet protein level on feeder pig scour scores.

Table 2. Effect of receiving diet crude protein level on performance of comingled pigs.

Item[a,b]	Receiving diet crude protein		
	12	16	20
ADG, lb			
16 days[c]	.43	.81	.85
Final	1.47	1.50	1.47
F/G[d]			
16 days[c]	3.81	2.62	2.47
Final	3.19	3.21	3.22

[a]10 pigs/pen; 8 pens/receiving diet.
[b]Performance calculated based on market arrival weight.
[c]Linear diet effect (P<.005).
[d]Includes feed offered while at auction market.

Following the arrival at the Northeast Center, N pigs ate more feed than FW pigs. However, when overall feed intake was calculated taking into account the feed intake at the auction market, this increased intake was nonsignificant.

For the first two weeks after arrival at the Northeast Center there was an improvement in gain and feed efficiency with increasing crude protein in the receiving diet (Table 2). This increased gain was accompanied by an increase in scour severity (Figure 1).

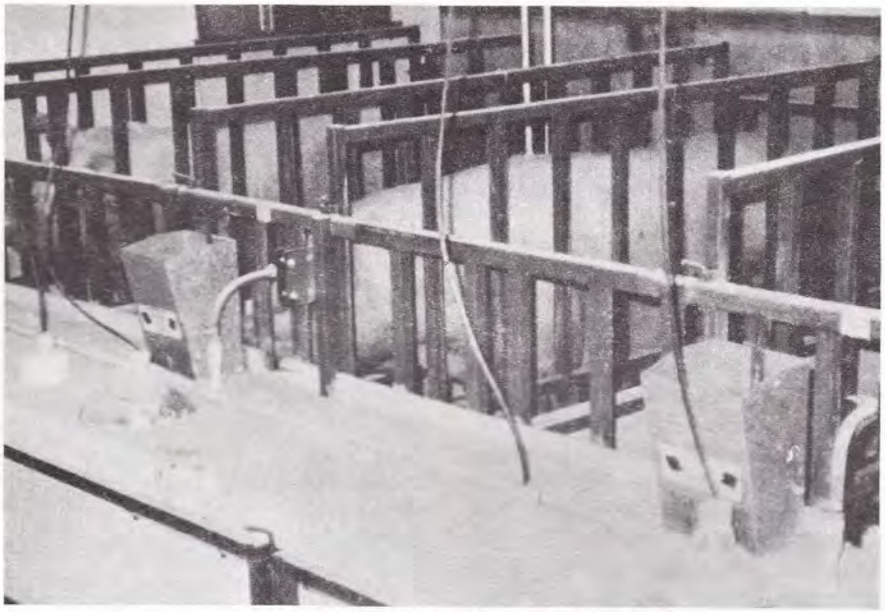
Conclusion

These results indicate that a 12% crude protein receiving diet is not sufficient to support maximum gain or efficiency during the initial period for a comingled feeder pig weighing 40 to 50 pounds. However, the lack of an overall effect indicates that feeding the deficient diet for only two weeks did not hinder the performance of the pigs to the extent that they could not compensate when subsequently fed a diet adequate in protein.

In these trials, the successful reduction in weight loss during the marketing and transportation process with feed and water access resulted in significantly reduced rates of gain. The results indicate that the normal stresses involved in feeder pig marketing may not be detrimental to performance as commonly believed.

---

[1]M. C. Brumm is Assistant Professor, Animal Science. C. W. Jesse is Associate Professor, Animal Science, University of Missouri. H. F. Mayes is Agriculture Engineer, USDA-ARS, University of Missouri. G. M. Zinn, Department of Veterinary Medicine and Surgery, University of Missouri.



Environment controlled by micro-processor.

Computer Control

Farrowing House Environment

James A. DeShazer
Jerry E. Plessing
Dennis D. Schulte[1]

A computer-aided control system for a Nebraska farrowing house was investigated during the fall, winter and spring of 1983-84. The use of a micro-processor in a farrowing facility decreases the need for thermostats and reduces the time needed for environmental management. The micro-processor can monitor and control the environmental conditions in many buildings simultaneously, thus reducing the cost per pig for environmental control.

This study was concerned with the use of a computer to control or effectively coordinate the use of solar and commercial energy to potentially reduce energy cost while freeing the producer for other management needs. Micro-processors are serving such purposes in public buildings today and it appears the same type of system could be applied to swine housing.

Building Description

The research was conducted using two identical six-crate farrowing rooms at the University of Nebraska Energy Integrated Farm at the University Field Laboratory near Mead, Nebraska. A favorable micro-environment in the creep areas for the young pigs was provided through the use of infrared heat lamps and an in-floor heat storage system. Half of the crates in each room were conventional with each side creep heated by a 250-watt infrared lamp. Enclosed front creeps were used for the other half of the crates and were found to need only 100-watt infrared lamps with a 25-watt incandescent bulb. The 25-watt bulb was used primarily for a continuous light source to attract the pigs to the front creep. No heat was provided in the side creep areas of the front creep farrowing crates.

Ventilation of each room was through use of exhaust fans in the north wall with a continuous slot air inlet on the top of the south wall. Incoming ventilation air could be preheated through the use of a solar Trombe wall along the south wall of the farrowing rooms. The Trombe wall was constructed of dry-stacked solid concrete blocks. Incoming ventilation air could be directed through the wall for pre-

(Continued on next page)

Environment . . .

(continued from page 19)

heating or could bypass the wall to reduce heat load during the day caused by excessive sunshine while conserving stored solar heat for cooler periods.

Computer Environmental Control System

The computer-aided environmental control system was developed to (1) maintain the static pressure in the farrowing room at a desired level by adjusting an inside ventilation baffle, (2) control the air temperature entering the building by either bypassing the solar wall or going through the wall (3) control the operation of the ventilation fans to help maintain the desired room temperature and (4) control the heat lamps and floor heat to provide a favorable microenvironment for the young pigs.

The environmental control schematic is shown in Figure 1.

Experimental Procedures

Five trials were conducted using the two farrowing rooms during the period of September 1983 to March 1984. In each trial the pigs were weaned at four weeks of age. During each trial the environmental control of one room was accomplished using conventional control methods such as thermostats, while the other room used the computer. The method of control was exchanged between rooms after the completion of each trial to negate any effect of the room location. The performance of the pigs, the energy use and the behavior of the pigs were recorded during the five trials.

Results

The use of the computer control of the outside baffle resulted in a more uniform air inlet temperature than for the conventional inlet. This system also reduced the heat load of the computer controlled farrowing room compared to the conventional room and thus reduced the ventilation energy requirement by 32%.

It should be noted that manual operation of the outside baffle to achieve the same results as the computer would be fairly difficult. The baffle was opened by the computer during the late evening and early morning hours and not during times when the needed labor would be available.

The computer control of the heat lamps in the creep area resulted in a decrease of the total energy consumption by 16 kWh per litter. The conventionally controlled heat lamps were usually left on continuously throughout the trial which resulted in higher creep air temperatures and increased electrical energy consumption.

The total electrical energy saved with the computerized control system for all five trials was 14% or 18 kWh per litter farrowed which amounts to a saving of $1.23 (7 cents per kWh) per litter. For the five farrowings this amounts to $6 per crate for the heating season. The $6 can be multiplied by the number of crates to determine the advantage of using computer control over a conventional control system for your facility.

Utilizing the computer for temperature control of the floor with solar air and water heating caused more energy to be used. This is because extended natural gas usage was caused by heat being transferred from the water to the solar air system instead of the floor surface.

There was no difference in number of pigs farrowed, average daily gain or the weaned weight between the computer or conventional control system. Therefore, the more exacting room temperature control did not appear to affect swine performance.

The amount of energy saved by the computer control system was greater for the September trial than during the other trials. Thus, the computer system is more adaptable for use in the early fall or spring when temperature fluctuates widely between the day and night. There would probably be negligible energy savings during the summer months due to the similarity of the operation of the environmental control components between the computer system and the conventional control system. The control of outside baffle and heat lamps should increase the environmental control efficiency of a farrowing facility resulting in energy savings over a conventional control system. However, it should be noted that both a computer control system and the conventional control methods were able to adequately maintain environmental conditions in each farrowing room though neither was always within the desired operating range.

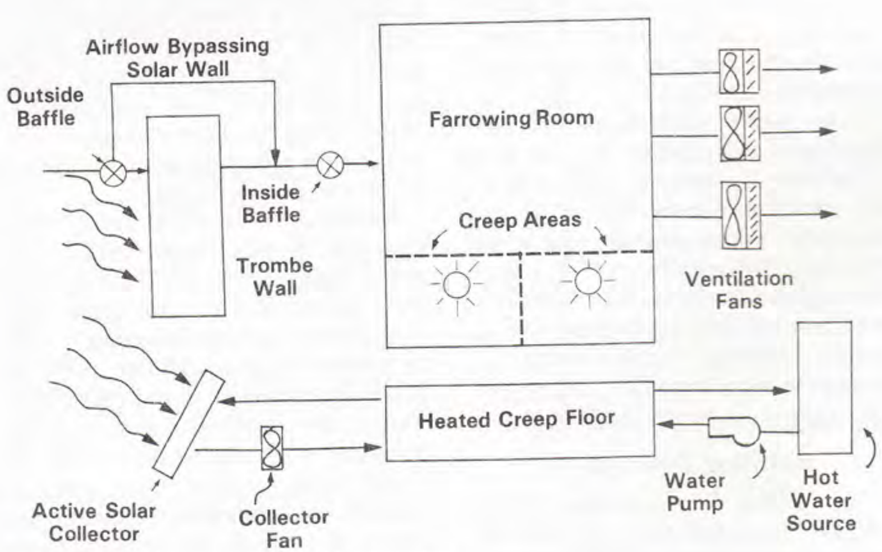


Figure 1. Environmental control schematic.

[1]James A. DeShazer is Professor, Livestock Environment. Jerry D. Plessing was a graduate assistant, Ag Engineering. Dennis D. Schulte is Associate Professor, Structures, Processing.

Naturally vs Mechanically Ventilated Solar-Assisted Swine Nurseries

Marcus J. Milanuk
James A. DeShazer
Dennis D. Schulte[1]

Naturally ventilated swine nurseries have been successfully used in Nebraska to reduce energy consumption. However, concern has been raised that a naturally ventilated system does not allow enough ventilation control to obtain a proper environment for the nursery age pig.

A two-trial experiment was conducted to assess the performance of a mechanically ventilated solar-assisted nursery and a naturally ventilated solar-assisted nursery. The parameters evaluated were building energy use, environmental conditions, pig performance and pig behavior during winter conditions in Nebraska. A construction cost analysis was made for the two nurseries. Trial 1 was conducted from January 10 to February 7, 1983 and trial 2 from February 14 to March 14, 1983.

Building Description

The nurseries were located at the University of Nebraska's Energy Integrated Farm near Mead, Nebraska. The pens within both nurseries were 21.5 ft. long by 4 ft. wide. Pens were designed with insulated hovers equipped with infrared heat lamps over the back 8 ft. of the pens, solar floor heating in the 8 ft. rear portion of the pens, and 30 in. open flush gutter at the front of the pens. Each nursery contained four pens with a capacity of 24 pigs/pen or a total building capacity of 96 pigs. The insulated hovers were constructed of two layers of 1/4 inch plywood with one inch of polystyrene insulation sandwiched between the plywood. Both nurseries utilized earth berms where possible with wall R-values of 13 and six inches of batt insulation in the ceilings (R = 19). The naturally ventilated nursery had double glazed passive solar windows that were 5 ft. tall along the south wall of the building. The mechanically ventilated nursery utilized a solar storage wall for preheating the ventilation air.

Animals

Crossbred, newly-weaned pigs, three to four weeks of age were used for both trials. A total of 192 pigs were needed for each trial, causing some pigs to be bought outside the Energy Farm complex. A total of 100 pigs were purchased for the first trial and 125 pigs were bought for the second trial. Pigs were placed in the nurseries four days before the trials started to allow them to become acclimated to their new surroundings and to allow them to overcome transportation stress. The pens were randomly filled in regard to sex and weight. However, the pigs were sorted according to their point of origin. A ground custom mixed pig starter containing 16% protein with ASP250 was fed.

Table 1. Nursery pig performance in mechanically ventilated and naturally ventilated solar heated nurseries for winter 1983 at Mead, NE.

Pig performance	Trial 1 Mec a	Nat b	Trial 2 Mec	Nat
Pig number	96	95	95	96
ADG (G), lb/day	1.03	1.01	0.97	0.92
Feed intake (F), lb/pig/day	1.98	1.78	2.22	2.00
F/G, lb feed/lb gain	1.91	1.76	2.29	2.17
Starting weight, lb	18.4	18.2	26.7	26.9
Ending weight, lb	47.3	47.1	54.0	52.5

a/Mec = mechanical ventilated nursery
b/Nat = natural ventilation nursery

Methods and Results

Animal Performance: Animals were weighed at two-week intervals and total pen weights were recorded. Feed consumption was recorded on a biweekly basis for each pen. Animals that died during the course of a trial were sent to a diagnostic laboratory to determine the cause of death.

No statistically significant differences were detected between nurseries with respect to feed efficiency and feed intake for either of the two trials (Table 1). The pigs housed in the mechanically ventilated nursery did have a significantly higher average daily gain during the second half of the first trial. There were no differences in average daily gain between nurseries during the second trial.

Electrical Energy Utilization: Electrical energy was metered separately at each building for the solar collector fans and ventilation fans using standard watthour meters. The electrical usage for the heat lamps was calculated based on the time the 250-watt bulbs were used.

Table 2. Electrical energy utilization in mechanically ventilated and naturally ventilated solar heated nurseries for winter 1983 at Mead, NE.

Energy utilization	Trial 1 Mec a	Nat b	Trial 2 Mec	Nat
Infrared heating (kWh)	112.8	112.8	112.8	112.8
Ventilation fans (kWh)	54.0	0	72.7	0
Solar collector fans (kWh)	19.5	21.2	27.7	29.0
TOTAL (kWh)	186.3	134.0	213.2	141.8
Nat/Mech (%)	-	72%	-	66%
kWh/pig	1.94	1.41	2.24	1.48

a/Mec = mechanical ventilation nursery
b/Nat = natural ventilation nursery

The electrical energy utilization data for both trials are summarized in Table 2. Electrical usage for infrared heating was identical for

(Continued on next page)

Ventilation . . .

(continued from page 21)

both nurseries in each trial because the heat lamps were removed from the pens at the end of the first two weeks of each trial.

The energy required for the ventilation fans in the mechanically ventilated nursery was 35% greater for the second trial due to a period of warmer weather. The electrical energy used to operate the solar collector fans was slightly higher for the naturally ventilated nursery because the fan used was larger. The total energy required to operate the naturally ventilated nursery averaged 69% of the electrical requirement for the mechanically ventilated nursery and ranged between 1.41 to 1.48 kWh/pig for trials one and two respectively. If the buildings were maintained at 75°F with no solar assistance, 6 to 12 times more energy would have been required for the system during the same weather and building structural conditions.

Building Performance: Air, floor, and collector plate temperatures were measured and recorded hourly. Relative humidity was recorded on a continuous basis.

The room temperatures of both nurseries averaged about 55°F for the first trial and 71°F for the second trial (Table 3). The mechanically ventilated nursery tended to have a higher ambient room temperature and a lower relative humidity with the hover temperatures being lower than the naturally ventilated nursery. However, warmer micro-environments were provided by the hovers. The hover air and floor temperatures averaged 73°F and 86°F respectively, for the first trial.

Table 3. Environmental conditions in mechanically ventilated and naturally ventilated solar heated nurseries for winter 1983 at Mead, NE.

	Trial 1				Trial 2			
	(1/10 to 1/24)		(1/25 to 2/7)		(2/14 to 2/28)		(3/1 to 3/14)	
Environment	Mec a	Nat b	Mec	Nat	Mec	Nat	Mec	Nat
Outside temp. (F)	25	25	23	23	37	37	41	41
Room temp. (F)	57	54	63	59	70	70	72	72
Room RH (%)	63	69	65	73	67	69	70	66
Hover air temp. (F)	72	75	77	81	81	-	82	-
Hover floor temp. (F)	84	88	90	90	91	-	91	-
Room floor temp. (F)	61	-	79	-	72	-	82	-

a/Mec = mechanically ventilation systems.
b/Nat = naturally ventilation systems.

Table 4. Behavioral responses of pigs assisted nurseries for winter 1983 at Mead, NE.

	Trial		Trial 2		Experiment	
Activity	Mec a	Nat b	Mec	Nat	Mec	Nat
Hover utilization, %	56.1	55.3	43.3	50.4	48.5	51.5
Lying outside hover (OH), %	10.9	4.0	20.2	7.0	16.1	5.5
Standing OH, %	8.0	9.3	10.1	13.8	9.3	11.9
Eating, %	10.3	9.3	11.1	12.5	11.0	10.8
Other activity, %	14.7	22.1	15.3	16.3	15.1	20.3
Wetted floor area, %	25.6	37.7	23.7	31.7	23.3	33.8

a/Mec = mechanically ventilated nursery.
b/Nat = naturally ventilated nursery.

Animal Behavior: The dunging patterns of the pigs were recorded on a daily basis by drawing the wetted line on floor plan diagrams of each pen. In addition, the number of pigs under the hovers and indications of huddling were recorded on data sheets. These observations were taken at three times each day; 8:00, 12:00 noon and 4:30 pm. Photographs were also taken of each pen at these times to help in determining pig activities in the area outside of the hover.

There were no statistically significant differences in hover utilization between the two nurseries during the first trial (Table 4). However, in the second trial the pigs in the naturally ventilated nursery used the hovers more extensively (50.4% vs 43.3%). The pigs tended to utilize the hovers less as they became older.

More pigs were observed lying outside of the hover area in the mechanically ventilated nursery during both trials. However, during the second trial a larger percentage of pigs within the naturally ventilated nursery were observed standing outside of the hover area and also eating in comparison to the mechanically ventilated nursery. The total amount of floor area wetted was significantly greater for the naturally ventilated nursery for both trials.

Building Cost: The construction cost of the naturally ventilated nursery was less expensive. The major reasons for the greater cost of the mechanically ventilated nursery were the ventilation system and the solar storage wall. The data showed a $35/pig capacity savings with the naturally ventilated solar assisted nursery.

Conclusions

1. The electrical energy use of the naturally ventilated solar assisted swine nursery was 60 percent of the energy requirements for the mechanically ventilated nursery.

2. Slightly lower ambient room temperatures with higher percent relative humidities were observed for the naturally ventilated nursery. Hover air and floor temperatures were warmer in the naturally ventilated nursery.

3. No major differences were noted for feed efficiency, feed intake and average daily gain of the pigs in the two nurseries.

4. The degree of hover utilization by the pigs was greater for the naturally ventilated nursery. A larger number of pigs were observed lying down outside of the hover area in the mechanically ventilated nursery. The number of pigs standing outside of the hover area and the wetted floor area were greater for the naturally ventilated nursery.

5. The naturally ventilated nursery was less expensive to construct than the mechanically ventilated nursery by approximately $35/pig capacity.

[1]Marcus J. Milanuk is Energy Farm Swine Manager, Mead Field Laboratory. James A. DeShazer is Professor, Livestock Environment. Dennis D. Schulte is Associate Professor, Structures, Processing.

"Grounding" Spells Safety

Gerald R. Bodman
LaVerne E. Stetson
Jack L. Schinstock[1]

Electricity serves as a silent and dependable workhand on nearly every modern-day swine farm. When flowing through motors, lights, electrical conductors and other devices, electricity is a safe and efficient energy source.

However, when current flows through other components of a livestock production facility, hazards can exist and cause loss of life or property. A recent example of a loss of life occurred in 1983 when a young Iowa producer was electrocuted in a swine unit. A Nebraska producer lost 175 pigs in 1984. In the Nebraska situation, the pigs weighed approximately 80 lb and were killed when a "hot" electrical conductor energized the water system and gates. All metallic components were not interconnected and grounded. The pigs were sleeping on metal slats, were lying against the gates and were electrocuted.

Figure 1. UF cable entering dust- and water-tight, nonmetallic boxes in corrosive environments must be secured to structure within 8 inches of box.

Proper Equipment

The first step towards a safe farmstead electrical system is to arrange for a licensed electrician to install the system in accordance with the *National Electrical Code* (NEC). A knowledgeable electrician will help assure a safe system through proper sizing of all components. Proper conductor (wire) sizing requires increasing wire size to compensate for voltage loss due to length of circuit conductors. Voltage loss allowances are important for all circuits, whether inside or outside of the building. An inside example would be a motor used to operate a feed auger or fan at the opposite end of the building from the main electrical panel.

Selection of materials appropriate for use in a livestock housing environment is another NEC requirement. Type UF cable, nonmetallic boxes and conduit, and similar corrosion-resistance devices are essential for a long service life (Figure 1). Type NM (non-metallic) cable should NOT be used in any livestock facility. Even with appropriate components, proper installation is still required to assure a safe electrical system.

Even when all previously described requirements are met, the risk of current flow through metallic parts of the environment remains a possibility due to equipment malfunctions, down or damaged conductors or lack of maintenance. To minimize risks associated with such system failures, all equipment in a swine facility should be electrically grounded. For maximum safety, all grounds must be interconnected.

Service Grounding

The *National Electrical Code* (NEC) sets forth minimum standards and procedures necessary to reduce the risk of electrical hazards to humans or animals. The NEC requires a grounding electrode at the main farm service entrance. Additionally, the service entrance to each building must have a grounding electrode (Figure 2). The electrode at the main farm service might be constructed by using a coil of copper wire attached to the base of the main farm or center pole. The most common electrode at individual buildings is a "ground rod." Ground rods should be at least 5/8 in. diameter, made of copper-coated steel and at least 8 ft long. The rod should be driven full length into the soil. Pro-

(Continued on next page)

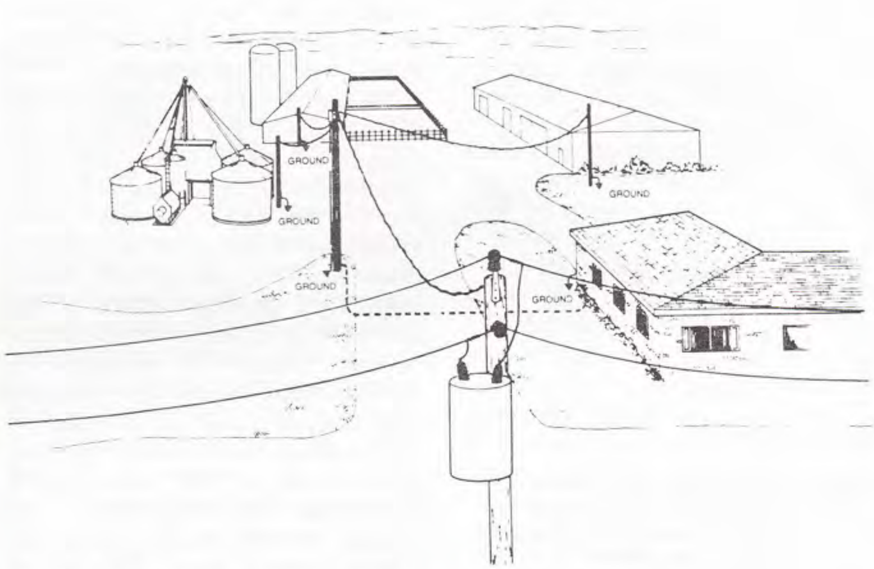


Figure 2. The electrical system must be grounded at each service.

Grounding . . .

(continued from page 23)

tect both the top of the rod and the electrical conductor from the ground rod to the service entrance box. Clamps designed for such attachments and for direct soil burial are necessities (Figure 3).

The NEC further defines two specific types of "ground" conductors. The first is a ground**ED** conductor. This is commonly referred to as the "neutral" and is designed to carry current under normal operating conditions. This wire covering must be white or light grey in color.

A second type of "ground" conductor is the ground**ING** conductor. The grounding conductor is intended to carry current only under fault conditions and thus serves only as a safety wire. The grounding conductor may be bare or have an insulation covering. If insulated, the covering will be green or green with yellow stripes. All metallic frames and enclosures of electrical equipment must be grounded. The grounding conductor must be attached directly to all metallic frames and enclosures and must be connected to the grounding system. A separate ground rod driven into the soil at the site of the metallic equipment is not adequate since it is not interconnected with the grounding system. A grounded neutral may or may not be required, depending upon the type of electrical equipment and the operating voltage.

To reduce the amount of current passing through metallic equipment and grounding conductors under normal operation, the grounded neutral conductors and the grounding conductors MUST be kept separate at all points in the electrical system except at the service entrance. Most installations would involve bonding of the grounded and grounding conductors at the service entrance. In the recommendation to provide 4-wire service to livestock buildings, the grounding and grounded conductors would be interconnected only at the main farm service entrance; that is, they would be kept completely separated at all other points (Figure 4).

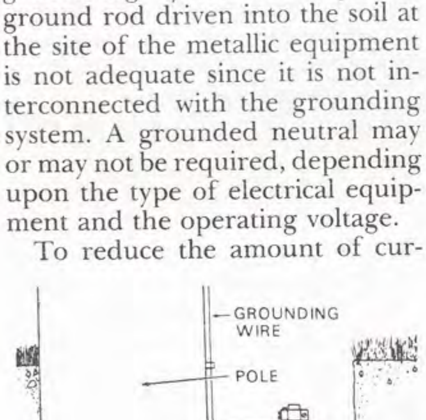


Figure 3. Grounding wire attached to grounding rod with approved clamp. Attach wire firmly to building and position top of rod and clamp below ground level for protection.

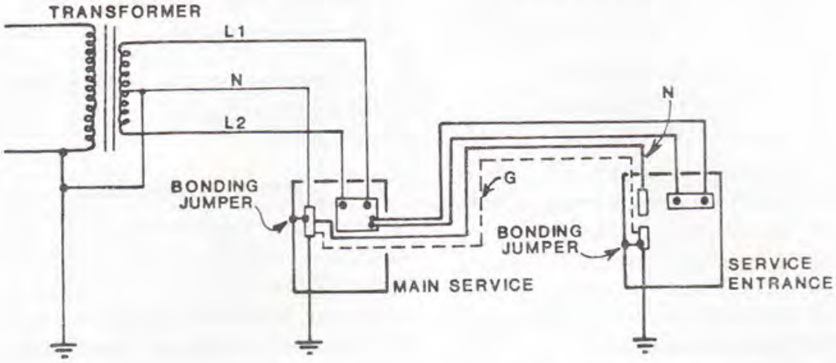


Figure 4. Proper connection between ground and neutral in a 4-wire service.

Supplemental Grounding

No matter how well installed an electrical system might be, the possibility always exists that a short could develop in a piece of electrical equipment or that rodents might damage electrical insulation.

To reduce the risk of loss or injury in the event of such occurrences, all metallic components within the animal environment should be interconnected and grounded (Figure 5). All connections must be made with techniques or devices which resist corrosion and assure electrical continuity. Acceptable methods include welding, pressure connectors and clamps made of copper or other alloys. Connections made by twisted wire or steel bolts are not acceptable. Where flexibility is required, such as on a gate, the interconnecting wire should be stranded or braided copper.

Among the metallic components which must be interconnected are the water system, gates, feeders, posts, farrowing or gestation crates, and floors made of woven wire mesh, aluminum slats or stainless steel. All connections should be made at locations where the risk of damage to the connections by animals or workmen is minimized. After all components are interconnected, a grounding wire should be extended from them to the electrical grounding system.

Especially in farrowing houses, where animals are confined to a small area and intimate contact with various metallic components occurs on a routine basis, use of an equipotential plane is recommended (Figure 5). An equipotential plane is constructed by interconnecting welded wire mesh in the floor with all other metallic components. The use of an equipotential plane assures low voltage between animal contact points such as the floor or grates and nipple waterers. Voltages between animal contact points and subsequent flow of current through the animal have been problems in many cases. Among health problems which can occur in animals as a result of these voltages are swollen joints, decreased milk production, increased mastitis, deterioration of body condition due to reduced feed or water intake, and in severe cases, death.

Electrical Inspection

Insist that your electrician be licensed and that he installs the system in accordance with the *National Electrical Code.* Arrange to have the

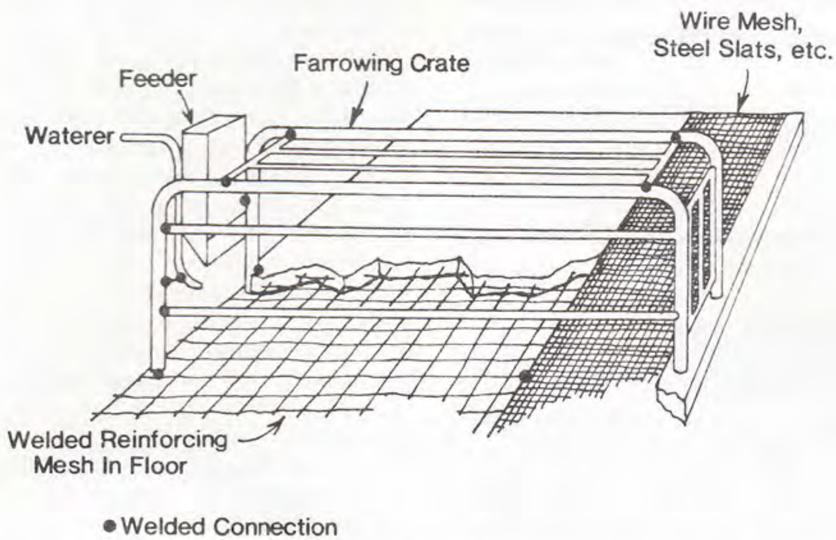


Figure 5. All metallic components in the animal environment should be electrically interconnected and bonded to the electrical system grounding system to form an equi-potential plane.

system inspected by a representative of the Nebraska State Electrical Board. For a nominal fee, they will provide advisory service regarding any safety deficiencies and provide recommendations on how to improve the system. The inspector for your area can be identified by contacting the State Electrical Board at 1313 Farnam Street, Omaha, Nebraska (phone: 402/554-2127). Final payment to the electrician should be made only after the system has been approved.

Summary

An efficient and safe electrical system requires use of appropriate materials installed by a qualified electrician in accordance with a well-designed plan. When coupled with proper maintenance, the risk of electrical hazards is minimized. All electrical systems, regardless of how well installed they might be, should be complemented with appropriate interconnections and grounding of all metallic components to protect animals and humans in the event of equipment malfunctions. When interconnections and supplemental grounding are installed as part of the initial installation, the added costs are minimal.

"Live better electrically" is a slogan of many years' standing. When coupled with good design, installation and maintenance, you can also live safely with electricity.

---

[1]Gerald R. Bodman is Extension Argricultural Engineer, Livestock Systems. LaVerne E. Stetson is Agricultural Engineer, USDA. Jack L. Schinstock is Associate Professor, Agricultural Engineering.

Manure Gases—They Can Kill You

Gerald R. Bodman
Rollin D. Schnieder[1]

Manure is an integral part of all livestock production operations. Although its value is often less than the cost of management and handling, it's a material producers must contend with. When properly managed, manure can reduce the amount of "red ink" in the farm account if it is used as a source of crop nutrients. Regardless of the management system, liquid manure can create a death trap for the unaware, uninformed, or careless. Drowning and injury or death due to toxic gases are among the hazards. An operator's nose is not a reliable method of "measuring" the potential hazard.

Bacteria in manure decompose organic matter. Gradual decomposition occurs regardless of the type of storage facility. Gases are formed as decomposition progresses. Most of these gases can reach hazardous concentrations within several days from the time manure is placed in storage.

Odors released from manure are a combination of numerous gases. Under normal conditions, a well-designed ventilation system will provide sufficient fresh air to keep the concentration of gases below toxic levels. However, in confined spaces such as a manure pit or a poorly ventilated livestock building, gases may be present at toxic levels. Similarly, during an electrical power interruption or failure of a ventilation system the concentration of gases can reach toxic levels within a very short time.

Failure to recognize the safety hazards associated with manure gases has resulted in an estimated 20-25 livestock producer deaths in North America. Experiences since 1980 indicate that farmers in South Dakota, Iowa, Utah, California, Kansas, Missouri and Nebraska are not exempt from the lethal characteristics of these manure gases. Many of the instances involved multiple deaths when rescuers were also overcome by toxic gases.

Primary Gases

The five gases of primary concern with stored manure and a brief description of their characteristics and symptoms at elevated concentrations are:

1. *Hydrogen sulfide*—A lethal killer!

Colorless, flammable, smells like rotten eggs, heavier than air, tends to collect at the manure surface, blackens copper.

Symptoms include: fear of light, nervousness, loss of appetite, vomiting, diarrhea, swelling of pulmonary tissue, watery eyes and many others. It can also cause rhin-

(Continued on next page)

Manure Gases . . .

(continued from page 25)

itis due to irritation of the respiratory tract.

A single breath can result in death due to paralysis of the diaphragm and nervous system.

2. *Carbon dioxide*

Heavier than air, odorless, tasteless, can be a problem in deep pits, causes suffocation by preventing the exchange of oxygen in the lungs, produced both by the breathing of animals and the decomposition of manure.

Symptoms include: deep rapid breathing, dizziness and possibly unconsciousness.

3. *Ammonia*

Pungent odor, colorless, slightly lighter than air, primary source is volatilization of ammonia from urine, causes irritation of mucous membranes in the respiratory tract.

Symptoms include: sneezing, headaches, excess perspiration, excess salivation, loss of appetite, nausea, vomiting, watery eyes, and increased respiratory problems.

4. *Methane*

Lighter than air, colorless, odorless, highly explosive when mixed at the proper proportion, can cause suffocation.

Symptoms include: shortness of breath and unconsciousness.

5. *Carbon Monoxide*

Odorless, colorless, lighter than air, toxic, developed when insufficient oxygen is present for complete combustion, primary source is from operation of unvented liquid or gaseous fuel heaters in poorly- or under-ventilated buildings.

Symptoms include: uneasiness, headaches, nausea, dizziness, drowsiness, poor adaptation to light, blurred vision, "blurred thinking" and general lack of vigor. There may also be a cherry-red skin or mucous membrane color in caucasians. Low levels are particularly hazardous to persons with heart problems and restricted blood flow.

Table 1. Guidelines for allowable gas concentrations in swine buildings.

Gas	Maximum allowable (TLV, ppm)	Recommended maximum for pigs (ppm)
Carbon Dioxide (CO_2)	5,000	2,500
Ammonia (NH_3)	25	12
Hydrogen Sulfide (H_2S)	10	5
Methane (CH_4)	1,000	500
Carbon Monoxide (CO)	50	25

Table 2. Commonly used gas detection tubes.

Ammonia	No. 3L	(low range, 2-30 ppm)
Carbon Monoxide	No. 1LL	(extra low range, 5-50 ppm)
Carbon Dioxide	No. 2LL	(extra low range, 300-5000 ppm)
Hydrogen Sulfide	No. 4LL	(extra low range, 5-60 ppm)

Gas Levels

To reduce the risk of injury to personnel, safety standards have been developed which establish limits on the level of toxic gases present in a human environment. These are for 8-hour exposure and are called the "threshold limit values" (TLV). The TLV values for the five common gases are listed in Table 1.

Information on allowable concentrations of these gases in the livestock environment and for long-term exposure is extremely limited. Also, the influence of mixtures of gases is poorly understood. The best judgment at this time is to limit the concentration of gases in the animal environment to levels not exceeding 50% of the TLV values for long-term or continuous exposure. Young animals tend to be more susceptible to the harmful effects of gases. Gas concentrations in the first 1 ft of space above the floor are most important for swine buildings since that is where the animals obtain their air for breathing.

Gas Detection

The concentration of gases in the animal environment can be determined with acceptable precision using gas detection tubes. The sampling syringe and gas tubes are available commercially. Commonly used tubes are listed in Table 2.

Producers interested in a less accurate quick check for hydrogen sulfide can use the following procedure: Polish a piece of copper tubing with steel wool just as you would in preparing the pipe for soldering. Wrap three pieces of plastic electrical tape around the pipe. Lay the pipe in the pig environment. At 10-minute intervals, remove one piece of tape to provide an initial color reference. Use the taped sections of pipe as references in evaluating color change. If the continually exposed section of pipe shows a deep rust color within 30 minutes, hydrogen sulfide concentrations are probably high enough to be detrimental to young pigs. A significant color change in a shorter time period indicates a more severe problem.

High relative humidity levels increase the difficulty of removing detrimental gases from the animal environment. Under no circumstances should the relative humidity in the animal space be allowed to exceed 80%. Even under winter conditions, the relative humidity should be maintained in the range of 50-65%. Failure to control relative humidity results in additional stress on the animals and increased susceptibility to problems associated with manure gases, dust and pathogens.

Prevention Techniques

The risk of gases in the animal environment reaching toxic levels can be minimized through proper ventilation of the animal space. Ventilating at an extremely low rate in an effort to save heating energy frequently results in high gas and odor levels and depressed animal performance. All too often, this results in producers sacrificing a "dime's worth" of production and health for a "nickel's worth" of energy.

Any time manure is stored in or below a livestock building for seven or more days, the storage space should be ventilated. Maintaining the liquid manure level 18" or more below the slats will limit the movement of heavy gases up into the animal space. In facilities equipped with mechanical ventilation systems, winter and spring/fall air should be drawn down through the flooring and out across the manure surface. In non-mechanically ventilated buildings such as a modified-open-front (MOF) growing-finishing building, airflow through the pit can be achieved either through use of fans and ducts or by a series of PVC pipe "chimneys."

Ventilation of manure storages is intended to keep the concentration of gases in the animal zone at acceptably low levels. No pit ventilation system will guarantee safety to personnel who might enter an "empty" manure pit.

Safety Precautions

Each of us has at times ignored "common sense" rules of safety with a mental fix which in essence states, "It won't happen to me." Records of animal and human deaths indicate that no part of the country is immune from problems. The mere fact that your neighbor, or perhaps you, have entered a manure storage without apparent incident in the past does not mean the next time may not prove disastrous. To reduce the risk of injury or death to animals and personnel, basic safety guidelines should be adhered to in all cases. Follow these safety rules at all times:

1. NEVER smoke around a manure storage.

2. NEVER enter a manure storage tank or silo without self-contained breathing apparatus and an air supply plus someone outside the tank with a rescue line and harness attached. These precautions are necessary with both open top and enclosed tanks regardless of the position of the storage relative to the earth's surface. Be certain the person who remains outside the storage has adequate equipment available to extract you in a collapsed condition in the event of an emergency or mishap.

3. Provide grates, covers and protective fences or rails over and around all openings on underground storages.

4. Install a substantial woven or welded wire fence around all in-ground storages.

5. Start access ladders on above-ground storages above the reach of children.

6. Construct outward sloping fences around the top of above-ground storages to reduce the temptation by children to scale the wall.

7. Install a ladder on the inside of all storages for emergency escape.

8. Erect a sign near the storage to alert and inform visitors regarding the presence of the storage and associated hazards.

9. Beware of toxic gases. Stored manure always produces toxic gases. These gases are released continuously but at very high rates during agitation and pumping. Watch for signs of ill effects in livestock or personnel. Discontinue agitation and ventilate building at maximum rate if ill effects are observed. DO NOT enter the building until evidence of problems has dissipated. Operate or adjust ventilation equipment, openings and doors from the outside only.

Summary

Any time manure is stored, odors and gases will be present. Ventilation of the storage, coupled with application of basic common sense and safety rules will reduce the risk of injury or death. Ventilation of swine facilities at reasonable airflow rates will reduce the risk of depressed animal performance due to prolonged exposure. In most cases, inadequate ventilation provides a poor balance between reduced or depressed performance and energy savings. Although odors are part of livestock production, they should not be so intense that an extra share of courage is necessary to even enter the swine facility. If odor or gas levels cause you to hesitate to enter the facility, it is likely that the concentrations are high enough to be depressing animal performance and to be influencing (in an adverse fashion) the incidence of disease and health problems.

---

[1]Gerald R. Bodman is Extension Agricultural Engineer, Livestock Systems. Rollin D. Schnieder is Extension Safety Specialist.

Raw Soybeans for Gestation and Lactation Diets

Mark Crenshaw
Murray Danielson[1]

Increasing the energy of lactation diets has been reported to decrease the interval from weaning to first estrus, as well as to improve pig weaning weight. Raw soybeans, naturally high in fat content (18% crude fat), would be one way of increasing the fat content of a diet without the handling problems usually associated with addition of liquid fat.

Raw soybeans contain anti-growth factors which are destroyed by proper heating. To properly heat soybeans, equipment, energy and labor are required. If raw soybeans could be used instead of processed beans then the expense incurred for processing could be eliminated.

It was reported in the 1984 Nebraska Swine Report that raw soybeans could be effectively used as a source of supplemental protein and energy for gestating swine but not for growing-finishing pigs. That report generated questions about the value of feeding raw soybeans as a source of supplemental protein in lactation diets.

Experiment Design

A study was conducted comparing reproductive performances of sows fed gestation and lactation diets supplemented with either raw soybeans (RSB) or soybean meal (SBM) for three reproductive cycles. Forty crossbred gilts, about

(Continued on next page)

Raw Soybeans . . .

(continued from page 27)

eight months of age, were bred and randomly allotted to two dietary treatment groups (Tables 1 and 2). The two gestation diets, fed in this study, were formulated on a 50% alfalfa hay basis. Soybean meal (44% crude protein) provided the protein supplement for the control group (diet I). Raw soybeans (36% crude protein) replaced SBM on an equal weight basis for the other treatment group (diet II). Because RSB replaced SBM on an equal weight basis, the gestation-lcatation diets containing RSB were lower in crude protein than the SBM diets. All diets, regardless of source of supplemental protein, contained adequate lysine. Gilts were fed the same source of supplemental protein (SBM or RSB) in the lactation diet as contained in their respective gestation diet.

During gestation, all gilts were maintained in drylots. Each was fed 4.2 lb/day of the diet to which it was assigned. The gestation diets were fed in a complete ground meal form, by means of individual feeding stalls, from breeding to 110 days of gestation.

At about 110 days of gestation, the gilts were moved to a farrowing house and fed their respective lactation diet (4.0 lb/day) until they farrowed. After farrowing, the lactation diet was offered *ad libitum* until the pigs were weaned (about 28 days). After weaning, the gilts were rebred on the first estrus cycle and fed the same gestation diet that they received during their previous gestation. The gilts were weighed at breeding, 110 days of gestation, 24 hours postpartum and at weaning (about 28 days postpartum). Number of pigs and pig weights were recorded at birth, 7, 14 and 21 days. No creep feed was provided in the farrowing house.

Table 1. Composition of gestation diets.

Ingredient	Diet[a] SBM	RSB
Corn	36.00	36.00
Soybean meal, 44% protein	10.00	
Raw soybeans, 36% protein		10.00
Alfalfa hay, ground	50.00	50.00
Sodium phosphate	1.50	1.50
Limestone	.30	.30
Dicalcium phosphate	.50	.50
Salt, iodized	.40	.40
Trace mineral mix[b]	.05	.05
Vitamin premix[c]	1.25	1.25

[a]SBM = soybean meal and RSB = raw soybeans.
[b]Contributed in mg/lb of diet: Zn, 45.35; Fe, 22.68; Mn, 12.47; Cu, 2.49; I, .34.
[c]Contributed per pound of complete diet: vitamin A, 2505 IU; vitamin D, 252 IU; riboflavin, 2.5 mg; niacin, 15 mg; calcium pantothenate, 9 mg; choline chloride, 250 mg; and vitamin B_{12}, 7.5 μg.

Table 2. Composition of lactation diets.

Ingredient	Diet[a] SBM	RSB
Corn	53.30	53.30
Oats	15.00	15.00
Soybean meal, 44% protein	15.00	
Raw soybeans, 36% protein		15.00
Alfalfa hay, ground	5.00	5.00
Wheat bran	7.50	7.50
Dicalcium phosphate	2.20	2.20
Limestone	.88	.88
Salt, iodized	.62	.62
Trace mineral mix[b]	.10	.10
Vitamin premix[c]	.40	.40

[a]SBM = soybean meal and RSB = raw soybeans.
[b]Contributed in mg/lb of diet: Zn, 90.7; Fe, 45.35; Mn, 24.94; Cu, 4.99; I, .68.
[c]Contributed per pound of complete diet: vitamin A, 2505 IU; vitamin D, 252 IU; riboflavin, 2.5 mg; niacin, 15 mg; calcium pantothenate, 9 mg; choline chloride, 106.25 mg; and vitamin B_{12}, 7.5 μg.

Experimental procedures and management practices were comparable for all reproductive cycles.

Total Sow Performance

Results of this study are listed in Tables 3, 4 and 5. All values represent the average of three reproductive cycles.

Sow weight and weight changes are listed in Table 3. At each stage of the study the average weight of sows fed the SBM diets was greater than the weight of the RSB group. This difference may be a reflection of the lactation weight change of the two groups. Although gestation weight change and postpartum weight change were not different between the dietary groups, the amount of weight loss during lactation was greater for the RSB group. The difference in lactation weight change might initially be interpreted as a result of treatment effects. However, when the other measurements are considered, treatment effects accounting for all of the difference in lactation weight change would seem unlikely.

As one might expect, due to the different energy levels of the lactation diets, lactation feed intake tended to be higher for the SBM group than the RSB group (Table 4). This slight difference in feed intake would not be expected to account for the difference in lactation weight change because the RSB group was consuming more energy than the SBM group.

Second Parity Effect

The second reproductive cycle appeared to have the greatest influence on overall lactation weight change. Gestation weight change, postpartum weight change and lactation weight change for the second parity were: SBM; 38, 16 and 7 and RSB; 51, 34 and −32, respectively.

The second gestation occurred in the winter of 1983-84. Each sow was limit fed 4.2 lb/day of her respective gestation diet regardless of season. Apparently, the sows fed the SBM gestation diet were deficient in energy (estimated metabolizable energy: SBM; 1123 kcal/lb and RSB; 1153 kcal/lb) whereas, the sows fed the RSB diet were provided enough energy to maintain growth as well as pregnancy. Eight of 20 sows in the SBM group failed to settle for the second gestation. One of the 20 sows displayed a similar response in the RSB group. (The sows which became repeat breeders were removed from study and fed a corn-soybean meal ges-

Table 3. Sow weights and weight changes, average of three reproductive cycles.

	Diet SBM	RSB
Sow weight (lb)		
at breeding	322	300
110 day	389	365
Postpartum (24 hour)	366	343
At weaning (28 day)	351	313
Gestation wt change[a]	67	65
Postpartum wt change[b]	44	43
Lactation wt change[c]	−15	−30

[a]Gestation weight change = 110 day weight − breeding weight.
[b]Postpartum weight change = postpartum weight − breeding weight.
[c]Lactation weight change = weaning weight − postpartum weight.

Table 4. Lactation feed intake, average of three reproductive cycles.

	Diet	
	SBM	RSB
Lactation ADFI[a] (lb)		
First week	11.83	10.90
Second week	12.11	11.25
Third week	11.64	12.72
Overall	11.86	11.62

[a]ADFI = average daily feed intake.

tation diet. Subsequently, they returned to a normal reproductive state).

Apparently during the second lactation, the SBM sows were more efficient in feed utilization. The sows fed the SBM diet gained weight during lactation (possible compensatory effect) while a weight loss occurred for the RSB group even though average daily feed intake was about the same (SBM, 12.82 vs RSB, 12.61 lb).

Average pig birth weight of the SBM group was lower than the RSB group (2.99 vs 3.65 lb) however, at weaning average pig weight was greater for the SBM group (11.36 vs 10.47 lb). It is noted that the RSB group was nursing one pig per litter more than the SBM group (7.83 vs. 6.83 pigs/litter). This may have influenced pig weaning weight and sow lactation weight change in the second lactation.

Total Pig Performance

Litter performance is listed in Table 5. The average number of pigs farrowed live was not different between the dietary groups. The average number of pigs per litter at 21 days tended to be greater for the SBM group resulting in a slight improvement in pig survival.

Average pig birth weight was higher for the group fed RSB diets but at 21 days of age average pig weight was greater for the SBM group.

Conclusion

Interpretation of the resuls of this study is complicated by the effects of severe weather conditions. It appears the performance of sows fed raw soybeans as a source of supplemental protein in gestation

Table 5. Litter performance, average of three reproductive cycles.

	Diet	
	SBM	RSB
Average litter performance		
No. litters farrowed[a]	42	52
Pigs farrowed live	9.00	8.98
Pigs at 7 days	8.00	7.90
Pigs at 14 days	7.81	7.65
Pigs at 21 days	7.64	7.48
Survival %	84.9	83.3
Average pig weight (lb)		
Birth	3.2	3.5
7 days	5.8	5.9
14 days	8.5	8.6
21 days	11.4	11.2

[a]60 litters were possible for each treatment group. Three sows of the RSB have not completed the third parity at this time.

and lactation diets is similar to the performance of sows fed gestation and lactation diets supplemented with SBM. Further research concerning the feeding of raw soybeans in lactation diets is being studied at the North Platte Station.

[1]Mark Crenshaw is Swine Operations Manager, West Central Center, North Platte. Murray Danielson is Professor, Swine Nutrition, West Central Center, North Platte.

In Growing-Finishing Diets

Roasted Soybeans vs Soybean Meal

Murray Danielson
Mark Crenshaw[1]

Previous swine reports have indicated that properly roasted whole soybeans are nutritionally equal or possibly superior to soybean meal for swine.

As reported in the 1984 Nebraska Swine Report, the use of raw soybeans as a source of supplemental protein for growing and finishing swine diets is not recommended.

Since the 1984 report equipment to roast raw whole soybeans has been acquired. The roasting process inactivates the growth-inhibitors found in raw soybeans. At the same time, the oil (fat or energy) of the raw soybean is retained. Raw soybeans contain approximately 18% crude fat. Raw whole soybeans normally contain 36-38% crude protein but can vary significantly from this figure. Chemical analysis of whole soybeans being used to formulate diets is recommended. As a source of protein and energy, roasted soybeans should be excellent in formulating growing-finishing diets.

Three growing-finishing studies were conducted to determine the effects of replacing soybean meal with ground roasted soybeans. Several methods were used in replacing soybean meal with roasted soybeans.

Procedure

Study A. Ninety-six crossbred pigs were stratified by weight and sex and randomly allotted to four replicates of four growing-finishing diets. The meal diets (Table 1) consisted of: (1) the basal corn-soybean meal, (2) ground roasted soybeans replacing the soybean meal of the basal diet on a pound for pound basis, (3) diet 2 plus 3 lb added lysine per ton and (4) ground roasted soybeans replacing the soybean meal of the basal on an isonitrogenous basis (equal protein). The basal diet was initially a 16% crude protein diet, followed by a 14% crude protein diet when the animals of the control pen of each replication weighed 130 lb.

Study B. Ninety-six crossbred pigs were allotted as in Study A to four replicates (two replicates of barrows and two replicates of gilts) of four growing-finishing diets. The

(Continued on next page)

Roasted Soybeans . . .

(continued from page 29)

meal diets (Table 2) consisted of: (1) the basal corn-soybean meal, (2) ground roasted soybeans replacing the soybean meal of the basal diet on a pound for pound basis, (3) diet 2 with a 10% increase in roasted soybeans and (4) diet 2 with a 20% increase in roasted soybeans. As in Study A, the animals were initially fed a 16% crude protein diet, followed by a 14% protein diet.

Study C. Eighty crossbred pigs were allotted by weight outcome groups to two replications (one replicate of barrows and one replicate of gilts) to two growing-finishing diets. The meal diets (Table 3) consisted of: (1) the basal corn-soybean meal and (2) ground roasted soybeans replacing the soybean meal of the basal diet on a pound for pound basis plus an added 15% in roasted soybeans. A 16% crude protein diet was fed for the first 35 days, followed by a 14% protein diet.

Studies A, B and C. Accommodations for the pigs in studies A and B were similar. Each pen of six pigs had like shelters, self-feeders and waterers. The pigs in study C were housed in a totally slotted building with each pen equipped with a self-feeder and automatic waterer.

Results and Discussion

Studies A and B. Performance data are shown in Tables 4 and 5, respectively. These two studies were started with pigs of comparable size (52-58 lb) and conducted under comparable environmental conditions. As indicated in Tables 4 and 5, pigs fed the basal diet for the two studies performed similarly with respect to both average daily gain (ADG) and feed conversion (FC). The replacement of soybean meal with roasted soybeans on a pound for pound basis provided similar pig performance in each of the two studies. Each of the studies indicated a slight reduction in performance of pigs fed diet 2 compared to the pigs fed the basal diet.

The pigs fed diet 3 (added lysine) in study A had similar ADG, FC and ADFI as pigs fed the basal diet. Pigs in study A fed the isonitrogenous (diet 4) had a slight reduction in ADG, a decrease in ADFI, but an improved feed conversion. Diet 4 was formulated on the basis of chemical analysis of the roasted soybeans used in this study

Table 2. Diet composition, Study B.

	Diet designation							
	1		2		3		4	
	Basal		lb/lb		GRS[a] lb/lb + 10% add		GRS lb/lb + 20% add	
Ingredients, %	16	14	16	14	16	14	16	14
Corn	72.5	79	72.5	79	70.35	77.5	68.2	76
Soybean meal, 44	21.5	15	--	--	--	--	--	--
Ground roasted soybeans	--	--	21.5	15	23.65	16.5	25.8	18
Base mix[b,c]	6	6	6	6	6	6	6	6

[a]GRS - Ground roasted soybeans.
[b]Base mix includes (% of total 16% diet) - alfalfa hay, 2.5; calcium carbonate, 0.9; cyphos (24% Ca, 18.5% P), 1.5; iodized salt, 0.5; trace minerals, 0.001 (Calcium Carbonate Company, Swine, 15% Zn); vitamin A, 1500 IU; vitamin D, 252 IU; riboflavin, 2.0 mg; niacin, 8.5 mg; calcium pantothenate, 4.5 mg; choline chloride, 10.0 mg; vitamin B_{12}, 10.0 mcg.
[c]Base mix includes (% of total 14% diet) - same as 16% diet premix with the following exceptions - vitamin A, 1000 IU; vitamin B_{12}, 5.0 mcg.

Table 3. Diet composition, Study C.

	Diet designation			
	1		2	
	Basal		GRS[a] lb/lb + 15% add	
Ingredients, %	16	14	16	14
Corn	72.5	79	69.275	76.75
Soybean meal, 44	21.5	15	--	--
Ground roasted soybeans	--	--	24.725	17.25
Base mix[b]	6	6	6	6

[a]GRS - Ground roasted soybeans.
[b]Base mix includes (% of total 16% diet) - alfalfa hay, 2.5; calcium carbonate, 0.9; cyphos (24% Ca, 18.5% P), 1.5; iodized salt, 0.5; trace minerals, 0.001 (Calcium Carbonate Company, Swine, 15% Zn); vitamin A, 1500 IU; vitamin D, 252 IU; riboflavin, 2.0 mg; niacin, 8.5 mg; calcium pantothenate, 4.5 mg; choline chloride, 10.0 mg; vitamin B_{12}, 10.0 mcg.
[c]Base mix includes (% of total 14% diet) - same as 16% diet premix with the following exceptions - vitamin A, 1000 IU; vitamin B_{12}, 5.0 mcg.

Table 4. Pig performance, Study A.

	Diet designation			
Criteria	1	2	3	4
No of pigs[a]	24	24(2)	24	24(1)
No of pigs per pen	6	6	6	6
Avg initial wt, lb	58.1	58.1	58.4	58.6
Avg final wt, lb	227.6	222.0	227.1	220.2
Avg daily gain, lb	1.83	1.77	1.83	1.75
Avg daily feed intake, lb	5.55	5.59	5.48	5.12
Feed conversion	3.04	3.14	3.00	2.92

[a]Number in parenthesis represents pigs in the treatment that did not complete study. All calculations based on only pigs completing study.

Table 1. Diet composition, Study A.

	Diet designation							
	1		2		3		4	
	Basal		lb/lb		GRS[a] lb/lb + lysine		GRS isonitrogenous	
Ingredients, %	16	14	16	14	16	14	16	14
Corn	72.5	79	72.5	79	72.5	79	67.5	74.75
Soybean meal, 44	21.5	15	--	--	--	--	--	--
Ground roasted soybeans	--	--	21.5	15	21.5	15	26.5	19.25
L-lysine monohydrochloride	--	--	--	--	.15	.15	--	--
Base mix[b,c]	6	6	6	6	5.85	5.85	6	6

[a]GRS - Ground roasted soybeans.
[b]Base mix includes (% of total 16% diet) - alfalfa hay, 2.5; calcium carbonate, 0.9; cyphos (24% Ca, 18.5% P), 1.5; iodized salt, 0.5; trace minerals, 0.001 (Calcium Carbonate Company, Swine, 15% Zn); vitamin A, 1500 IU; vitamin D, 252 IU; riboflavin, 2.0 mg; niacin, 8.5 mg; calcium pantothenate, 4.5 mg; choline chloride, 10.0 mg; vitamin B_{12}, 10.0 mcg.
[c]Base mix includes (% of total 14% diet) - same as 16% diet premix with the following exceptions - vitamin A, 1000 IU; vitamin B_{12}, 5.0 mcg.

Table 5. Pig performance, Study B.

Criteria	Diet designation 1	2	3	4
No of pigs[a]	24(3)	24	24	24
No of pigs per pen	6	6	6	6
Avg initial wt, lb	52.2	53.2	52.9	52.7
Avg final wt, lb	232.8	228.7	233.7	230.1
Avg daily gain, lb	1.78	1.74	1.80	1.76
Avg daily feed intake, lb	5.53	5.45	5.58	5.36
Feed conversion	3.11	3.13	3.10	3.05

[a]Number in parenthesis represents pigs in the treatment that did not complete study. All calculations based on only pigs completing study.

Table 6. Pig performance, Study C.

Criteria	Diet designation 1	2
No of pigs	40(1)[a]	40
No of pigs per pen	20	20
Avg initial wt, lb	69.7	69.4
Avg final wt, lb	221.9	219
Avg daily gain, lb	1.66	1.64
Avg daily feed intake, lb	5.63	5.37
Feed conversion	3.39	3.27
Days on study	91	91

[a]One pig succumbed. Calculations based only on pigs that completed study.

Table 7. Performance - barrows vs gilts, Studies B and C.

Criteria	Diet designation Basal	lb/lb	GRS + 10%	GRS + 15%	GRS + 20%
Avg daily gain, lb					
Study (barrows) B	1.77	1.92	1.95	--	1.84
(barrows) C	1.72	--	--	1.77	--
Study (gilts) B	1.80	1.57	1.64	--	1.68
(gilts) C	1.62	--	--	1.52	--
Feed conversion					
Study (barrows) B	3.26	3.09	3.16	--	3.09
(barrows) C	3.39	--	--	3.25	--
Study (gilts) B	2.97	3.18	3.05	--	3.02
(gilts) C	3.34	--	--	3.29	--

(36% crude protein) to be isonitrogenous with diet 1.

Pigs fed diet 4 in study B had a decrease in ADG and ADFI with limited improvement in FC as compared to the pigs fed diet 3.

Study C. As shown in Table 6, the number of pigs per pen were increased in this study. The shelter provided a 100% slotted floor, thus a different environment than provided pigs in studies A and B. ADG (1.66 vs 1.64) was not influenced in this study when roasted soybeans were used to replace soybean meal. However, there was a reduction in the ADFI (5.63 vs 5.37) and an improvement in FC (3.39 vs 3.27) of the pigs fed the diet containing roasted soybeans.

Studies B and C. The ADG and FC of barrows and of gilts are shown in Table 7 for studies B and C. Regardless of the manner in which roasted soybeans replaced soybean meal, the performance of the barrows was improved. For the gilts in these two studies, performance was reduced when roasted soybeans replaced soybean meal in their diets.

Summary

Two-hundred-seventy two crossbred pigs were fed diets differing in the manner in which ground roasted soybeans replaced soybean meal in 16 and 14% crude protein corn-soybean meal basal diets.

In general, the treatments used in these studies did not affect ADG. A slight improvement in feed conversion was observed when roasted soybeans were included in the diet.

It was not difficult during the study to detect which group of pigs were fed diets supplemented with ground roasted soybeans. The increased fat intake definitely improved the appearance of the animals as related to the condition of their skin and hair coat.

A considerable reduction in dust was observed in the diets containing ground roasted soybeans. Elimination of dust is difficult to economically identify but could be significant in confinement feeding systems.

In the two studies where barrows and gilts were separated for the duration of the studies the performance of the barrows appeared to improve while the performance of the gilts was reduced when roasted soybeans replaced soybean meal.

Overall, the replacement of soybean meal with roasted soybeans provided neither beneficial or adverse animal performance.

---

[1]Murray Danielson is Professor, Swine Nutrition, West Central Center, North Platte. Mark Crenshaw is Swine Operations Manager, West Central Center, North Platte.

Find Your Future

in

ANIMAL SCIENCE

at the

UNIVERSITY OF NEBRASKA

CURRICULUM OPTIONS

Undergraduate programs for Animal Science majors and for other students in the College of Agriculture help develop the student's capability to cope with problems of Nebraska's livestock industry. Because of the size of this livestock industry—65% or more of Nebraska's agricultural income—all agriculturists who work in Nebraska must understand livestock production. Several options are available in the undergraduate Animal Science program. These include:

1. Production
2. Business
3. Science
4. Range
5. Meats