EC77-219 Nebraska Swine Report

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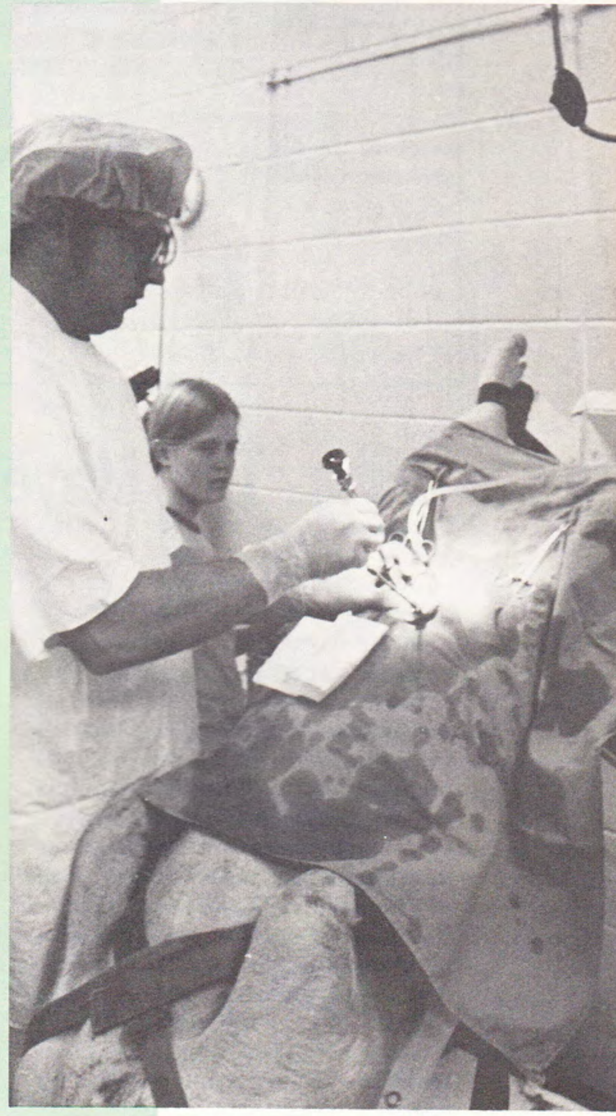
NEBRASKA SWINE REPORT



- Breeding
- Disease Control
- Nutrition
- Economics
- Housing

Prepared by the staff in Animal Science and cooperating Departments for use in the Extension and Teaching programs

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The Move to Mead

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Swine have been an integral part of the University of Nebraska Lincoln Campus for nearly 75 years. By the summer of 1978, they will be gone. The growth of Lincoln residential areas to the east has necessitated moving swine research activities from their current location at 75th and Adams.

The red brick research facility that many of you were instrumental in obtaining for the Animal Science Department in the late 1940's will be gone and hopefully replaced with facilities typical of what the swine industry is using today.

The new research unit will be developed at the University of Nebraska Field Laboratory at Mead, Nebraska. We must give tremendous credit to those of you who had the wisdom to obtain a portion of the old ordnance plant at Mead for a University of Nebraska Field Research Laboratory. While some distance from the Lincoln campus, and not as convenient for day to day inspection of research activities, the Field Laboratory has provided us with an excellent place to relocate our swine research facilities.

Monies to develop the new swine research unit will come from the sale of land close to Lincoln now owned by the University of Nebraska. Inflation has forced the expected cost of the new unit at Mead up to about $1,000,000. Planned for the new research facility are:

- Gestation unit (288 sow).
- Farrowing house (96 stall).
- Nursery to complement the farrowing house.
- Six modified-open front growing-finishing units.
- Swine reproductive physiology unit.

These facilities represent no expansion in our current swine research program. However, we will be changing our management system from basically a pasture program to one of total confinement.

Some swine research will continue on the Lincoln campus, but this will be intensified basic research confined to Marvel Baker Hall. This research will complement the applied research activities in the new unit at Mead.

We are optimistic and enthusiastic about the future of swine research within the Nebraska Agricultural Experiment Station. We need your support, and welcome your inputs as to how we can better serve the Nebraska swine industry.

Contents

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Acknowledgments

The Faculty and Staff of the Animal Science Department wish to acknowledge and thank all those who have supported the swine program during this past year. Many individuals and companies have provided grant and product support for research, teaching and extension.

The University of Nebraska Area of Excellence support for the swine area has strengthened the program. The Nebraska Pork Producers Association has been helpful to the staff in relating to Nebraska pork production problems. The efforts of the men and women who work in the research labs and farms are greatly appreciated.

Pseudorabies

Threat to the Swine Industry

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Pseudorabies, a highly contagious viral disease affecting swine and other warm-blooded animals, seems to be spreading rapidly in the United States. The threat to the swine industry is mounting steadily. The greatest number of laboratory confirmed cases of pseudorabies have been reported from mid-western swine states.

Pigs are the natural host and principal reservoir of infection. Dogs, cats, rodents and other wildlife can become infected and spread the infection from herd to herd. The causative agent is a herpes virus *(Herpes suis)* which is classified in the same group of viruses as Herpes simplex of humans (the cause of fever blisters), equine rhinopneumonitis of horses and infectious bovine rhinotracheitis (IBR) of cattle.

Pseudorabies, or Aujeszky's Disease, virus attacks the central nervous system (brain and spinal cord), causes high mortality in suckling pigs and impairs reproductive performance of the sow by decreasing fertility and by causing fetal death.

The virus can occur in an inactive form in a host animal without producing clinical disease. Certain forms of stress (farrowing, weather changes, transportation) stimulate virus multiplication and shedding of the virus. Consequently, the host animal can develop the acute form of the disease or can become a carrier animal.

Diagnosis

A diagnosis of pseudorabies infection is frequently based on the results of a combination of tests:

Gross examination of affected tissues (liver, spleen and tonsil) for characteristic (0.5 to 3 millimeter) white lesions (area of dead tissue). Affected pigs frequently lack visible lesions; therefore, several pigs from individual herds should be submitted for examination. A presumptive diagnosis is based upon dual consideration of gross examination of tissues and herd history.

Histopathological examination based on microscopic examination of affected tissues that have been fixed in formalin. Characteristic microscopic lesions can be observed in the central nervous system (brain and spinal cord), spleen, liver, and lung tissues collected from suspect animals. Microscopic lesions are not always detectable, but when present are relatively good evidence of pseudorabies virus infection.

Isolation of pseudorabies virus in cell cultures. In this test, material prepared from affected tissues

Pseudorabies is spreading rapidly.

(brain, spinal cord, tonsil) are inoculated into living cell cultures. If pseudorabies virus is present, it will kill the cell cultures after a few days. Fluorescent antibodies (antibodies tagged with a dye) are often used to confirm identity of viruses isolated in cell culture. If cell cultures are protected by anti-pseudorabies serum pseudorabies virus is present.

Negative results from virus isolation tests do not always mean pseudorabies virus was never present. Instead, it indicates the virus was not culturable at that time. Generally, virus isolation is a reliable diagnostic test; however, the procedure often requires several days or weeks.

The fluorescent antibody technique (FAT) based on the principle of specific reaction between specific test pseudorabies antibody tagged with a fluorescent dye and reacted with the wild virus (antigen) in infected tissues. A special microscope equipped with an ultraviolet light source is used in this procedure. The fluorescent antibody technique is a rapid diagnostic procedure. However, its use as a pseudorabies diagnostic tool has been limited in some laboratories by a lack of confidence in its reliability when used to search for virus in tissues.

Serum neutralization (SN) test procedures used to demonstrate antibodies to pseudorabies virus in swine blood. Blood serum is reacted with a measured dose of the test pseudorabies virus. The mixture of the serum and test virus is inoculated into cell cultures. Failure of development of the deadly effects of pseudorabies test virus in the cell cultures is evidence for presence of pseudorabies virus antibodies.

A positive diagnosis of an active infection of pseudorabies is based on serum neutralization tests performed on paired serum samples collected from the suspect animal. The first serum sample is collected as soon as possible after onset of the illness. The second serum sample is collected from the same animal 10-14 days later. This time interval is necessary to allow time for development of anitbodies in response to virus infection. A positive diagnosis is indicated when a significant increase in antibody level (titer) is detected in the second sample.

Carrier Test

Demonstration of pseudorabies antibodies in the blood serum of a pig is considered evidence of a potential virus shedder or carrier of infection. The SN test is currently the only available test for screening virus carrier animals.

The importance of appropriate high-quality specimens for reliable disease diagnosis cannot be overemphasized. When pseudorabies virus infection is suspected in a herd, the local veterinarian should be contacted immediately.

Sell Gilts After One Litter?

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Internal Revenue Service regulations permit pork producers to treat income from the sale of breeding stock which they have held 12 months or longer as a capital gain. Since only half of the capital gain is taxable for individuals, some producers routinely sell all gilts after one litter so that a larger proportion of the income from their swine enterprise will qualify as capital gains.

When doing this, they sacrifice litter size, as sows typically have larger litters than gilts. Also, gilts are unproven in their temperament in the farrowing house, mothering ability, and will have slightly smaller pigs. In addition, feed requirements may differ between the all gilt breeding herd and one in which sows are kept for several litters. How do these advantages and disadvantages of the all gilt breeding herd add up in dollars and cents?

To answer this question, costs and returns for two swine production systems were budgeted for:

1. An all gilt breeding herd.
2. A breeding herd in which sows were kept for four litters.

The latter system is employed by many Nebraska pork producers. The two types of production systems were compared by examining both a farrow to finish enterprise and a feeder pig producing enterprise.

Description of the Systems

Costs and returns for each system were calculated for a herd of females large enough to result in 32 farrowings, given normal conception rates and death losses. Labor efficiency and building costs were based on an ongoing operation, with a 32-stall farrowing house, used six times per year, with a total of about 100 females.

In both systems, gilts or sows that failed to conceive (10% for sows, 15% for gilts) were sold on the first heat period after breeding. Those that went into the farrowing house, did not wean a litter (6.25%) were sold at the end of the lactation period for that group. Pigs were weaned at six weeks of age, and sows were bred in the second heat period following weaning. A death loss of 1.5% from weaning to market weight was assumed.

Production and Sales

One of the major differences in the two systems is the number of hogs produced. Gilts will typically wean smaller litters than sows. The average number of pigs per litter for each successive farrowing of a sow, and the percentage of the herd in each category are presented in Table 1.

The number of pigs weaned per litter in successive farrowings of the female shown in Table 1 was established after reviewing several articles and studies. Due to constant attrition from the breeding herd, the 4-litter system contains nearly one-third gilts, and only 18% fourth-litter sows. This distribution is due in part to the rather severe culling policy assumed in this study. The net result is an average of 8.1 pigs weaned per litter for the 4-litter system. This is an increase of 0.9 pigs per litter over the all gilt system.

The number of pigs weaned from one farrowing of 32 females in each system and their disposition are presented in Table 2. Fractional numbers of animals were used for accuracy in subsequent calculations, and would of course average out in a large, ongoing swine enterprise.

As shown in Table 2, 17.5% of pigs weaned from each farrowing must be retained for breeding purposes in the all gilt system. In contrast, only 4.9% are retained for breeding purposes in the 4-litter system. Due to the smaller number required for breeding and the larger litter size, the 4-litter system has about 55 more pigs available for sale or finishing than the all-gilt system.

The expected sales from one farrowing of 32 females are presented in Table 3. All sales of cull breeding stock, except sales of open gilts, qualify as capital gains for income tax purposes. The breeding stock sales under the all

Table 1. Reproductive capacity and composition of breeding herds, all gilt and 4-litter systems.

Number of litter	Number of pigs weaned per litter	Composition of breeding herd: All gilt	Composition of breeding herd: 4-litter
First	7.2	100%	32%
Second	8.2		27%
Third	8.8		23%
Fourth	8.8		18%
		100%	100%
Average number of pigs weaned per litter—		7.2	8.1

Table 2. Number of pigs produced from one farrowing of 32 females.

	All gilt		4-litter	
	Number	Percent	Number	Percent
Pigs weaned	216	100	245	100
Pigs retained for breeding	37.75[a]	17.5	12.00	4.9
Pigs available for finishing or sale	178.25	82.5	233.00	95.1

[a]Fractional numbers used for accuracy in subsequent calculations.

gilt system are more than three times greater than those under the 4-litter system. Again, fractional numbers of animals are used for accuracy, and would balance out in a large, ongoing enterprise. The difference between the number retained for breeding in Table 2 and those culled and sold in Table 3 reflects the expected death loss.

The total value of sales from the feeder pig enterprise is greater for the all gilt system than for the 4-litter system, even though fewer animals are sold. This is due to the fact that 41% of the sales in all gilt systems came from large animals (cull breeding stock), while only 15% of sales in the 4-litter system came from cull breeding stock.

The total value of sales from the farrow to finish enterprise was greater from the 4-litter system than for the all gilt system. The increased tonnage of market hogs produced from the larger litters in the 4-litter system more than offset the larger amount of cull breeding stock sales in the all gilt system.

Expenses

The all gilt breeding herd required more feed than the 4-litter breeding herd. The primary factor was the feed required to grow a group of gilts to breeding age for each farrowing vs. maintaining a group of sows and only growing a small number of replacements. In addition, only the gilts were given a flushing ration before breeding. However, the gilts did receive less feed than the sows during lactation and post lactation, 9 pounds (4.1 kg) vs. 12 pounds (5.4 kg).

Feed expense for one farrowing interval of 32 females in the feeder pig production enterprise was $5,010.95 for the all gilt system, and $4,077.03 for the 4-litter system—a difference of about $1,000. Feed costs were calculated using prices of $2.50/bu ($.098/kg) for corn and $200/ton ($.22/kg) for 40% protein supplement. But, the total weight of hogs sold was 20,898 lb (9,479 kg) for the all gilt system, and 13,889 lb (6,300 kg) for the 4-litter system, resulting in units of feed required per unit of hog produced of 4.3 and 5.2, respectively.

Feed expense in the farrow to finish enterprise was $11,272.63 for the all gilt system; and $12,193.30 for the 4-litter system. The added feed required to finish the large number of market hogs in the 4-litter system more than offset the lower feed requirements of the breeding herd. Feed efficiency, in terms of units of feed per unit of hog produced, was 3.9 for the all gilt system, and 4.0 for the 4-litter system.

Tax deductible non-feed expenses included depreciation, repairs, taxes and insurance on buildings and equipment, and expenses for veterinary and medicine, utilities, marketing, trucking, interest, taxes, feed processing, and miscellaneous expenses. These totaled $78.06 per litter for the feeder pig production enterprise, and $148.18 per litter for the farrow to finish enterprise.

Profits Compared

Profits from each system are compared in Tables 4 and 5. For the farrow to finish enterprise, one farrowing of 32 females in the 4-litter system results in $928.87 more before-tax profit than the all gilt system. When income taxes are considered, the after-tax profits from the two systems are exactly equal at a tax rate of 39%. Below this point, the 4-litter system produces more after-tax profit. For tax rates above 39%, the all gilt system produces more after-tax profit. It should be emphasized that the "tax rates" used in Tables

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Table 3. Expected sales from one farrowing interval, 32 females into farrowing house.

	All gilt		4-litter	
	Number	Value[a]	Number	Value[a]
Breeding stock sales				
Treated as ordinary income	5.69	$598.00	1.75	$183.92
Qualifying as capital gains	31.68	4,272.91	9.89	1,374.30
Total	37.37	$4,870.91	11.64	$1,558.22
Feeder pig sales[b]	177.65	$6,874.44	232.82	$9,007.81
Total sales-feeder pig enterprise	215.02	$11,745.35	244.46	$10,566.03
Market hog sales[b]	175.00	$16,628.15	229.30	$21,790.48
Total sales-farrow to finish enterprise	212.37	$21,499.06	240.94	$23,348.70

[a]Average of weekly prices from January, 1974, through July, 1976, for Iowa and Southern Minnesota.
$38.69 per head for 40 lb (18.2 kg) feeder pigs
$43.19 per cwt. ($.952/kg) for 220 lb (99.8 kg) barrows and gilts
$36.24 per cwt. ($.799/kg) for 290 lb (131.5 kg) cull open gilts
$35.67 per cwt. ($.786/kg) for 350-380 lb (158.8-172.4 kg) cull sows
$34.59 per cwt. ($.762/kg) for 425 lb (192.8 kg) cull sows

[b]Either feeder pigs or market hogs would be sold.

Table 4. After-tax profit—from one farrowing interval, 32 females—farrow to finish enterprise.

	All gilt	4-litter
Gross sales		
Ordinary income	$17,232.45	$21,979.65
Capital gains	4,272.91	1,374.30
Total	$21,499.06	$23,348.70
Tax deductible expense		
Feed	$11,272.63	$12,193.30
Non-feed	4,638.80	4,638.80
Total	$15,911.43	$16,832.10
Before tax profit	$5,587.63	$6,516.60
Taxable income	3,451.18	5,829.45
Net after-tax profit at alternative tax rates		
20%	$4,897.40	$5,350.71
30%	4,552.28	4,767.77
40%	4,207.16	4,184.82
50%	3,862.04	3,601.88

Sell Gilts . . .

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4 and 5 are not marginal tax rates. They are average rates—they apply to all of the taxable income. Later, when we discuss the "full-time hog enterprise," actual income tax and social security tax rate schedules are utilized.

In the feeder pig production enterprise the profits (both before-tax and after-tax) were higher with the all gilt system, compared to the 4-litter system.

Full-Time Enterprises Compared

Comparisons to this point reflect costs and returns of one farrowing of 32 females in each system. Let's now compare the systems on a "full-time man basis." Under typical farm building and equipment systems, one man, working full-time with hogs, could produce 192 litters farrow to finish per year or 298 litters of feeder pigs per year. This person might be a young man who has assumed the responsibility for the hog enterprise in a father-son working arrangement. For purposes of calculating income taxes, he takes the standard personal deduction, and has four personal exemptions.

The net after-tax profits for the full-time farrow to finish enterprise are presented in Table 6. The after-tax profits resulting from four market hog price levels are shown. The production costs discussed earlier are used here and are held constant as the market hog price is varied. At $40/cwt. ($.882/kg) market hogs, the 4-litter system yields $1,071 more after-tax profit than the all gilt system. However, the all gilt system is $888 more profitable at the $50/cwt. ($1.102/kg) price level, and $2,304 more profitable at the $60/cwt. ($1.323/kg price level). However, these differences represent a relatively small percent of the after-tax profit, and are induced by hog price levels which would probably not be sustained over time.

Table 5. After-tax profit—from one farrowing interval, 32 females—feeder pig production enterprise.

	All gilt	4-litter
Gross sales		
Ordinary income	$7,427.44	$9,191.73
Capital gains	4,272.91	1,374.30
Total	$11,745.35	$10,566.03
Tax deductible expense		
Feed	$5,010.95	$4,077.03
Non-feed	2,467.21	2,467.21
Total	$7,478.16	$6,544.24
Before-tax profit	$4,267.19	$4,021.79
Taxable income	2,130.74	3,334.64
Net after-tax profit at alternative tax rates		
20%	$3,841.04	$3,354.86
30%	3,627.97	3,021.40
40%	3,414.89	2,687.93
50%	3,201.82	2,354.47

Table 6. Annual after-tax profits resulting from a full-time farrow to finish hog enterprise (192 litters per year).

Market hog price		Net after-tax profit (loss)	
Per cwt.	Per kg.	All gilt	4-litter
$30	$.661	($5,888.28)	($3,689.28)
40	.882	16,854.13	17,837.82
50	1.102	37,867.20	37,000.61
60	1.323	54,517.95	52,231.77

A similar comparison for the full-time feeder pig producer yields quite different results. Table 7 shows that after-tax profits for the all gilt system are greater over the entire range of feeder pig price levels. These differences in after-tax profits between the all gilt and 4-litter systems are significant, both absolutely and in proportion to the total. The all gilt system produces nearly twice as much after-tax profit as the 4-litter system at a $30 per head feeder pig price.

Thus, the potential profit advantage of the all gilt system is doubtful for the farrow to finish producer, but it is very significant for the feeder pig producer. One reason for this situation is that cull breeding stock sales for the all gilt system comprise 42 percent of the feeder pig producer's income (Table 3), while breeding stock sales only account for 23 percent of the farrow to finish producer's income. Thus, the effect of the capital gains is diluted by additional income from market-weight hogs. And, when comparing the two breeding herd strategies in the farrow to finish enterprise, the tax-saving effects of the capital gains in the all gilt system are offset by additional sales of market hogs in the 4-litter system, resulting from larger litters.

Other Considerations

The preceding discussion has centered on factors which can be quantified and validated with research studies, such as pigs weaned per litter, and feed requirements. Other factors, more difficult to quantify and validate, should also be considered when comparing an all gilt breeding herd with one in which sows are kept for several litters. Some considerations are:

Advantages of the all gilt system:

1. The market value of weight gains are typically higher with gilts than with older sows.
2. Rapid improvement in the breeding herd is possible due to rapid turnover of the breeding herd.
3. Pecking order problem sometimes associated with sow herds of mixed ages is reduced in all gilt herds.
4. Volume of production can be maintained easier in the all gilt herd, as the sow herd is subject to attrition.
5. Gilts can withstand hot weather stress better than sows.

Advantages of keeping sows for more than one litter:

1. Sows typically wean more pigs per litter than gilts.
2. Sows typically wean heavier pigs than gilts.
3. Sows usually protect pigs better from cold weather.
4. Some disease control advantage may result from fewer new animals being introduced into the breeding herd.

Table 7. Annual after-tax profits resulting from a full-time feeder pig production enterprise (298 litters per year).

40# feeder pig price per head	Net after-tax profit (loss)	
	All gilt	4-litter
$20	($13,115.05)	($10,085.94)
30	15,100.78	9,248.72
40	33,001.77	26,778.37
50	52,530.14	41,172.12

5. Sows can be synchronized naturally by scheduling weaning dates.

6. It is not necessary to change boars so often to avoid inbreeding with a sow herd.

7. Sows may require less attention (and operator labor) in the farrowing house.

Summary and Conclusions

The all gilt breeding herd appears to offer little advantage to the farrow to finish hog producer in terms of after-tax profits. His average income tax rate must be more than 39% for the all gilt system to be more profitable than a 4-litter system. Using income averaging and good income tax management, most producers would not be at or above this tax rate over an extended period of time. Also, the after-tax profit advantage at tax rates above 39% are not large, particularly when we consider the non-quantifiable factors, and the 50% maximum tax rate on earned income.

The situation is quite different for the feeder pig producer, however. The all gilt system produces more after-tax profit for him regardless of his income tax rate. But, the all gilt program requires large numbers of replacement breeding stock.

This may present a problem for the producer who sells his pigs at 40 lb (18.1 kg). He will need to select female pigs at 40 lb (18.1 kg) and feed them to near market weight before they enter the breeding herd. This will require facilities, labor, and may be difficult to incorporate into a crossbreeding system. If he buys his replacement gilts, he loses the capital gains advantage associated with raised breeding stock. However, a producer who regularly sells feeder pigs to the same finisher might work out an arrangement whereby he retains ownership of the number of gilt pigs which he will need for replacement, pays the finisher to custom-feed that number of pigs, and selects his replacements from the lot of pigs when they weigh approximately 200 lb (90.7 kg).

Management of environment is major factor in pig survival.

Survival After Weaning

Oats Can Make a Difference

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Associate Professor
(Swine Nutrition)

Weaning stress and getting feeder pigs started on feed and growing normally without developing scours or edema is a problem facing many swine operations.

Management of the pigs' environment plays an important role in their survival and ability to grow normally.

The type of diet to feed is another important factor to consider. Some questions being asked about diets for pigs of this type are: How complex should the diet be? Does the pig after weaning need milk in his diet or is a simple corn-soybean meal diet fortified with minerals and vitamins adequate? What source and level of protein and what type and level of antibiotic should be fed?

In an earlier study we found that pigs weaned at three to four weeks of age could be fed a relatively simple corn-soybean meal diet balanced to 18% protein and fortified with minerals and vitamins (*Nebraska Farm, Ranch* and *Home Quarterly*, Summer 1976). Pigs on this type of diet may make less efficient, but probably more economical, gains than on a complex starter containing high levels of milk. A broad spectrum antibiotic should also be added at around 50 to 250 g/ton (55 to 275 g/metric ton). ASP-250 is preferred over Aureomycin if the herd is infected with *Atrophic rhinitis*.

Study Started

Because of the confusion about what to feed young pigs, a study was conducted to determine the effects of ground oats and type of antibiotic on gain, feed intake, feed conversion and survival of pigs weaned at three to four weeks of age. In this study, 216 pigs were weaned, moved to an enclosed nursery (18 pigs/pen) and placed on experimental diet 1, 2, 3 or 4 (Table 1). The nursery was an environmentally regulated building with a ⅔ slatted floor. The slats were concrete, 5" (12.7 cm) wide with a 1" (2.54 cm) gap. Each pen was equipped with a cup waterer over the slats and a self feeder over the solid area.

The study was conducted during February and March. A space heater was used to heat the air in the building. Extra heat for the pigs was provided by heat lamps. Plywood panelling was placed on three sides of the pen over the solid area, in an attempt to decrease the heat loss from the heat lamps and to reduce drafts. A plywood plank was placed under the pigs to insulate them from the cold concrete floor. For the first few days the pigs were given medicated water and were fed on the floor to get them started eating and to start a proper dunging pattern. Feeding on the floor will help keep the pen dry, which is important for pigs of this age.

Pigs were three to four weeks of age and averaged 14.0 lb (6.9 kg) at weaning and 33.9 lb (15.4 kg) at

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Oats Can Make a Difference

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the end of the five week trial. For the first three weeks following weaning, four experimental treatments were used (diets 1, 2, 3 and 4). The two levels of oats (0% and 20%) were fed with either of two types of antibiotics (NF-180, 150 g/ton [165 g/metric ton] or ASP-250, 250 g/ton [275 g/MT]). During the last two weeks of the five week period all pigs were placed on diet 5, which contained 10% oats and 250 g/ton (275 g/MT) of ASP-250. All diets were balanced to 18.5% protein, .75% calcium and .65% phosphorus. There were 18 pigs per pen with three pens per treatment, giving a total of 54 pigs per treatment.

Results from this trial are given in Table 2. There were no significant differences observed in average daily gain or feed/gain for any of the treatments studied. This indicates that pigs fed a diet containing 20% ground oats produced an average daily gain and feed conversion similar to the corn-soybean meal control diet which contained no oats. The same was also true when NF-180 and ASP-250 were compared, with no differences observed between the two drugs for gain or feed conversion.

Pig Survival

The most interesting result of this study was the effect of oats and type of antibiotic on pig survival. The percent survival was greater (P<.10) when the diets contained 20% oats (97.2%) as compared to the control (90.7%) with no oats. Of the 108 pigs fed the 20% oat diets only 3 pigs died, and these died during the first 3 weeks after weaning, while none were lost during the last 2 weeks of the 5 week trial.

In the case of the control diet with no oats added, 8 pigs of the 108 died during the first 3 weeks and 2 additional pigs died within the next 2 week period. Similarly, for the first 3 weeks ASP-250 produced a survival of 98.2% compared to 91.6% for NF-180. This might be expected since ASP-250 is a broad spectrum antibiotic combination while NF-180 is rather specific. In this trial NF-180 was fed as the only source of antibiotic for those particular diets.

There was no significant oat x antibiotic interaction. However, the best diet for survival (100%) was the diet containing 20% oats and 250 g/ton (275 g/MT) of ASP-250. This is a rather simple diet which, during the 5 week trial, produced an average daily gain of .54 lb/day (.24 kg/day) and a feed/gain ratio of 1.83, and should be a relatively economical diet for pigs of this weight and age.

There were 216 pigs that started the test and 13 died by the end of the 5 week trial. But what is more striking is that 69% (9 pigs) of the losses occurred during the first 7 days after weaning, pointing out the importance of optimum management, including environment and nutrition, the first few days after weaning. A warm dry environment, free from drafts, and a relatively simple starter diet with 15% to 20% oats and a broad spectrum antibiotic is certainly recommended for pigs weaned at 3 to 4 weeks of age. Also, some of the management practices used in this study should be considered to aid in reaching optimum pig survival.

Table 1. Experimental Diets[a,b,c] (Nebraska Experiment 76409)

	1	2	3	4	5
Ground corn	60.7	42.7	60.7	42.7	52.4
Soybean meal	24.5	22.6	24.5	22.6	22.9
Ground oats	—	20.0	—	20.0	10.0
Dried whey	5.0	5.0	5.0	5.0	5.0
Dried fish solubles	2.5	2.5	2.5	2.5	2.5
Dried brewers yeast	1.0	1.0	1.0	1.0	1.0
Lard	2.5	2.5	2.5	2.5	2.5
Dicalcium phosphate	1.5	1.5	1.5	1.5	1.4
Limestone	.6	.6	.6	.6	.7
Trace mineral mix	.1	.1	.1	.1	.1
Salt (iodized)	.5	.5	.5	.5	.5
Vitamin-antibiotic premix	1.0	1.0	1.0	1.0	1.0
NF-180, 150 g/t (165 g/MT)	+	+	–	–	–
ASP-250, 250 g/t (275 g/MT)	–	–	+	+	+

[a]Trial conducted for 5 weeks.

[b]Diets 1, 2, 3 and 4 started at weaning and fed for 3 weeks; all pigs were fed diet 5 for the last 2 weeks of the 5 week trial.

[c]All diets contained 18.5% protein, .75% calcium and .65% phosphorus.

Table 2. Effect of oats and type of antibiotic in pig starter diets (Nebraska Experiment 76409)[a,b,c]

	Level of oats			
	0%		20%	
	NF-180[c]	ASP-250[c]	NF-180	ASP-250
Avg. daily gain, lb (g)				
Weaning to 3 wk	.30 (136)	.32 (145)	.34 (154)	.31 (141)
3 to 5 wk	.87 (395)	.89 (404)	.94 (426)	.88 (399)
Weaning to 5 wk	.55 (249)	.56 (254)	.58 (263)	.54 (245)
Avg. daily feed, lb (g)				
Weaning to 3 wk[d]	.55 (249)	.59 (268)	.61 (277)	.58 (263)
3 to 5 wk	1.67 (757)	1.69 (767)	1.75 (794)	1.59 (721)
Weaning to 5 wk	1.02 (463)	1.04 (472)	1.07 (485)	.99 (449)
Feed/gain				
Weaning to 3 wk	1.87	1.87	1.79	1.86
3 to 5 wk	1.91	1.92	1.86	1.81
Weaning to 5 wk	1.85	1.86	1.84	1.83
Survival %				
Weaning to 3 wk[e,f]	88.9	96.3	94.4	100
Weaning to 5 wk[e]	87.0	94.4	94.4	100

[a]Five week trial; 216 pigs; initial weight 14 lb (6.4 kg), final weight 33.9 lb (15.4 kg), age at weaning 3–4 weeks.

[b]Treatments were terminated at 3 wks and all pigs were placed on the same diet for 2 weeks (ASP-250 + 10% oats).

[c]NF-180, 150 g/ton (165 g/MT); ASP-250, 250 g/ton (275 g/MT).

[d]0% vs 20% oats (P<.05).

[e]0% vs 20% oats (P<.10).

[f]NF-180 vs ASP-250 (P<.10).

Crossbred Boars and Heterosis

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Availability of crossbred boars in the breeding stock market has stimulated vigorous discussion among all segments of the pork producing industry. Commercial producers who have used crossbred boars are sought for testimonials. Purebred breeders who feel their hold on the boar market threatened are understandably concerned.

Discussions by commercial producers usually emphasize the alleged superior breeding performance and durability of crossbred boars. Purebred breeders tend to discuss several genetic handicaps which they envision when crossbred boars are used. Among these predicted handicaps is the loss of heterosis when crossbred boars are used. Since heterosis is one of the primary purposes of crossbreeding, one would want to avoid using crossbred boars if that lead to a substantial loss of heterosis.

To more thoroughly understand the loss of heterosis a study of the expected heterosis in crossbreeding systems was made.

Hybrid Vigor

Heterosis or hybrid vigor is defined as the superiority of the crossbred over the average of the breeds in the cross. In a two-breed first cross, one of each pair of genes comes from each breed. Thus, the offspring are heterozygous at each locus (gene pair) for which the breeds are different. Heterosis is based on the heterozgous gene configuration. Heterosis is at its maximum level for a given breed cross when each pair of genes represents two breeds. Percent heterosis refers to the proportion of loci (gene pairs) at which the two genes represent different breeds. In a less rigorous way, percent heterosis could be defined as the proportion of gene pairs which are crossbred.

Some crossbreeding systems produce offspring which have less than 100% crossbred gene pairs. If a Duroc boar is mated to a sow which is half Yorkshire, ¼ Hampshire and ¼ Duroc, the resulting offspring will be "crossbred" at only ¾ of the gene positions. In this case, the offspring would be said to have 75% heterosis.

Level of Heterosis

The expected levels of heterosis for rotational crossbreeding systems are listed in Table 1. Both purebred and crossbred boars are included. Letters are used to designate breeds. Case 1 is a traditional three breed rotational crossbreeding program. About 86% of the potential heterosis is expected. In three-breed terminal crosses, such as an AxB sow mated to a C boar, the sow and the offspring have 100% heterosis.

Case 2 uses only crossbred boars. First crosses among three breeds are used in rotation. This system retains 71% of the heterosis, compared to 86% for Case 1. Using all crossbred boars in a controlled way reduces heterosis about 17 percent. Two other 3-way rotations using three breeds are of interest.

Case 3 uses boars from three breed terminal crosses in rotation. This system yields 68% heterosis.

Case 4 uses crossbred boars produced in Case 1. In this case 69% of the heterosis is realized. Again there is less than a 20% reduction in heterosis.

Table 1, Percent heterosis in 3-way rotational crossbreeding systems.

Case No.	Boar breed	% Heterosis
1	A, B, C. . . .	86
2	AxB, BxC, CxA	71
3	Ax(BxC), Bx(CxA), Cx(AxB)	68
4	Crossbreds from Case 1	69
5	AxB, AxC, AxD	71
6	AxB, AxB, AxB	50

Case 5 is different in that it involves four breeds and one breed is repeated in each crossbred boar type. Case 5 yields 71% heterosis.

In each of these cases using crossbred boars, heterosis was reduced. However, much of the heterosis remained. In each case it was assumed that the system was carefully followed.

Not following the crossbreeding system carefully can lead to a loss in heterosis. The most common abuse of a rotational crossbreeding system is to repeat a breed of boar for consecutive generations.

Case 6 represents Case 2 with the AxB boar repeated generation after generation. Fifty percent of the heterosis remains. If Case 1 is abused by repeating the same breed of purebred boar, heterosis is rapidly lost. In Case 1, if breed C is used two generations in a row, the resulting cross retains only 43% heterosis. Repeated use of the same breed soon removes essentially all of the heterosis.

Percent heterosis is not a sufficient criterion for deciding which breed or cross of boar to use. The question "percent of what?" remains. Do breeding systems with higher percentages of heterosis mean more profit? To evaluate the economic impact of differences in level of heterosis, results from a crossbreeding experiment at Oklahoma State University were used. The research involved the Duroc, Yorkshire and Hampshire breeds in two-way and three-way crosses and purebreds.

Performance levels of the purebreds (0% heterosis) and of three way crosses (100% heterosis) were established from the Oklahoma study. Performance levels for litter size weaned, age at market weight and feedout feed costs were estab-

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Crossbred Boars

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lished for the various percentages of heterosis by adding those percentages of the performance difference between the purebreds and three way crosses to the purebred performance levels. Budgets were calculated for each level of heterosis for feeder pig production and for feeding to market.

The feeder pig budget represents the costs of producing a litter of weaned pigs. Larger litters cost more, but per pig costs are less in larger litters. The feedout budget includes all costs of feeding out pigs from weaning to market. Both feed and non-feed costs were considered. Feed efficiency and days to market weight were the variables affected by heterosis during this period. Each level of heterosis combines the three breeds equally. Thus, the three-breed rotation averages the performance of the Duroc sired generation, the Hampshire sired generation and the Yorkshire sired generation.

The budget was based on feed at $120 per ton ($132.27 per metric ton), labor at $3 per hour and an average of 7.5 pigs per litter. With the three breed rotation (7.9 pigs weaned per litter) the cost per 220 lb (100 kg) pig was estimated to be $83.56. Figures in Table 2 represent the profit on 100 litters when 220 lb (100 kg) market hogs are sold for $88.00. The advantage of crossbreeding is greatly increased because more pigs are produced at less cost per pig.

These budgets were also calculated using both higher and lower market hog prices. With higher hog prices, the higher levels of heterosis enjoyed even larger profit advantages. At lower hog prices losses were minimized with higher heterosis percentages. When 220 lb (100 kg) market hogs are sold for $66, the difference between no heterosis and 100% heterosis was $3,620 on 100 litters. When market hogs sold for $110 each, the difference was $11,144 on 100 litters.

Since the studies these estimates are based on do not include matings using crossbred boars, the

Table 2. Profit on 100 litters with various levels of Heterosis.

% Heterosis	Pigs sold	Profit
100%	814	$4501
86%	790	$3508
71%	764	$2461
68%	759	$2254
50%	729	$1013
43%	717	$ 538
0%	643	−2341

figures include none of the possible advantages of crossbred boars. Crossbred boars are alleged to be more aggressive breeders, to get more sows pregnant, to sire larger litters and to have longer useful lives. If true, these advantages would have to be considered in decisions on using crossbred boars. Since no unbiased records are available on these aspects of boar performance, economic evaluation cannot be made. The limited research available tends to support these potential advantages of the crossbred boar.

Based on the budget figures in Table 2, a three-way rotation of purebred boars yields $1,047 more profit per 100 litters than a three-way rotation among first crosses of the same three breeds. This difference could be made up by a 0.3 increase in litter size. A higher pregnancy rate with fewer sows culled could also make up the difference.

One interesting comparison is one generation of repeated sire breed in a three breed rotation. The offspring of the repeated sire have 43% heterosis, their dam 86% heterosis. The next generation, assuming that the rotation is again started, the dam will have 43% heterosis and the offspring 93% heterosis. Using the same budget method, the average profit for these two generations is $2,043. Mistakes in following the rotation using purebred boars are costly.

Most examples using crossbred boars cited above resulted in a reduction in heterosis. Some crossbreeding systems using crossbred boars lose no heterosis. A terminal cross where both parents are two-way crosses (AB x CD) has 100% heterosis in both dam and offspring. Others increase heterosis compared to similar systems with purebred boars. A three-way rotation among two-way crosses of six breeds (AxB, CxD, ExF) has more heterosis than a three-way rotation of purebreds. Substitution of a crossbred boar for one of the purebreds in a three breed rotation (A, B, CxD) increases the heterosis in the offspring of the crossbred boar.

Summary

The use of crossbred boars may lead to the loss of some heterosis from some crossbreeding systems. In other systems, using crossbred boars may actually increase the level of heterosis. Budget considerations indicate that the loss of heterosis in conventional crossbreeding systems can cause a substantial reduction in profit. This reduction must be weighed against unknown but probable benefits in the breeding pen of using crossbred boars. Potential losses in rotational crossbreeding systems due to using crossbred boars are not as large as the loss caused by repeating the breed of sire in a rotation of purebred boars.

Use of Growth Promotants in AR Infected Swine Herd

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Reports from the field indicate that pigs infected with atrophic rhinitis (AR) are either unresponsive or respond poorly to growth promotants such as Mecadox.[1] Since there was little or no research data available to support or refute the field reports, an experiment was conducted to determine the efficacy of Mecadox and Aureo SP-250[2] for the mainte-

[1]Pfizer, Inc.
[2]American Cyanamid Co.
[3]Pfizer, Inc.

Table 1. Effect of Mecadox and Aureo SP-250 on gains and feed conversion of growing swine (Phase I—start to drug switch)[a]

	Treatments[b]		
	1	2	3
	Basal	Basal + 50 g Mecadox/T (55 g/MT)	Basal + 250 g ASP-250/T (275 g/MT)
ADG, lb[c]	0.91 (0.41 kg)	0.98 (0.44 kg)	1.09 (0.49 kg)
ADFI, lb[d]	2.53 (1.15 kg)	2.66 (1.21 kg)	2.87 (1.31 kg)
G/F	0.36	0.37	0.38

[a]Nebraska Agricultural Experiment Station Swine Nutrition Experiment 75420.

[b]Data based on average of 4 pens of 8 pigs/pen, initial weight 18.0 lbs (8.2 kg), 63 days from start to switch.

[c]Difference between treatments 1 vs 2 + 3 and 2 vs 3 significant (P<.001).

[d]Difference between treatments 1 vs 2 + 3 significant (P<.05); between 2 vs 3 (P<.10).

nance of gains, feed conversion, and prevention of turbinate erosion in pigs from a herd known to be infected with AR.

Experimental dietary treatments were:

1. Basal (14% opaque-2 corn-soybean meal diet) with no medication from start to slaughter.

2. Basal diet plus 50 grams/ton (55 gms metric ton) of Mecadox fed from start to 75 lbs (34 kg) body weight; then 50 gms of Terramycin[3]/ton (55 gms/metric ton) to slaughter.

3. Basal diet plus 250 gms/ton (275 gms/metric ton) of ASP-250 from start to 75 lbs (34 kg) body weight; then 50 gms Terramycin/ton (55 gms/metric ton) to slaughter.

The 96 pigs used in the study originated from the University of Nebraska herd which had been identified to have a high incidence of AR (this herd is currently being repopulated with primary SPF swine). Pigs started on test at an average weight of 18 lb (8.2 kg) with two pens of 8 barrows and two pens of 8 gilts assigned to each dietary treatment. Pigs were housed in a totally enclosed growing-finishing unit. The pens were 6′ x 12′ (1.8 x 3.7 meters) in dimension, 2/3 slatted floor, and housed 8 pigs/pen. Waste removal from the pit was accomplished with a "flush" system activated 5 times per day and discharged about 250 gallons (946 liters) of water/side/flush. The rearing environment appeared to be excellent in this research unit.

All pigs were swabbed and cultured by Professor Norman Underdahl of the Department of Veterinary Science for *Bordetella b.* at the beginning of the trial, at the middle when the pigs were switched from Mecadox and Aureo SP-250 to Terramycin, and at the end of the trial just before slaughter. Pig weights and feed data were collected bi-weekly. At slaughter, the pigs were checked for lung lesions and for erosion of the turbinates in all four quadrants of the nasal passage by Professor Alex Hogg and the field staff of the Nebraska SPF program.

Effects

The effects of Mecadox and Aureo SP-250 on gains and feed conversion during the first phase of the study are shown in Table 1.

Pigs fed Mecadox or Aureo SP-250 gained faster, consumed more feed and showed better feed conversion than pigs fed the non-medicated basal diet. Pigs gained faster and more efficiently when fed Aureo SP-250 compared to those fed Mecadox. This latter finding is somewhat contrary to that observed by researchers at Pfizer Central Research in one field trial and three University experiments. They found that pigs fed Mecadox gained faster and more efficiently than those fed drug combinations comparable to Aureo SP-250 (Table 2). Barrows

and gilts responded similarly to the dietary treatments.

When the pigs averaged about 80 lb (36 kg), they were either continued on the non-medicated basal diet or switched from Mecadox and Aureo SP-250 to Terramycin until slaughter (Phase II). Results of Phase II are shown in Table 3. Pigs on all treatments gained similarly with about the same feed intake and feed conversion during the finishing phase of the experiment. Thus, the results reemphasize the well-known fact that most of the response to growth promoting drugs occurs with the young animal. Whereas there was little difference between barrows and gilts in gains and feed conversion during Phase I, as expected, barrows gained faster and less efficiently during the finishing phase than gilts.

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Table 2. Performance efficacy of pigs fed Mecadox in the presence of Atrophic Rhinitis[a]

Dietary Treatment[b] (gm/T; (gm/MT)	No. pigs	Initial weight lb	Days on test	ADG lb	G/F
Nonmedicated control	81	27.3 (12 kg)	49	0.95 (.43 kg)	0.37
Mecadox (50) (55)	90	27.7 (12 kg)	49	1.12 (.51 kg)	0.39
Nonmedicated control	73	30.4 (13 kg)	48	0.97 (.44 kg)	0.36
Mecadox (50) (55)	78	30.4 (13 kg)	47	1.12 (.51 kg)	0.39
Chlor+Sulfa+Pen (100+100+50) (110+110+55)	80	30.1 (13 kg)	47	1.06 (.48 kg)	0.38
Nonmedicated control	48	38.3 (17 kg)	34	1.14 (.52 kg)	0.36
Mecadox (50) (55)	48	38.1 (17 kg)	34	1.21 (.55 kg)	0.40
Chlor+Sulfa+Pen (100+100+50) (110+110+55)	48	37.8 (17 kg)	34	1.12 (.51 kg)	0.37
Tylosin+Sulfa (100+100) (110+110)	48	37.8 (17 kg)	34	1.23 (.56 kg)	0.40

[a]Data courtesy Pfizer Central Research, Pfizer Inc., Terre Haute, Indiana. Based on the average results of 4 experiments—one field trial and 3 University tests.

[b]Sulfa = sulfamethazine; Chlor = chlortetracycline; Pen = penicillin.

Growth Promotants

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The overall combined results for Phase I and Phase II are shown in Table 4. The increase in performance established with Mecadox and Aureo SP-250 during Phase I (growing period) carried over sufficiently to result in an overall improvement in gain and feed conversion of pigs fed the two drugs as compared to those fed the non-medicated control diet. Thus, getting pigs off to a good start following weaning through the use of growth promoting antibiotics or chembiotics should result in an overall improvement in gains and feed conversion even though the drugs are withdrawn from the diet during the finishing period.

Pigs were swabbed and cultured for *Bordetella b.* at the beginning of the study, at the time of drug switch and just before slaughter. When animals were slaughtered, they were checked and scored for lung lesions and atrophy of the nasal turbinate bones. Results of the health evaluation are shown in Table 5.

Lung Lesions

The percentage of animals exhibiting lung lesions was similar among the three treatments. No significance is attached to the higher percentage of lung lesions in the pigs fed Mecadox.

Turbinate atrophy (deviations of the scrolls from the septum) was greater in the pigs fed the basal diet than in those fed Mecadox or Aureo SP-250. Surprisingly, perhaps, turbinate atrophy tended to be greater in pigs fed Aureo SP-250 than in those fed Mecadox. This latter observation was also evident when turbinate atrophy was expressed as percentage of scrolls deviating more than 6 mm from the septum. Only 29% of pigs fed Mecadox showed greater than 6 mm deviation as compared to about 67% and 41% for pigs fed the basal diet and Aureo SP-250, respectively.

Simply by chance, 6.3% of the pigs fed the basal diet and those fed Mecadox tested positive for *Bordetella b.* at the beginning of the study, before any of the drugs had been fed. When the drugs were switched to Terramycin (end of Phase I and start of Phase II), all pigs showed an increase in *Bordetella b.* The increase was much more marked in the pigs fed the basal diet. Researchers at Pfizer, Inc. have reported that Mecadox possesses activity *in vitro* against *Bordetella b.* but that Mecadox was not effective in eliminating the organism from naturally infected swine.

Pigs fed the basal diet had the highest incidence of *Bordetella b.*, followed by those fed Mecadox, with those fed ASP-250 showing the lowest incidence. When incidence of *Bordetella b.* is related to gain and feed conversion, pigs with the higher incidence gained slower and less efficiently than those fed Aureo SP-250 — the pigs with the lowest incidence of *Bordetella b.* up to the time of the drug switch. *Bordetella b.* may have been inhibiting the performance of pigs fed the non-medicated basal diet, but certainly this was not true for pigs fed Aureo SP-250 since they too were infected with the organism.

Table 3. Effect of Mecadox and Aureo SP-250 on gains and feed conversion of finishing swine (Phase II—Drug switch to slaughter)[a]

	Treatments[b]		
	1	2	3
	Basal	From Mecadox to 50 g/T Terramycin (55 g/MT)	From ASP-250 to 50 g/T Terramycin (55 g/MT)
ADG, lb	1.83 (.83 kg)	1.81 (.82 kg)	1.85 (.84 kg)
ADFI, lb	5.38 (2.44 kg)	5.33 (2.42 kg)	5.42 (2.46 kg)
G/F	0.34	0.34	0.34

[a]Nebraska Agricultural Experiment Station Swine Nutrition Experiment 75420.

[b]Data based on average of 4 pens of 8 pigs/pen. Initial weight at drug switch approximately 75 lb (34 kg) for the basal, 80 lb (36 kg) for Mecadox and 86 lb (39 kg) for ASP-250. 64 days from drug switch to slaughter.

Effective Growth Promotants

Mecadox and Aureo SP-250 are effective growth promotants for young swine. Their effect is apparent even in the presence of a relatively high or relatively low incidence of atrophic rhinitis or *Bordetella b.*, a microorganism often identified as the causative agent of AR.

Table 4. Effect of Mecadox and Aureo SP-250 on gains and feed conversion of growing-finishing swine (overall response, start to slaughter)[a]

	Treatment[b]		
	1	2	3
	Basal	Mecadox	ASP-250
ADG, lb[c]	1.37 (.62 kg)	1.40 (.64 kg)	1.47 (.67 kg)
ADFI, lb[d]	3.97 (1.80 kg)	4.00 (1.81 kg)	4.16 (1.89 kg)
G/F[e]	0.34	0.34	0.36

[a]Nebraska Agricultural Experiment Station Swine Nutrition Experiment 75420.

[b]Data based on average of 4 pens of 8 pigs/pen. Initial wt 18.0 lb (8.2 kg). 127 days from start to slaughter.

[c,d,e]Difference between treatments 1 vs 2 + 3 and 2 vs 3 significant (P<.10).

Table 5. Effect of Mecadox and Aureo SP-250 on lung lesions, turbinate atrophy and incidence of *Bordetella b.* in growing-finishing swine[a]

	Treatment		
	1	2	3
	Basal	Mecadox	ASP-250
Lung lesions, %[b]	68.8	75.0	65.6
Turbinate atrophy, mm[c]	5.37	4.15	4.59
Turbinate atrophy, % > 6 mm[d]	66.7	29.0	40.6
Septum deviation, %[e]	20.0	15.6	9.4
Bordetella b. incidence, %[f]			
Initial	6.3	6.3	0.0
At drug switch	68.8	40.6	37.5
At slaughter	56.3	46.9	53.1

[a]Nebraska Agricultural Experiment Station Swine Nutrition Experiment 75420.

[b]% of pigs on each treatment showing lesions on one or more lobes of the lung.

[c]Average distance between scrolls and septum in all 4 quadrants.

[d]% of pigs on each treatment with a deviation between scrolls and septum of more than 6 mm.

[e]% of pigs on each treatment with distorted septums (crooked snouts).

[f]% of pigs on each treatment culturing positive for *Bortetella b.*

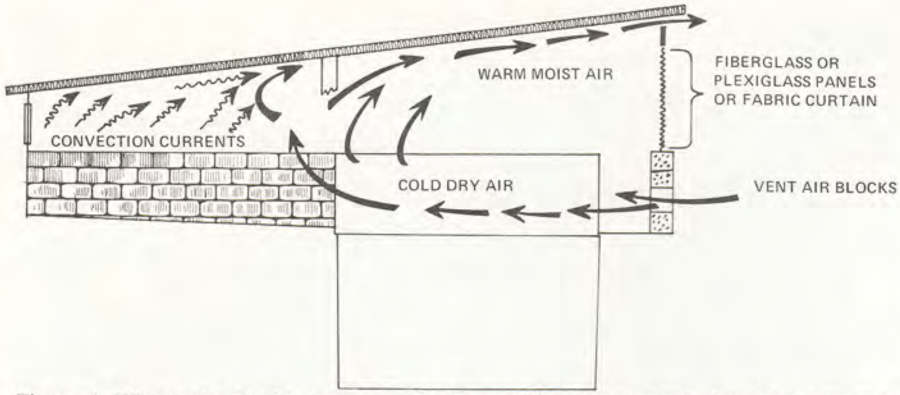

Figure 1. Winter air should enter near the floor with minimum velocity. As it warms it picks up moisture, rises, and escapes through the ceiling outlet. The low insulated ceiling in the sleeping area provides a hover effect, reducing drafts and making this the warmest area during winter.

Gravity Ventilating the MOF

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Natural (gravity) ventilation is the oldest method of ventilation known. Because of the high cost of mechanical ventilating equipment and the energy cost required to operate it, gravity ventilation may become the only way to ventilate many livestock buildings in the future.

Ten years of day to day, all-weather experience in gravity ventilation have been accumulated at the Northeast Station in modified open-front (MOF) growing-finishing units. Pig performance and health data from thousands of pigs reared in gravity and mechanically ventilated buildings have also been accumulated during this time. This experience, together with field or Extension experience, has resulted in management patterns that appear important in making gravity ventilation a success. Much of the success of the MOF building over the environmentally regulated (mechanical ventilation) building may be attributed to gravity ventilation.

Gable Style MOF

Most early MOF buildings had the gable style roof. Summer ventilation is achieved by facing the modifiable side or front of the building toward the prevailing summer winds—which for Nebraska are predominantly from the south-southeast. During summer, the modifiable front is opened to allow free air entry. Doors on the back of the pen, or north side of the building, equalling 1/4 to 1/3 of the wall area, allow summer air flow-through. In many, but not all of these buildings, foggers are used as an adjunct to gravity ventilation.

Winter gravity ventilation in the gable style MOF is achieved by allowing a small amount of air to enter along the modifiable side, which for the winter is almost completely closed. The air outlet is usually achieved during winter by means of some type of ridge vent.

It is recommended that there be 1 inch (2.54 cm) of continuous ridge opening for each 10 feet (3.04 m) of building width. A ridge cap is sometimes used to prevent moisture from entering through this opening. The 1 inch (2.54 cm) of continuous ridge opening per 10 feet (3.04 m) of building width should be considered maximum since slightly narrower openings appear to work equally well.

Generally, air is allowed to enter the building along the modifiable front near the floor. However, some use a fabric curtain attached at a point about 36 inches (91.44 cm) above the floor and then raised to close the modifiable front. This then allows the air to enter near the plate or eave, 7 or 8 feet (2.13 or 2.43 m) above the floor level. With the gable style building, whether the fabric curtain is attached at the top or bottom and pulled up or dropped down is not considered important. However, this is not true with the mono-slope MOF as will be discussed later. Doors at the back of the pen or along the north side must be capable of being absolutely and totally closed during winter to prevent drafts and to enhance pig performance.

Mono-slope MOF

The mono-slope MOF growing-finishing building, while having the same floor plan as the gable style building, results in a different gravity ventilation pattern because of its roof design. The mono-slope roofed MOF is designed to take advantage of the physical characteristics of air at different temperatures and the thermal requirements of pigs. The mono-slope MOF was introduced in a modern sense in 1972. Since then, hundreds have been erected in Nebraska while only a comparative few gable style MOF have gone up during the same period.

Cold air is heavy and has limited or no moisture carrying capacity, while warm air is lighter, rises and has relatively great moisture carrying capacity. This is the basis for gravity ventilation. Variables that influence the effectiveness of gravity ventilation include:

Roof slope and style.
Animal heat production.
Insulation.
Air inlet location and design.
Air outlet location and design.
Presence or absence of structural air flow obstructions.
Building width.

Winter air movement in a mono-slope MOF building is shown in Figure 1.

Some mono-slope buildings have a removable plywood or similar panel on the lower half of the modifiable front. Figure 1 illustrates the use of a partial block wall, four rows or about 32 inches (81.28 cm) high. In the second row

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Gravity Ventilation

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of blocks, alternate blocks are laid on their sides to allow air to enter during winter.

Several arrangements are available to make these block air vents adjustable. One method is to place a 1.5 inch (3.81 cm) angle iron in the mud joint above the vent block row and a 1.25 inch (3.17 cm) angle iron in the lower mud joint and extend it into the alley .25 inch (.63 cm), running the length of the building. This forms a track that a flat piece of fiberglass or similar material can be placed in and slid to adjust the amount of block vent opening desired. A single piece of fiberglass for each vent block is necessary. Another arrangement for adjusting the opening of the vent blocks is shown in Figure 2.

As the winter air comes in through the vent blocks or similar inlets near the floor the velocity decreases since the building is already somewhat pressurized. Convection currents rising off the pigs in the sleeping area may have a slight drawing effect on the air entering near the floor. As this air warms it rises, picks up the moisture and moves toward the front along the ceiling, escaping through the outlet near the ceiling. Hence most of the moisture escapes through the outlet near the ceiling.

On very cold days moisture also collects on the modifiable panels or curtains. This moisture or condensation will then either evaporate or run into the pit. Since these panels or curtains are not structurally part of the building any deterioration this moisture may cause over a period of years will not harm the building.

The ceiling air outlet on the high side of the mono-slope MOF is usually formed by means of a 2″ x 6″ (5.08 x 15.24 cm) placed so it forms a 3 to 4 inch (7.62 to 10.16 cm) fixed opening that should be adjustable by means of a baffle or similar method. With this type of air outlet, if a fabric curtain is used, it must be fastened at the top and lowered to close. In this manner as more air is needed than can enter via the vent blocks or other openings near the floor, the curtain can be raised to supplement it. If the curtain is fastened at the bottom and pulled up, any cold air coming into the building by adjusting the curtain is near the ceiling. Bringing the air in near the ceiling outlet simply short-circuits the gravity ventilation system and may result in higher odors and condensation.

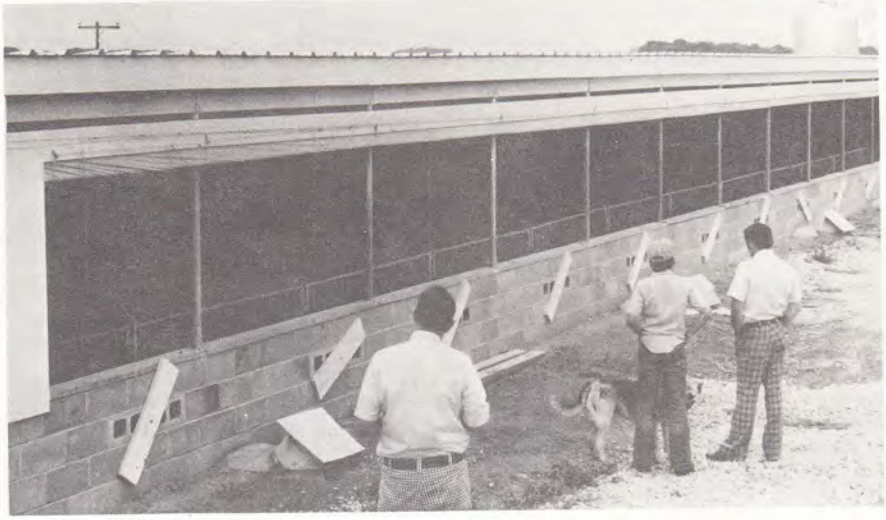
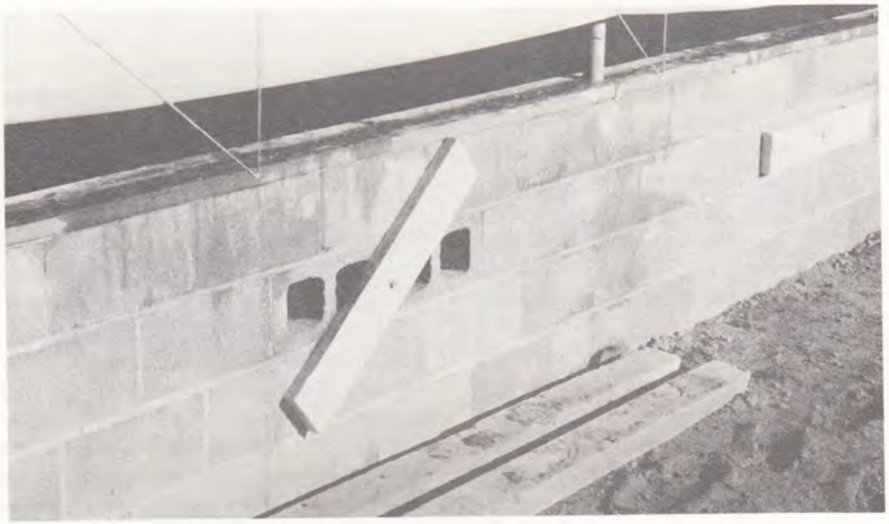


Figure 2. Upper photo: Mono-slope MOF during summer. Note the continuous opening near the ceiling, the upper attachment of the curtain and the lower block air vents. Lower photo: Block air vents, one partially open and the other closed.



The summer vent doors on the north or low side must be capable of being tightly sealed for optimum winter performance and should be equal to 1/4 to 1/3 of the back wall area for optimum summer ventilation. During summer usage when the back vent doors are open the velocity of air increases as the distance from the ceiling to the floor decreases.

The floor to ceiling air movement is a primary route of air flow for winter gravity ventilation. Therefore a smooth ceiling free of structural obstructions is essential. Most mono-slope MOF buildings have a 4″ x 8″ (10.16 x 20.32 cm) or larger lateral header for roof support along the length of building. This header does not appear to interfere with air flow and in many buildings the water line is located on the back or pig sleeping side of the header because some warm air is trapped there, thus reducing the chance of freezing. However, any other structural ceiling objects may reduce gravity ventilation effi-

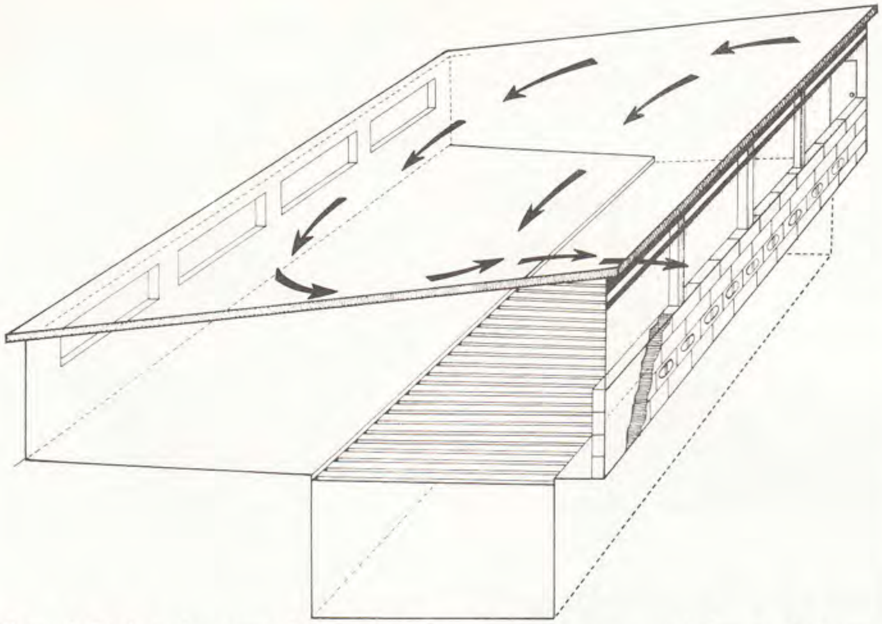


Figure 3. During winter one of the primary directional air movements is from east to west. Therefore, the air inlets near the floor and the outlets near the ceiling should be adjustable to control the amount and velocity of air.

ciency. It is reported that in fact, any obstruction more than 1 inch (2.54 cm) in cross section along the ceiling length can seriously change the air flow pattern.

Winter winds prevail from the north-northwest in this region. Inside the mono-slope MOF this results in a general east to west air movement as shown in Figure 3.

The floor to ceiling and east end to west end winter air flow makes it important to have the lower air inlet and upper air outlet adjustable. The smooth ceiling is important to facilitate air flow laterally. Often the question arises on whether to have a floor to ceiling partition at intervals to interrupt the east to west air flow. Preliminary tests and observations do not indicate a need for partitions above the pen dividers. The air velocity in the pig sleeping area is quite low if the back wall is tight and free from drafts. This is especially true within the confines of the solid pen partitions. As one measures the air velocity above the partition it increases slightly but not enough to cause pig performance problems in most buildings. A building free of partitions above the pen divider level ventilates better during summer.

Buildings with two different size pens provide for greater economy of space utilization. Knowing that air moves from east to west in the building suggests that pens be arranged to take advantage of this air flow. Figure 4 illustrates a floor plan where the narrower starter-grower pens are on the west end and the larger finishing pens on the east end. By locating the pigs in this manner the body heat from the larger pigs drifts toward the west and contributes to the heat budget of the smaller pigs. This is partly why producers with this style building report that the west is the warmest during the winter. Another reason is that air velocity is more controllable on the west end.

Summary

Natural or gravity ventilation is adaptable and successful, particularly in MOF buildings. Winter air movement in the MOF follows two primary routes, (1) floor to ceiling, and (2) east end to west end. Insulation is important to the success of the mono-slope MOF. This style building should be insulated as well as any environmentally regulated building with the exception of the south or modifiable side. The primary difference between the two buildings is that the mono-slope MOF is gravity ventilated while the environmentally regulated building is mechanically ventilated. Allowing the required winter air to enter near the floor and exhaust near the ceiling is important. Important too, is a smooth ceiling that will not obstruct floor to ceiling or east end to west end air flow.

Ventilation of swine houses has no meaning if it does not (1) provide the pig an opportunity to perform biological functions that are oxygen dependent, and (2) provide the worker a salubrious environment. Such terms as "uniform air distribution", "fresh air", and "good air movement" have no value or meaning if the net result doesn't benefit the pig.

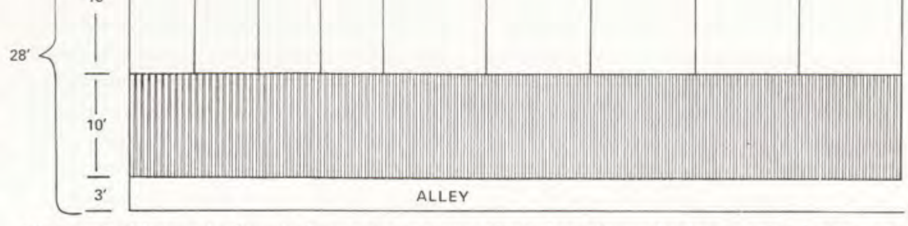
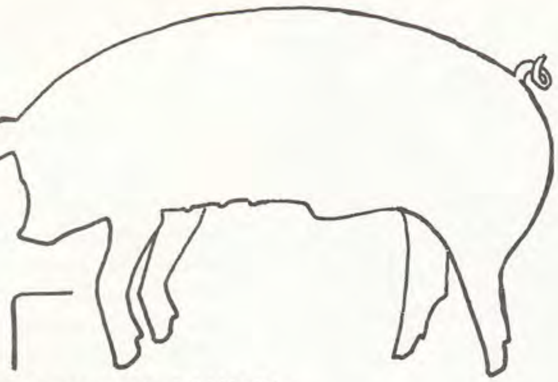


Figure 4. Winter air flow is from east to west. Body heat from the larger pigs in the east end of the building will move to the west, contributing to the heat budget of the smaller pigs.



Nutrition & Skeletal Soundness

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A structural soundness problem may result from any serious malformation of the skeletal system. Stockmen often refer to such problems in swine as buck-kneed, knock-kneed, bow-legged, pigeon-toed, toeing-out, too straight of shoulder, posty-legged, sickle-hocked, barrel-hocked, short toes, or a mobility problem in the hip.

Many nutritional, management, infectious and genetic causes have been suggested. Little research is available to provide solutions for these problems.

Protein

A protein deficiency does not usually cause a structural soundness problem in the pig. Moser and Gilster (University of Nebraska–Lincoln) conducted a field trial studying the effect of dietary protein level on growth rate, feed efficiency, backfat probe and leg soundness score of Duroc boars.

Percent protein sequences studied were 18-18, 18-16, 16-16 and 16-14. No extremely low protein sequence was studied. Boars were on test from about 68 to 230 lb (30.8 – 104.3 kg). There was no significant difference in leg soundness score due to dietary protein level. The protein levels caused differences in growth rate and feed efficiency.

Minerals

Tanksley (Texas A & M University) evaluated the dietary level of calcium and phosphorus required by fast growing boars to give optimum growth performance and maximum bone development. Boars were fed from 55 to 210 lb (24.9 to 95.2 kg). His conclusions were:

1. Optimum gain and feed efficiency were obtained at diet levels of 0.50% calcium and 0.50% phosphorus.
2. Maximum bone breaking load (femur) was found at diet levels of 1.20% calcium and 1.00% phosphorus.
3. Maximum bone breaking load (metacarpal) was obtained at 0.75% calcium and 0.75% phosphorus.

This research indicates that the optimum dietary level of calcium and phosphorus for growth performance may not be the same and may be lower than that required for maximum bone breaking load. The relationship of bone breaking load to structural soundness in the pig has not been determined. It seems logical that if bone breaking load was very low the susceptibility to structural soundness problems would be increased.

It has been reported that boars have a greater percentage of bone in the carcass than barrows or gilts. Bayley and workers (University of Guelph) have reported that the phosphorus requirement for gain and bone breaking strength is greater for boars than for gilts. Perrin and workers (University of Alberta) reported that *extra* calcium or phosphorus alone or in combination with *extra* manganese did not affect the severity of leg weakness or cartilage damage in boars housed in confinement.

A major reason for thinking that the calcium and phosphorus requirement of the boar may be different than that of market gilts or barrows is:

1. Boars grow faster and more efficiently.
2. Boars are subject to greater stress such as breeding.

Let us imagine the following situation:

	Boar	*Barrow*
Average daily gain	2.20 lb (1.00 kg)	1.70 lb (.77 kg)
Feed/gain ratio	2.41	3.12
Daily feed consumption	5.30 lb (2.40 kg)	5.30 lb (2.40 kg)

If the boar and barrow are each full-fed a diet that contains .65% calcium and .50% phosphorus, then the boar and barrow are each consuming 15.6 grams of calcium and 12.0 grams of phosphorus a day. The boar is consuming 7.1 grams of calcium and 5.5 grams of phosphorus for each pound of gain. The barrow is consuming 9.2 grams of calcium and 7.1 grams of phosphorus for each pound of gain. This means that the boar has a higher gain/calcium and phosphorus intake ratio. This could possibly result in greater skeletal weakness in the boar.

Pigs deficient in manganese may have lameness, stiffness, weak bone structure and retarded skeletal growth. Manganese should be supplemented to all Nebraska swine diets.

Symptoms of copper deficient pigs include leg joints that lack rigidity, hind legs that are extremely flexed and crooked front legs. Copper should be added to all Nebraska swine diets. Other minerals are not mentioned since a

deficiency of each of them is not closely related to a structural soundness problem.

Vitamins

Vitamin deficiency rarely causes a structural soundness problem in the pig. Vitamin D deficiency results in a disturbance of calcium-phosphorus absorption and metabolism, causing a reduction in calcification of bones. In young, growing pigs rickets may result. A vitamin D deficiency in mature swine may result in reduction of the mineral content of the bone causing spontaneous fractures to some of the larger bones. Supplemental vitamin D should be added to all Nebraska swine diets. Swine fed practical Nebraska swine diets supplemented with vitamin D should not have a vitamin D deficiency.

Signs of a biotin deficiency in the pig may include lameness, stiffness, spastic hind legs, cracked feet and sore feet. Improper facilities and rough floors also can cause cracked feet and sore feet. *A biotin deficiency in the pig is very uncommon in Nebraska.* Usually, biotin does not need to be supplemented in Nebraska swine diets.

Reports have been made that choline may be involved in the cause of the spraddle leg condition in baby pigs. However, other factors have also been implicated as a major cause. Choline should be added to all Nebraska swine diets.

A deficiency of Pantothenic acid may be reflected in such symptoms as incoordination, stiffness and goosestepping. This goosestepping condition should not be confused with pigs that goosestep due to a structural soundness problem. Many pigs in today's industry goosestep. However, this goosestep condition is often associated with a posty legged problem. Some pigs may appear to be sound in their structure and still goosestep. Unsoundnesses in the hip may cause goosestepping.

The goosestepping condition commonly observed in swine in this country is probably due to a structural soundness problem. Pantothenic acid should be supplemented in all Nebraska swine diets. Other vitamins will not be discussed, since no major structural soundness problem has been associated with any of them.

Conclusion

If Nebraska swine diets are properly fortified, nutrition should not be a major problem associated with structural unsoundness in the pig. The majority of structural soundness problems are probably not due to malnutrition. However, the hog of the 70's—fast growing, efficient, low-fat and muscular—may have a higher nutrient requirement than a slow growing, inefficient, fat and light muscled pig.

More structural soundness problems in swine have been noticed during recent years. It appears that many of these problems have *genetic* causes. Structural soundness problems seem to appear in specific genetic lines under a variety of environmental conditions.

Currently, much of the discussion about structural soundness revolves around cushion in the skeletal system. Proper *cushioning* allows easing and softening in the joints of pressure caused by the weight and movement of the pig. However, the *cushion* area still must have great strength and support. A properly *cushioned* pastern has a slope of about 45° and has both excellent give and strength.

The six main areas of skeletal cushion are the shoulder, knee, pastern, hip, hock and foot. Pigs that exhibit proper *cushion* appear to stand and move soundly. If additively genetic in nature, the use of boars and gilts sound in their structure can improve an existing structural soundness problem. If the cause of a structural soundness problem is genetic, then diet cannot cure the problem. For example, diet cannot correct a genetically caused buck-kneed or sickle-hocked condition.

Interactions with environmental circumstances have also received attention. The pig cannot escape the surface beneath him. Higher incidences of feet and leg problems in confinement have made the understanding of genetic causes more difficult.

Ovulation Rate And Sexual Age

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Good reproductive performance continues to be critical to the economic success of a swine farrowing enterprise. Increasing the number of piglets farrowed is one aspect of reproductive efficiency which should be given considerable emphasis, since it would allow the producer to spread the costs of maintaining the sow herd over a larger number of piglets.

The University of Nebraska started an experiment in 1967 to determine the effectiveness of selection for ovulation rate (number of eggs produced as indicated by number of corpora lutea on the ovaries) in swine. Results after six generations of selection were reported in the 1975 Nebraska Swine Report.

After eight generations of selection, the Select line gilts produced 3.0 more ovulations at 2nd estrus than the Control line gilts. No difference was observed in the number of piglets farrowed as a result of the advantage in ovulation rate.

Not Fully Understood

Why litter size was not increased in response to selection for higher ovulation rate is not fully understood. Ovulation rate sets the upper limit for litter size, and one would expect about 60-70% of the ova released to be represented by live piglets at term. The failure to obtain a correlated litter size response suggests that the loss of ova has increased. The possible explanation is that the ovulation rate difference measured at 2nd estrus was no longer present at breeding. Gilts in the selection experiment were mated at a fixed calendar time (December) without regard to their sexual age (number of estr-

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Ovulation Rate

(continued from page 17)

ous periods expressed). The estrous period at mating ranged from the 2nd to the 7th estrus.

The present study was undertaken to determine if the advantage in ovulation rate at 2nd estrus is maintained at subsequent estrous periods. Another aspect of the study was to determine the effect of number of estrous periods expressed before breeding on the ovulation rate at the first estrus following weaning.

Within four days following the expression of first estrus, gilts were placed on a "flushing" regimen. Ovulation rate was measured by counting the corpora lutea (CL) 9-11 days following 2nd estrus via the laparoscopy technique. Gilts not selected as replacements, based on this measurement, were then allotted within line to be slaughtered following either their 3rd, 4th or 5th estrus. The reproductive tracts were recovered a few days after the gilts expressed the assigned estrous period to obtain ovulation rate information. Gilts from each line were managed together and received the same diet.

The averages for the two lines are presented in Table 1. The ovulation rate of Select line gilts was significantly higher than the Control line gilts at each estrus. There was virtually no change in the magnitude of the line difference between 2nd estrus (16.2 − 13.0 = 3.2) and fifth estrus (17.2 − 14.3 = 2.9). Overall (both lines combined), small but consistent increases in ovulation rate were observed as sexual age increased from the 3rd estrus (14.6 CL) to the 4th (15.2 CL) and the 5th (15.7 CL) estrous periods. No increase in ovulation rate was observed between 2nd and 3rd estrous.

Table 1. Ovulation rate at subsequent estrous periods following puberty[a].

Estrus	Control line	Select line	Combined
2	13.0 (59)	16.2 (56)	14.6 (115)
3	13.4 (20)	15.9 (19)	14.6 (39)
4	13.4 (19)	17.0 (18)	15.2 (37)
5	14.3 (20)	17.2 (19)	15.7 (39)

[a]Numbers in brackets = number of gilts in each subclass.

Table 2. Ovulation rate following first gestation and lactation[a].

Reproductive stage	Control line	Select line
2nd estrus	13.1 (33)	16.1 (47)
1st estrus post-weaning	14.6 (33)	18.2 (47)

[a]Numbers in brackets = number of gilts in each subclass.

The failure to obtain some increase in ovulation rate between 2nd and 3rd estrus was surprising, as it is generally accepted that the greatest improvement in ovulation rate occurs during the first two estrous cycles following puberty. The possibility that the laparoscopy procedure employed following 2nd estrus may have suppressed the 3rd estrus ovulation rate and any corresponding increase could not be evaluated in this experiment, but it cannot be excluded from consideration. However, there were no visible effects on the gilts as they all recovered quickly and without any visible signs of infection or stress. No measurements were made of first heat ovulation rate, so the change between 1st and 2nd estrus could not be determined. Other data suggest that the expected increase is greatest at that particular time.

The ovulation rate of gilts kept for farrowing was measured again via laparoscopy 9-11 days following their first post-weaning estrus. Recommended diets were used throughout breeding, gestation and lactation. Sows were provided 12 hour access to self-feeders every 48 hours after weaning.

Table 2 shows mean ovulation rates for the two lines.

The 2nd estrus ovulation rate of Select line gilts which farrowed was 3.0 CL greater than the Control line (16.1 vs 13.1 CL). This advantage was still present at the 1st postweaning estrus (3.6 CL). Both lines exhibited increases in ovulation rate between 2nd estrus and 1st postweaning estrus (controls, 13.1 to 14.6; selects, 16.1 to 18.2) that were similar to the increase observed peviously between the 2nd and 5th estrus periods (Table 1). The increase tended to be larger, however, in the Select line gilts at the 1st postweaning estrus.

There was a general trend for ovulation rate at the 1st postweaning estrus to be higher in those gilts which experienced more estrous cycles before breeding, through the 5th estrous period (Table 3). Farrowing performance for these gilts is also presented in Table 3 by the estrous period at which they were bred. There is a general trend for an increase in the number of pigs farrowed if one waits until after the 3rd estrus period to breed the gilt. More information is needed on this. Use caution in interpreting these limited data.

Conclusion

In conclusion, it appears that ovulation rate at 2nd estrus is a good indicator of future ovulation performance. The Select line gilts apparently maintain their advantage in ovulation rate in subsequent estrous periods, and also after one gestation and lactation. Therefore, the absence of difference in litter size cannot be explained by a lack of difference in ovulation rate at time of breeding.

It has been generally accepted that there is an increase in ovulation rate with each succeeding estrous period following puberty with the largest increase occurring from 1st to 2nd estrus. Ovulation rate was not measured at 1st estrus in this study. However, from these data it is questionable whether a producer could justify the increased maintenance costs of holding a gilt for breeding after the 2nd estrus in order to increase ovulation rate. It appears that one might still realize an increase in litter size if the gilt is not bred until after the 3rd estrus. Perhaps the reproductive tract does become more functional with increasing sexual age.

Table 3. Ovulation rate at first post-weaning estrus and number of pigs farrowed as affected by the estrous period at breeding.

Estrous period bred	No. gilts	Ovulation rate post-weaning	No. pigs farrowed
2	8	15.1	9.4
3	12	16.4	9.5
4	24	16.6	11.2
5	13	17.4	11.9
6	20	16.8	10.8
7	3	16.2	9.0

Cooking, Reheating

Restructured Pork Products

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Restructured pork products are manufactured by cutting into small pieces the less desirable portions of the pork carcass and reforming this meat into a product uniform in shape, size and weight.

Institutional food service establishments are the primary marketplaces for these products. Because of the unique preparation and handling procedures used in the institutional trade, a study was conducted to determine the most appropriate techniques for preparing these products.

Restructured pork patties were manufactured to contain 25% fat. These patties were prepared by one of two methods: an electric grill or a convection oven. All patties were immediately vacuum packaged and refrozen following cooking. These products were reheated at 0, 2, 4 or 6 weeks following cooking by either a microwave oven, a convection oven, or an infrared oven. The reheated samples were then evaluated by a 43 member consumer taste panel to determine acceptability. Dimensional and chemical analyses were made at these times.

Effects of Cooking Method

Table 1 shows effects of cooking method on the restructured pork patties. Percent protein, cooking loss and area change were significantly greater for patties cooked using the electric grill. This was probably due to the severity of heating experienced by the patties cooked in this manner. When a product is severely heated the loss in weight, moisture and area will be increased. Percent protein was higher because of the lower moisture content of samples prepared using the electric grill.

Table 1. Effects of cooking method.

Trait	Cooking method	
	Electric grill	Convection oven
TBA[a] value	0.400	1.261
Protein, %	27.13	23.02
Moisture, %	50.16	53.00
Fat, %	19.65	19.17
Ash, %	1.72	1.59
Cooking, %	45.62	40.06
Area Change, %	39.01	30.69
Color score	5.5	5.2
Texture score	5.3	5.3
Flavor score	5.4	5.1
Juiciness score	4.6	5.4
Aroma score	5.0	4.7

[a]Thiobarbituric Acid Adsorption.

TBA (Thiobarbitutic Acid Adsorption) values were used to measure rancidity. As TBA values increase products become more rancid. Table 1 shows that patties cooked on the electric grill were less rancid than those cooked by the convection oven. This difference in rancidity was not detected by the taste panelists. The taste panelists did find that patties cooked using the electric grill were less juicy and had a stronger aroma than those prepared using the convection oven. The higher juiciness scores for samples cooked in the convection oven agree with the greater percent moisture for this treatment.

Effects of Storage Time

Table 2 shows effects of storage time on properties of restructured pork. Percent protein, moisture, fat and ash did not change with increased storage time. As storage time was extended from 0 to 2 weeks the samples became more rancid (indicated by the increase in TBA values). No increases in rancidity were noted for storage periods beyond two weeks.

Taste panelists found that the only trait affected by storage time was color. Samples stored for six weeks had a poorer color than those reheated immediately following cooking. This is probably associated with the increased rancidity, since as meat becomes more rancid color of the product often deteriorates.

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Table 2. Effects of storage time.

Trait	Weeks storage after cooking			
	0	2	4	6
TBA[a] value	0.431	0.973	0.899	1.020
Protein, %	26.13	26.02	25.90	26.21
Moisture, %	51.46	51.31	52.12	51.43
Fat, %	19.43	19.48	19.07	19.65
Ash, %	1.60	1.63	1.75	1.65
Color score	5.5	NA	NA	5.2
Texture score	5.4	NA	NA	5.1
Flavor score	5.4	NA	NA	5.1
Juiciness score	5.0	NA	NA	5.1
Aroma score	5.0	NA	NA	4.8

[a]Thiobarbituric Acid Adsorption

Restructured Pork

(continued from page 19)

Effects of Reheating Methods

Effects of the different reheating methods are shown in Table 3. Control samples, which were not reheated, exhibited the least cooking loss and samples reheated using the infrared oven the greatest. Samples reheated by the convection oven showed the least cooking loss compared to the microwave and infrared reheating treatments. These results are also reflected in the moisture contents and juiciness scores of samples prepared by these methods with samples which had greater cooking losses having lower moisture contents and juiciness scores. There were no other important differences between the reheating methods studied.

Study results show that cooked restructured pork products are still acceptable after six weeks of frozen storage. Further research to determine actual shelf lives of these products is necessary. Restructured pork should be cooked and reheated using convection ovens as this will result in higher yields and juicier products. However, if time is important reheating with microwave ovens may be considered although this method will yield a less juicy product along with lower yields of cooked meat.

Table 3. Effects of reheating method.

	Reheating method			
Trait	Control	Infrared oven	Microwave oven	Convection oven
TBA[a] value	0.969	0.375	0.923	1.054
Protein, %	23.89	27.75	27.22	25.39
Moisture, %	54.44	49.36	50.20	52.33
Fat, %	19.09	19.81	19.45	19.29
Ash, %	1.53	1.73	1.71	1.64
Cooking Loss, %	37.48	47.45	44.74	41.39
Area Change, %	32.49	38.21	33.37	35.33
Color score	5.4	5.4	5.2	5.5
Texture score	5.5	5.1	5.2	5.4
Flavor score	5.5	5.4	5.0	5.1
Juiciness score	6.0	4.4	4.5	5.3
Aroma score	5.2	4.9	4.8	4.6

[a]Thiobarbituric Acid Adsorption

When to Sell Sows After Weaning

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The decision as to when to sell sows after weaning is of considerable economic importance. This is true especially in gilt operations where only gilts are farrowed, but may be equally significant in larger sow operations when one considers that an average of 20% to 25% of the sows are replaced by gilts each year. In both kinds of operations, sizable numbers of females must be maintained after weaning and before marketing, at considerable cost.

The cost of maintaining post-weaning females depends largely on their daily feed intake and the period of maintenance. The return depends on the gain and feed conversion of the post-weaning females and changes in market value. Limited information available concerning the weight gain and feed intake of sows or gilts after weaning led to this study to determine the weight gain, feed intake and feed conversion of first litter sows at various intervals after weaning.

Procedure

Forty-four first litter sows were weaned following a 6 week lactation period. They were weighed, placed in dirt lot pens and self fed a 14% corn-soybean meal diet. Weight gain and feed intake were determined at 3, 10, 17 and 24 days after weaning. The above intervals were chosen in an attempt to partition the possible influences of post-weaning stress and post-weaning estrus on feed intake and weight gain. This procedure was effective, since none of the sows was in standing heat on any of the weigh days. The average number of days to first post-weaning estrus was 5.9, with a range of 4 to 9 days.

The average daily gain, daily feed intake and feed/gain for each interval are presented in Table 1. The sows consumed 11.5 lb (5.2 kg) of feed per day for the first three days after weaning, but gained little weight (.2 lb; .09 kg/day). This produced a very high feed/gain ratio of 54.5, indicating that the sows were making poor use of the feed they were consuming. Average daily gain tended to increase as days after weaning increased, with the maximum daily gain (3.7 lb; 1.7 kg/day) being reached between 11 and 17 days after weaning. During the same period the sows consumed the most feed per day (14.9 lb; 6.8 kg) and showed the most efficient feed conversion (4.0). During the total period (0 to 24 days) after weaning, the sows gained 2.1 lb/day (1.0 kg/day) and consumed 13.3 lb (6.0 kg) of feed per day with a feed/gain ratio of 6.3.

Table 1. Weight and feed intake of sows following weaning (Nebraska Experiment 76413)[a,b,c]

Variable	Post-Weaning, days				
	0 – 3	4 – 10	11 – 17	18 – 24	0 – 24
Avg. daily gain, lb (kg)	.2 (.09)	1.1 (0.5)	3.7 (1.7)	2.2 (1.0)	2.1 (1.0)
Avg. daily feed, lb (kg)	11.5 (5.2)	11.5 (5.2)	14.9 (6.8)	14.5 (6.6)	13.3 (6.0)
Feed/gain	54.5	10.8	4.0	6.7	6.3

[a]44 first litter sows, 6 week lactation.

[b]Average days from weaning to first estrus, 5.9

[c]Average weight of sows at weaning 344.5 lb (156.3 kg).

The cumulative gain, feed intake and some economic considerations are shown in Table 2. The value of a sow after weaning depends upon her condition and the dryness of the udder. Sows are typically docked in price to recover the value of the weight lost from trimming off the wet udder sections. The wetter the udder at slaughter the more waste and the larger the dock. Most packers dock wet sows \$1 to \$3/cwt for the estimated trimming losses. Thus, as the udder dries the value of the sow will increase.

The economic data used in Table 2 are estimates based on Fall 1976 prices and feed intake and gain data obtained in this experiment. They serve only to illustrate some of the factors to consider when determining the most economical time to sell cull sows after weaning.

Results

It generally takes two to three weeks after weaning for the udder to completely dry. Thus, sows were considered to have the lowest value (\$27/cwt) (59.4¢/kg) at weaning and the first few days after weaning. The dockage was decreased as the time post-weaning and degree of drying off increased until no dockage was included at day 24 (\$30/cwt) (66¢/kg). Weight gain of the sows increased as days after weaning increased (Table 2). The sows weighed 344.5 lb (156.3 kg) at weaning and 395 lb (179.2 kg) at 24 days after weaning. However, this increase in weight was not free. The feed cost (6¢/lb) (13.2¢/kg) and non-feed cost (7¢/day) must be deducted from the total value of each sow. For example, sows sold the same day they were weaned would have a total value of \$93.02 (344.5 lb × \$27/cwt) (156.3 kg × 59.4¢/kg) with no additional cost incurred, leaving a net value of \$93.02. In contrast, sows marketed at 24 days after weaning were valued at \$118.50 (395.0 lb × \$30/cwt) (179.2 kg × 66¢/kg) and had a net value after deducting the feed cost (\$19.17) and non-feed cost (\$1.68) of \$97.65.

If sows were marketed at day 17, they were still receiving a \$1/cwt dock, which produces a net value less than that at day 24, but greater than at weaning. If the sows were dry enough to receive the top market value, then the net value would be \$99.65, which is greater than at day 24. Sows marketed at 3 or 10 days post-weaning actually showed a net value less than sows marketed at weaning.

Based on these data it is most economical to sell cull sows at weaning (\$93.02) or to wait about two weeks after weaning. It was not until about day 10 after weaning that they started making efficient enough gain to offset some of the invested feed and non-feed costs. With the data used in this example it would be more economical to keep the sows on full feed until 24 days after weaning.

Table 2. Cumulative weight gain, feed intake and net economic value of sows at various intervals following weaning (Nebraska Experiment 76413)[a]

	Days after weaning				
	0 (Weaning)	3	10	17	24
Gain & feed					
Avg. weight, lb (kg)	344.5 (156.3)	345.0 (156.5)	353.7 (160.4)	380.0 (172.4)	395.0 (179.2)
Cumulative gain, lb (kg)		.6 (.27)	9.2 (4.2)	35.5 (16.1)	50.5 (22.9)
Cumulative feed, lb (kg)		34.5 (15.6)	115.0 (52.2)	219.3 (99.5)	319.2 (144.8)
Economics					
Value, cwt[b] (45.5 kg)	\$ 27	\$ 27	\$ 28	\$ 29	\$ 30
Total value	\$ 93.02	\$ 93.5	\$ 99.04	\$110.20	\$118.50
Feed cost (6 ¢/lb) (13.2 ¢/kg)		\$ 2.07	\$ 6.90	\$ 13.16	\$ 19.17
Non-feed cost (7 ¢/day)		\$ .21	\$ .70	\$ 1.19	\$ 1.68
Net value	\$ 93.02	\$ 90.87	\$ 91.44	\$ 95.85	\$ 97.65

[a]First litter sows.

[b]Price per cwt based on a dock of \$3/cwt between wet and dry sows (\$27 vs \$30/cwt).

Ham From Beans

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Irrigation development has been increasing in western Nebraska. Dry edible beans is one of the crops produced as a result of this increase.

Whenever a crop is readily available in a certain area, questions arise regarding its value as livestock feed. This was the case with dry edible beans.

A small percentage of beans, after harvest, is not of prime grade (highest quality). This portion is often referred to as "cull and cracked" beans and is worth less when sold.

The high prices of energy and protein have caused people to search for alternate feedstuffs for swine. The feeding value of "cull and cracked" dry edible beans is one of these alternatives.

Procedure

A study was designed to evaluate performance of pigs fed growing-finishing swine diets containing Great Northern (GN) and Pinto (P) variety beans. Chemical analysis indicated the GN and P beans contained 21.0 and 22.0% crude protein, respectively.

A total of 36 barrows and 36 gilts were divided into 4 initial weight (IW) replications and fed three diets: A. Great Northern (GN) bean, B. Pinto (P) beans, and C. a standard corn-soy (C-S). Composition of the diets is shown in Table 1. Diets were calculated to contain 16% crude protein, 0.65% calcium and 0.50% phosphorus. The GN and P beans also contained adequate lysine as the lysine content of the three diets was nearly equal (A = 0.83% lysine, B = 0.82% and C = 0.80%. Since the crude protein content of the GN and P beans was greater than in the grain, the GN and P beans replaced over half of the soybean meal in the standard C-S diet.

All three diets were self-fed in a pelleted form. The oil content of the GN and P beans enhanced the pelleting process.

Housing and management were essentially the same for all pigs. Each pen contained three barrows and three gilts and the pelleted diets were self-fed and water was available at all times. The performance of pigs on the three diets was evaluated by comparing average daily gain (ADG) and feed conversion, feed/gain (F/G).

Table 1. Percentage composition of diets

Ingredients		Diets A	Diets B	Diets C
Corn		51.45	52.4	73.4
Soybean Meal (44%)		8.5	8.0	20.5
Dehydrated alfalfa		2.5	2.5	2.5
Great Northern beans		34.0	—	—
Pinto beans		—	33.5	—
Ground limestone		0.95	1.0	1.0
Cyphos[a]		1.0	1.0	1.0
Iodized salt		0.5	0.5	0.5
Trace minerals[b]		0.1	0.1	0.1
Vitamin premix[c]		1.0	1.0	1.0
	Total	100.0	100.0	100.0
Calculated analysis				
Crude protein		16.07	15.99	15.99
Calcium		0.66	0.66	0.67
Phosphorus		0.54	0.51	0.52
Lysine		0.83	0.82	0.80

[a]Contains 18.5% phosphorus & 18.0% calcium.

[b]Calcium Carbonate Co., swine, 20% zinc.

[c]Contributed the following per kilogram of complete diet: Vitamin A, 3300 IU; Vitamin D, 444.4 IU; Riboflavin, 2.2 mg; Calcium pantothenate, 9.9 mg; Choline chloride, 220 mg; and Vitamin B_{12}, 22.0 mcg.

Table 2. Effect of dry edible beans on performance of growing-finishing swine.

Diet	No. pigs	Average weight—lb (kg) Initial	After 42 days	ADG	F/G
A(GN)	24	121.5 (55.2)	132.8 (60.4)	.25 (.11)	80.62
B(P)	24	121.0 (55.0)	159.0 (72.3)	.91 (.41)	6.10
C(C-S)	24	121.3 (55.1)	210.6 (95.7)	2.12 (.96)	3.44

Table 3. Subsequent performance of pigs initially fed bean diets (28 day period).

Former diet	No. pigs	Final weight[a] lb (kg)	ADG	F/G
A(GN)	24	204.8 (93.1)	2.57 (1.17)	2.62
B(P)	24	223.0 (101.4)	2.28 (1.04)	3.01

[a]Weight following 28 days in which all pigs received a 16% corn-soy diet.

Results

The addition of both GN and P beans to the diets had a dramatic effect on ADG and F/G ((Table 2). Statistical analysis indicated that pigs on the standard C-S diet gained significantly faster than those on the GN or P diets, 2.12 vs 0.58 lb/day (0.96 vs 0.26 kg/day). ADG of the GN and P bean diets also differed significantly. Pigs on the GN diet gained only 0.25 lb/day (0.11 kg/day) while those on the P diet gained somewhat faster at 0.91 lb/day (0.41 kg/day).

Similar differences occurred in feed conversion. Pigs on the standard C-S diet had a F/G of 3.44. This was significantly less than the pigs on the GN and P diets where the average F/G was 43.36. Efficiency of pigs fed the GN diet was significantly less than that for those fed the P diet (80.62 vs 6.10).

These analyses covered a 42 day period from an average IW of 121.3 lb (55.1 kg) for the 72 pigs until the 24 pigs on standard C-S diet reached an acceptable finished weight of 210.6 lb (95.7 kg).

The Rest of the Story

Although pigs fed the C-S diet had grown normally the pigs fed

the GN bean diet averaged only 132.8 lb (60.4 kg) and those fed the P bean diet averaged 159.0 lb (72.3 kg).

The 48 pigs on the GN and P bean diets were switched to a 16% crude protein standard C-S diet to determine if they would resume "normal" growth or if they were "stunted."

The remaining 48 pigs were fed another 28 days at which time their ADG and F/G were measured. Results are shown in Table 3. Following this 28 day feeding period, the pigs that had been fed the GN bean diet averaged 204.8 lb (93.1 kg) and gained 2.57 lb/day (1.17 kg/day) with an average feed conversion of 2.62. The pigs that had been fed the P bean diet averaged 223.0 lb (101.4 kg) and gained 2.28 lb/day (1.04 kg/day) with an average feed conversion of 3.01 during this 28 day period.

It is obvious from the performance during the follow-up period that the pigs were not permanently "stunted."

During the initial 42 day period, pigs fed the GN and P bean diets had stools that were looser than normal as evidenced by the fecal material observed in the lots. By the end of the 42 day test period bean fed pigs had somewhat enlarged abdomens.

Feed consumption of the pigs fed the bean diets was about 1/3 less than feed consumed by those fed the standard C-S diets. ADG was about 2/3 less for pigs fed bean diets than for pigs fed the C-S diet. Thus, a poorer feed conversion was observed for the pigs fed beans as compared to the pigs fed the C-S diet.

Summary

The quantity of beans in the GN and P bean diets significantly reduced ADG, and F/G was significantly greater when compared to a C-S diet. Evidently in the raw bean, there is a substance that affects metabolism and limits "normal growth."

There is some indication that lesser amounts of the dry edible bean or possibly high heat treatment may eliminate or inhibit this growth limiting substance.

Backfat Thickness and Weight

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As pigs increase in weight their backfat thickness increases. Recently, the relationship between backfat thickness and weight has been discussed. Some propose the relationship to be linear (straight line) while others propose a curvilinear relationship. The exact nature of the relationship can affect the type of testing procedure used.

A study was started in the spring of 1976 to investigate this relationship. A total of 255 pigs (124 gilts and 131 boars) composed of Duroc, Yorkshire and Hampshire were evaluated. All pigs were probed a minimum of five times begining at 150 pounds (68 kg) and ending at 275 pounds (125 kg). The average of three probes taken above the point of the elbow, last rib and last lumbar vertebrae, with a Scanoprobe machine, was used as the measure of backfat thickness. All probes were taken 2.0 inches (5 cm) off the midline at each probing site.

The average 220 pound (100 kg) probe was 0.84 inches (2.13 cm) for boars and 0.93 inches (2.36 cm) for gilts indicating gilts are fatter than boars at 220 pounds (100 kg). The difference of 0.09 inches (0.23 cm) between gilts and boars is consistent with earlier published results.

On the average, differences in weight were responsible for 75 and 85% of the differences observed in backfat thickness among boars and gilts, respectively. Backfat thickness of gilts over time was less influenced by factors other than weight than was true for boars. Physiological changes occurring at puberty in boars (ranting) may be responsible for the lower relationship existing for boars.

Backfat Thickness Related to Weight

Of the variation in backfat which is due to variation in weight, 98% could be explained by a linear (straight line) relationship. These results indicate that the backfat thickness of a pig at a particular time is highly related to his weight at that time. Also, the average rate of fat deposition in pigs is linear, and increases in backfat per unit increase in weight are the same for all weights between 150 (68) and 275 pounds (125 kg).

The average rate of fat deposition was 0.0038 in/lb (0.0212 cm/kg) for boars and 0.0049 in/lb (0.0275 cm/kg) for gilts. Gilts deposited fat at a significantly faster average rate than boars during the weight interval studied. The rate of fat deposition for boars was

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Backfat

(continued from page 23)

similar to the 0.004 in/lb (0.0224 cm/kg) presently in common use by the industry. However, the rate of fat deposition for gilts was considerably more rapid. Use of the standard adjustment factor is less accurate for gilts than for boars.

To further investigate the relationship between backfat probe and weight, correlations between adjusted probes at 150, 175, 200, 225, 250 and 275 pounds (68, 80, 91, 102, 113 and 125 kg) were calculated for each sex separately. These correlations are summarized in Table 1. Maximum value for a correlation is +1.0 or −1.0 if no errors of measurement occur. Measurement errors on either weights or probes would reduce the maximum correlation possible to something less than 1.0. Correlations higher than 0.90 might not be expected just due to measurement errors.

Corresponding correlations between probes at different weights are higher for gilts than boars. Gilts are less prone to a change in their ranking for backfat thickness at different weights than boars. Gilts which were fattest or leanest at 150 pounds (68 kg) had a greater tendency to be the fattest or leanest at 275 pounds (125 kg) than was true for boars.

Adjacent probes are more highly correlated than non-adjacent probes. This is not surprising, but does illustrate that the closer pigs are probed to the desired weight the greater the accuracy in ranking pigs relative to their backfat thickness at that particular weight.

These results would argue for probing pigs on a weight constant basis rather than an age constant basis, particularly for boars. In addition, if it is desirable to compare the backfat thickness of pigs at a weight in excess of 200 pounds (91 kg), it would be advisable to not probe pigs weighing less than 200 pounds. Again, this is particularly true for boars.

The relatively low correlations between probes of boars at different weights indicate a change in the ranking of boars as weight increases. This does not mean the relationship between backfat and weight is not linear, only that the linear relationship is not the same for all boars. Only 18% of the 131 boars gave any indication at all of a curvilinear relationship between backfat and weight. Even for these 24 boars, the curvilinear components accounted for considerably less variation than the linear component.

The range in rates of fat deposition among the boars was 0.0011 to 0.0084 in/lb (0.006 to 0.047 cm/kg) with approximately 70% of the boars depositing fat at rates between 0.0024 and 0.0052 in/lb (0.013 and 0.029 cm/kg). For gilts, the individual rates of fat deposition were less variable; 0.0020 to 0.0086 in/lb (0.011 to 0.048 cm/kg). These results indicate that pigs should be probed as close to the desired weight as possible. Weight constant end points would definitely be preferred.

Results also indicate that separate adjustment factors for each pig would be preferable. Use of a single adjustment factor for all pigs will over adjust some pigs and under adjust others depending on their weight and true fat deposition rate. Since pigs are generally probed only once, individual rates of fat deposition are difficult to determine. Further investigation needs to be made in this area to determine if appropriate procedures for using proportional adjustments for individual pigs can be developed.

Objective: Lean Market Pigs

In comparing backfat thickness of boars, the primary objective is to identify boars which will sire the leanest market pigs. Since the ranking of boars appears to be different at different weights, it would be desirable to know at what weight boar probes would most accurately reflect the backfat thickness of their offspring.

Ideally, to determine this, boars should be probed at different weights and these probes correlated with the backfat thickness of their offspring at market weight. This was not possible in this study. However, it was possible to correlate litter means for boars and gilts from the 55 litters represented in this study. These results should provide some insight into this

Table 2. Correlations between litter means for backfat of boars and gilts.

Boars Weight, lb (kg)	Gilts; Weight, lb (kg) 150 (68)	175 (80)	200 (91)	225 (102)	250 (113)	275 (125)
150 (68)	0.62	0.52	0.44	0.53	0.31	0.44
175 (80)	0.68	0.56	0.46	0.44	0.28	0.43
200 (91)	0.38	0.48	0.32	0.24	0.19	0.32
225 (102)	0.18	0.28	0.20	0.08	0.05	0.28
250 (113)	0.35	0.39	0.26	0.23	0.17	0.39
275 (125)	0.49	0.55	0.51	0.51	0.45	0.58

Table 1. Correlations between backfat probes at different weights for boars and gilts.

Weight, lb. (kg)	Weight, lb (kg) 175 (80)	200 (91)	225 (102)	250 (113)	275 (125)
		Boars			
150 (68)	0.67	0.24	0.36	0.41	0.39
175 (80)		0.36	0.39	0.46	0.35
200 (91)			0.74	0.60	0.56
225 (102)				0.75	0.63
250 (113)					0.76
		Gilts			
150 (68)	0.63	0.59	0.51	0.45	0.42
175 (80)		0.75	0.62	0.64	0.66
200 (91)			0.80	0.77	0.73
225 (102)				0.81	0.78
250 (113)					0.81

question since the genetic relationship between littermates is similar to the genetic relationship between parent and offspring. Correlations between litter means for boars and gilts at the various weights are summarized in Table 2.

The maximum value of these correlations would not be expected to be one. Litter means of the two sexes would be expected to be correlated due to the genetic relationship among littermates and due to environmental factors which are common to littermates. Theoretical calculations indicate that 0.70 would be an optimistic estimate of the upper limit for correlations of this type.

Litter mean probes of boars at 150 (68), 175 (80) or 275 pounds (125 kg) yielded the highest correlations with mean probes of littermate gilts at all weights. Many of these correlations were high relative to the maximum correlation possible indicating that selection of boars based on their probe at these weights would allow for the most accurate identification of the boars which would sire the leanest market pigs.

The fact that litter mean probes at weights at the two extremes of the weight interval studied had the highest correlations with litter mean gilt probes is puzzling. It may be related to physiological changes (puberty, etc.) occurring in boars and gilts during this time. Probes at light weights may be before these effects while probes at heavy weights may be after adjustment to these effects has occurred. Probes taken at light weights would have definite management advantages and probably would be prefered.

Summary

1. The relationship between backfat thickness and weight in swine is primarily linear.

2. The rate of backfat deposition is different for different pigs.

3. Weight constant test procedures are indicated.

4. Either 150 (68) or 175 pounds (80 kg) would be recommended weights for probing boars.

Straw Hovers Effective

Temperature Management for Pigs

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The current trend in swine growing-finishing confinement buildings is toward the modified-open front (MOF) concept. These buildings are naturally ventilated and generally do not have supplemental heating devices.

The recommended minimum weight of pig to put in the MOF building during winter operation is 40 lb (18.1 kg). For pigs that weigh less some type of supplemental heat may be needed. The objective of supplemental heat is to raise the air temperature high enough so the pig's environment will be within the thermoneutral zone, thus achieving best use of feed energy. The additional heat can be provided by electricity or fossil fuels or by utilizing the pig's own body heat.

A MOF building with 12 pens was used to study response to temperature management. The 120 pigs involved were on test from February 10, 1976 to April 1, 1976.[1] Pigs were received from a feeder pig order buyer on January 30, 1976. Delivery weight was approximately 22 lb (10 kg).

Prior to test, pigs were housed in an environmentally regulated (ER) building. Room air temperature was held at 85°F (29.4°C), while maintaining the floor temperature between 70°–74°F (21°–23°C). Pigs were on medicated water throughout the pre-test acclimation period.

Temperature Management Study

On February 10, pigs were allotted according to weight and sex, and put on test in the MOF building. The building has pens that are 6 ft × 16 ft (1.83 × 4.88 m) and have 50 percent slotted floors.

The study objective was to measure effect and costs of three temperature management treatments in a MOF building. Treatments were: oak overlay, straw hover and catalytic zone heat (7200 BTU rating). The catalytic heaters were positioned 3 ft (.91 m) off the floor. The oak overlays were 5.5 ft × 6 ft (1.7 × 1.8 m) overall and made out of rough 1 in (2.54 cm) lumber. The hover frames were made of 1.25 in (3.18 cm) steel pipe with a heavy gauge mesh to support the bales of straw. The hover was 31 in (78.7 cm) high in the front and sloped to 21 in (53.3 cm) at the back. The hovers and oak overlays covered 50 percent of the pen area.

Average daily gain, feed efficiency, and temperature data were taken. Temperatures were recorded every three hours at positions located 32 in (81.2 cm) above the sleeping area and pit area and under the oak overlays. Outdoor

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Table 1. Effects of zone heat, oak pallets and hovers on performance of pigs during the early growing phase—Winter[a].

Treatment	Metal framed straw hover	Oak pallet	Catalytic zone heat
No. pigs	40	40	40
Avg. bg. wt., lb	27.6 (12.5 kg)	27.7 (12.6 kg)	27.6 (12.5 kg)
Avg. final wt., lb	98.8 (44.8 kg)	95.0 (43.1 kg)	94.8 (43.0 kg)
Avg. da. ga., lb	1.40 (0.64 kg)	1.32 (0.60 kg)	1.32 (0.60 kg)
Feed/gain	2.56	2.58	2.59
Feed & utility cost/cwt gain	$17.92	$18.06	$18.58 Feed cost ($18.13) Propane ($.45)

[a]Feb. 10–April 1, 1976, Northeast Station, Concord.

Table 2. Effect of zone heat, oak pallets, and hovers on performance from March 4-March 18.

Treatment	Metal framed straw hover	Oak pallet	Catalytic zone heat
No. pigs	40	40	40
Avg. wt., lb (March 4)	53.7 (24.4 kg)	51.9 (23.5 kg)	52.6 (23.9 kg)
Avg. wt., lb	74.6 (33.8 kg)	72.6 (33.1 kg)	23.5 (33.3 kg)
Avg. da. ga., lb	1.49 (0.68 kg)	1.48 (0.67 kg)	1.48 (0.67 kg)
Feed/gain	2.45	2.42	2.38

Temperature Management

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temperatures were also monitored.

Effects of the zone heat, oak pallets and hovers during the early growing period from February 10 to April 1, are presented in Table 1. In general, gain and feed efficiency were about equal. Treatment effect on gain indicates that the pigs with the straw hover gained slightly faster than either of those with the oak overlay or catalytic heater.

Utilities such as propane and electricity are used in swine housing primarily for feed sparing effects. Therefore, the utility cost was added to the feed cost to obtain feed and utility cost per hundred weight. When this was done, the straw hovers reduced the feed/utility cost $.66 per hundred weight as compared to catalytic zone heat, but only $.14 as compared to the oak overlays.

Effects of zone heat, oak pallets and straw hovers on performance from March 4 to March 18 are presented in Table 2. Unseasonably mild weather did occur in February, but between March 1–18 outdoor temperatures were consistently below freezing. Average daily gain for the three treatments was essentially the same. Pigs under the catalytic zone heat did have a slight advantage in feed efficiency.

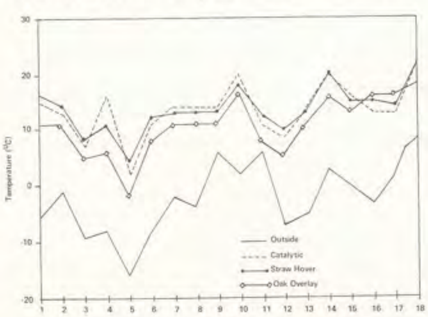

Figure 1. Comparisons of outside and sleeping area temperatures at 3 a.m. from March 1 to March 18.

Comparisons of outside and sleeping area temperatures at 3:00 am from March 1 through the 18th are illustrated in Figure 1. This was the coldest period of the study. The outside temperature varied from a low of 3°F (−16°C) on March 5 to a high of 46°F (8°C) on March 18. Temperatures above the oak overlay were equal to temperatures out over the pit.

Overall, the corresponding temperatures of the three treatments indicate that as outside temperature decreased, temperatures back in the sleeping area decreased an equal amount. The straw hover did produce a temperature increase of 3.6–7.2°F (2–4°C), when compared to the temperature above the oak overlay. However, the floor temperature of the oak overlay was consistently above 55°F (13°C). Sleeping area temperatures influenced by the catalytic heater also varied with outside temperatures. Even though the catalytic heaters were well cared for, after six years of use their efficiency has decreased considerably. The heaters did maintain a temperature in the sleeping area equivalent to that of the straw hover.

Summary

Straw hovers appear to be an effective method of temperature management for pigs during the early growing period. Pigs on the oak overlays had comparable gains and feed efficiency to the other treatments, but mild weather conditions may have an effect on performance. Catalytic zone heat did not enhance performance.

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[1]Appreciation is expressed to Dan Huwadlt and Jerry Jensen for feeding and care of pigs.

Coping With High

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We probably won't see any $400 per ton ($.441/kg) soybean meal this year, but the soybean supply and demand situation could result in some sharp fluctuations in protein supplement prices. We tend to watch the absolute level of protein supplement prices, but the price *relationship* between protein and energy sources should be observed and considered when formulating rations. Through most of the 1960's, with corn prices of about $1.00/bu. ($.039/kg) and soybean meal prices of about $90/T ($.099/kg), soybean meal was about 2.5 times the price of corn on a per unit basis, whether they be pounds or kilograms. In the spring of 1973, when corn was $1.50/bu (.059/kg) and soybean meal was $400/T (.441/kg), the soybean meal-corn price ratio was nearly 7.5. During the fall of 1974, corn and soybean meal prices per unit were nearly equal, when the ratio was 1.25. In the fall of 1976, with soybean meal at $190/T (.209/kg) and corn at $2.00/bu ($.079/kg), a pound (kilogram) of soybean meal cost 2.65 times as much as a pound (kilogram) of corn. This is close to the price relationship which existed during the 1960's.

As the price relationship between protein and energy sources varies, you should be alert to adjustments which you can make in your hog rations. These adjustments can be particularly important during periods of low hog prices when profit margins are thin, or negative. There are limitations on the amount of adjustment an individual producer can make in his rations, however. Availability of ingredients, metering and mixing equipment availability, feeding system design, and quantity of feed consumed are factors which may affect the flexibility of a producer to adjust his hog rations. But you should examine the possibilities for lowering the cost of gain in your hog enterprise and

use the techniques which will work for you.

Protein Level in Rations

The protein level in swine rations can be varied within a limited range without appreciably affecting animal performance. Higher protein rations can be fed when protein supplement is cheap, relative to corn. And, lower protein rations can be fed when corn is cheap, relative to protein supplement. The charts in Figure 1 are intended as guidelines to use in selecting the proper diet protein level at alternative corn and soybean meal prices.

Let's examine the points which have been plotted in the chart for 170-250 lb. (77.1-113.4 kg) pigs. Point "a" reflects the prices which existed through much of the 60's, $1.00/bu. ($.039/kg) corn and $100/T ($.11/kg) soybean meal, and it lies in the 12% region of the chart. This indicates that a 12% protein ration would be most economical, given these prices.

Point "b" reflects the high protein supplement price of spring, 1973, and indicates that a 10% protein ration should be fed. Point "c" reflects the price relationship which existed in the fall of 1974. Since point "c" lies on the breakeven line, either a 12% or a 14% ration could be fed, at an equal cost.

Point "d" reflects the fall, 1976, price situation, and lies well within the 12% range. The chart also shows us that if corn costs $2.00/bu. ($.079/kg), soybean meal must cost nearly $300/T (.33/kg) before we would drop to a 10% finishing ration, and the soybean meal price must drop to nearly $100/T ($.11/kg) to justify a 14% finishing ration. For additional information and supporting data for Figure 1, see "Feed Prices and Protein Levels for Pigs," *1974 Nebraska Swine Report*, EC 74–219.

Synthetic Lysine

Another alternative which should be evaluated when protein supplement prices are high relative to the corn price is the use of synthetic lysine. When you use synthetic lysine, you replace some of the soybean meal in each ton of a growing-finishing ration with a combination of corn and synthetic lysine. A rule of thumb is that 2.75 pounds (1.25 kg) of actual lysine (100% pure) and 97.25 pounds (44.1 kg) corn can replace 100 pounds (45.4 kg) of 44% soybean meal per ton of ration.

Table 1 shows the amount you could afford to pay per pound (kg) for synthetic lysine (100% pure) at various corn and soybean meal prices. For example, when soybean meal is $400 per ton ($.44/kg) and corn is $1.00 per bushel ($.039/kg), if you can buy synthetic lysine for anything less than $6.64 per pound ($14.64/kg) you could cut your feed costs by using it. On the other hand, if soybean meal is $200 per ton ($.22/kg) and corn is $2.00 per bushel ($.079/kg), you would have to be able to buy synthetic lysine for less than $2.37 per pound ($5.22/kg) in order to justify using it.

Table 1. The value of a pound (kg) of actual lysine[a].

Corn price per bu (kg)		44% soybean meal price per ton (kg)							
		$100	(.11)	$200	(.22)	$300	(.33)	$400	(.44)
$1.00	($.039)	$1.18	($2.60)	$3.00	($6.61)	$4.82	($10.63)	$6.64	($14.64)
2.00	(.079)	.56	(1.23)	2.37	(5.22)	4.19	(9.24)	6.01	(13.25)
3.00	(.118)	–0–	(–0–)	1.74	(3.84)	3.56	(7.85)	5.38	(11.86)

[a]The amount which you could afford to pay for one pound (kg) of 100% pure lysine when using 2.75 lb (1.25 kg) of lysine and 97.25 lb (44.1 kg) of corn to replace 100 lb. (45.4 kg) of 44% soybean meal per ton (907.2 kg) of ration.

The values shown in the table are for 100% pure lysine. You can convert these values to other materials containing less than 100% lysine by multiplying the percentage of your material by the value in the table. For example, if the value in Table 1 is $4.19 and your material is 78% lysine, you could afford to pay $4.19 × .78 or $3.27 per pound ($7.21/kg) for the 78% material.

In practice, the difference between the value of lysine and the amount you can buy it for may have to get fairly wide to justify changing your ration mixing procedures, and to eliminate frequent

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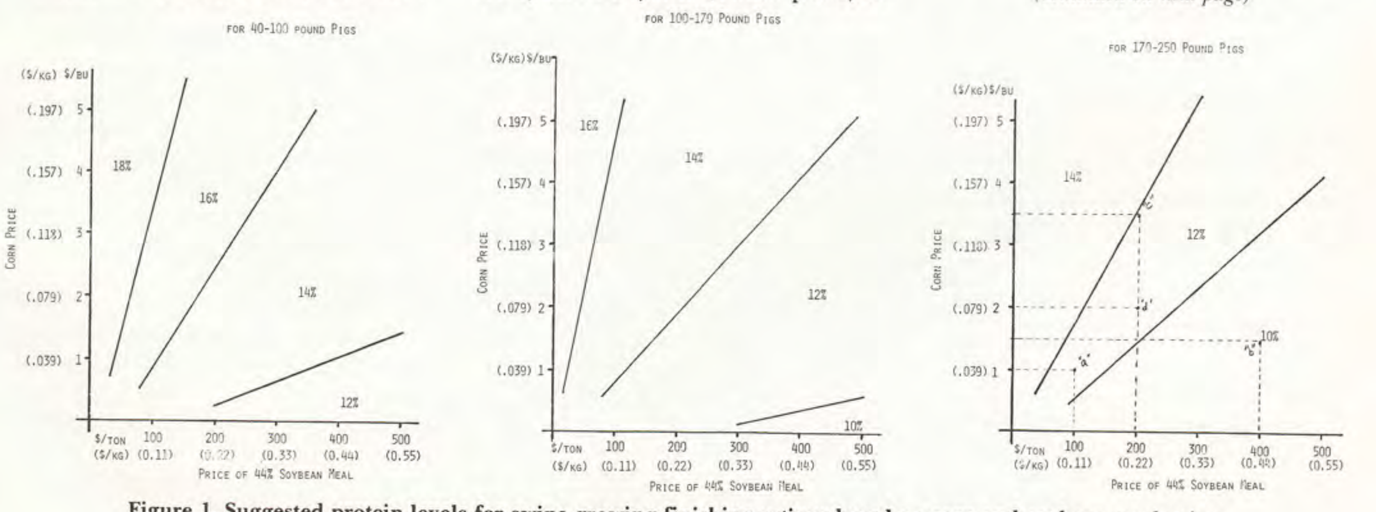

Figure 1. Suggested protein levels for swine growing-finishing rations based on corn and soybean meal prices.

High Protein Costs

(continued from page 27)

switching to and from the use of synthetic lysine.

Additional information on this topic appears in G74–128, *Synthetic Lysine in G–F Swine Diets.*

Cooked Soybeans

Feeding cooked soybeans to swine is generally profitable when feed grains are expensive relative to soybean meal and when soybean oil prices are low. When cooked soybeans are fed to hogs instead of soybean meal, the soybeans can substitute for all of the soybean meal and part of the corn in the ration.

Growing-finishing hogs will put on a unit of gain with about 8% less feed when fed rations containing cooked soybeans, as compared to comparable protein level rations with soybean meal as the protein source. This is due to the higher energy level of the cooked soybean rations.

Table 2 is presented as a guideline to help you determine the economic feasibility of feeding cooked soybeans. The values presented here recognize the 8% reduction in feed required per unit of gain with cooked soybean rations. When using this table, use soybean and soybean meal prices delivered at the feed mixer. For example, if you mix feed on the farm and have soybeans in storage there, use a delivered price for soybean meal, and a local elevator soybean price, less the cost of trucking the beans to the elevator.

If soybean meal costs $200/ton (4.22/kg) and the cost of cooking beans is $20/ton (.022/kg), you can afford to pay $6.20/bu. ($.228/kg) for raw soybeans. As noted in the footnote of the table, if corn is $2.00/bu. ($.079/kg) instead of $2.50/bu. ($.098/kg), the break-even soybean price would be $5.90/bu. ($.217/kg) instead of $6.20/bu. ($.228/kg).

During the past few years, periods during which the corn-soybean-soybean meal price relationship decisively favored feeding cooked soybeans have been relatively short. This is a consideration for the producer who is considering an investment in soybean cooking equipment, but not for the person who already has a cooker, or has access to a soybean cooking service.

For additonal information on cooked soybeans for growing-finishing swine, see "Soybean for Swine—an Update," *1971 Nebraska Swine Report,* EC 71–219.

Table 2. The value of soybeans in a swine finishing ration at alternative soybean meal prices and soybean cooking costs.

Price of 44% soybean meal		Price per bushel (kg) you can afford to pay for raw soybeans when the cost of cooking them is:[a]					
$/T	($/kg)	$10/T	($.011/kg)	$20/T	(.022/kg)	$30/T	($.033/kg)
100	(.110)	$3.90	(.143)	$3.60	(.132)	$3.30	(.121)
150	(.165)	5.20	(.191)	4.90	(.180)	4.60	(.169)
200	(.220)	6.50	(.239)	6.20	(.228)	5.90	(.217)
250	(.276)	7.80	(.287)	7.50	(.276)	7.20	(.264)
300	(.330)	9.10	(.334)	8.80	(.323)	8.50	(.312)

[a]A corn price of $2.50 per bushel ($.098/kg) was used in calculating the soybean prices in this table. To adjust for other corn prices, change the soybean price 60¢ per bushel ($.022/kg) in the same direction as each $1.00 per bushel ($.039/kg) change in the corn price from $2.50/bu. ($.098/kg).

High Lysine Corn

High lysine corn typically becomes popular when the price of protein supplement is high, relative to the price of corn. Decisions regarding high lysine corn are of a longer-run nature, as most hog producers must grow their own if they want to feed it. As a result, the relevant prices are the anticipated prices of protein supplement and corn for the following year.

High lysine corn typically yields about 10% less than normal corn, but is a higher quality feed grain. Rations containing high lysine corn as the energy source require less protein supplement and may produce gains more efficiently than comparable rations utilizing normal corn.

Table 3. Break-even yields of high lysine corn, expressed as a percent of normal corn yields, based on the price of normal corn and the price of soybean meal.

Price of 44% soybean meal per ton (kg)		Price of normal corn			
		$1.00/bu. ($.039/kg)	$2.00/bu. ($.079/kg)	$3.00/bu. ($.118/kg)	$4.00/bu. ($.157/kg)
$100	(0.11)	89.6%	97.5%	100.3%	102.0%
200	(0.22)	76.7%	89.4%	94.6%	97.3%
300	(0.33)	67.2%	82.5%	89.3%	93.2%
400	(0.44)	59.7%	76.6%	84.6%	89.3%

One of the best methods of evaluating high lysine corn is to examine break-even yields. That is, given the price of normal corn and soybean meal, how much must high lysine corn yield in order for it to be more profitable than normal corn? Break-even yields at alternative corn and soybean meal prices are presented in Table 3. For example, if normal corn is $2.00/bu. ($.079/kg), and soybean meal is $200/T ($.22/kg), high lysine corn must yield at least 89.4% as much as normal corn in order to be economically feasible. The producer must then evaluate the prospects for high lysine corn yields of this magnitude in his locality.

For additional information on high lysine corn for swine, see "High Lysine Corn Superior Feed Grain" and "High Lysine Corn for Swine—An Economic Analysis," *1972 Nebraska Swine Report,* EC 72–219, and "Feed Less Protein with High Lysine Corn," *1973 Nebraska Swine Report,* EC 73–219, and *The Economics and Use of High Lysine Corn,* Department of Ag. Economics Staff Paper #1973–4.

Computer Ration Analysis

The guidelines presented up to this point may be used by anyone, without even a pocket calculator. Computerized least-cost ration programs which incorporate all of the guidelines presented here, plus many more, are gradually becoming available from the University and commercial sources. This is the most sophisticated approach to swine ration formulation, and you should look into it if your swine enterprise is reasonably large, and if you have some flexibility in the acquisition of your feedstuffs.