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EC72-219 1972 Nebraska Swine Report

William Ahlschwede
billahls@neb.rr.com

Frank Baker
University of Nebraska-Lincoln

Roger W. Mandigo
University of Nebraska - Lincoln, rmandigo1@unl.edu

D.R. Zimmerman
University of Nebraska-Lincoln

D. Murray Danielson
University of Nebraska - Lincoln

See next page for additional authors

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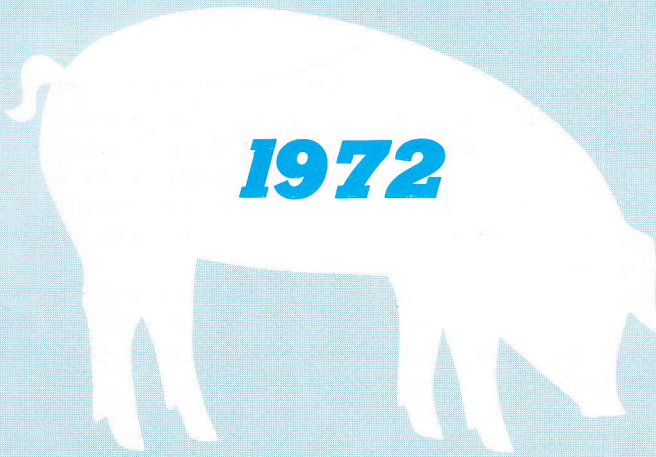
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Authors

William Ahlschwede, Frank Baker, Roger W. Mandigo, D.R. Zimmerman, D. Murray Danielson, B.D. Moser, Larry L. Bitney, E.R. Peo Jr., R. D. Fritschen, N.R. Underdahl, Steven L. Pilcher, E.A. Olson, and Wayne F. Fisher



NEBRASKA SWINE REPORT

- Breeding
- Disease Control
- Nutrition
- Economics
- Housing
- Meats

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

University of Nebraska-Lincoln College of Agriculture

E. F. Frolik, Dean

J. L. Adams

Director of Extension

R. W. Klels

Acting Director Experiment Station

E. F. Eldridge

Director, Resident Instruction



Sow Feeding Facility Pictured on Cover

The concept of individual sow gestation feeding facilities is no longer something new in the swine industry. There are many types and versions being used today. The facility on the cover page is currently being used at the University of Nebraska North Platte Station.

The 16' x 68' structure does little more than cover 80 individual sow feeding stalls. It is just a shed-type individual feeding barn, barely tall enough in the center for a man to stand. But that's all that's needed—and the reason for its low initial cost of approximately \$15 per ani-

mal stall plus labor.

Sows are free to wander around in earthen exercise pens with shelters located at the opposite end of each pen from the feeding stalls.

Once the sows have been in the barn a few days, they establish a so-called pecking order and for the most part use the same stall time after time. Even the most timid sow has a place to "get away from it all".

Stalls are 6 feet long by 20 inches wide, built of wood. There is a 4' alley down the center, plus a 5' concrete apron on each side. The

structure is wood frame, covered with metal siding—nothing fancy.

In hot weather the top door of the split doors at the ends of the alley are opened, creating a breeze effect, and the sows are comfortable.

The building really comes into its own in bad weather. Sows are still well protected and can be fed individually.

The building is quite versatile too. If it were used in shifts throughout the day, 300 or more sows could be fed by using this individual feeding unit.

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More Pigs for Nebraska Livestock Industry Development

William Ahlschwede
Livestock Specialist (Swine)

Frank Baker
Chairman
Department of Animal Science

Growth in livestock production is unfolding as Nebraska's great opportunity for economic development in the 70's. Nebraska's feed resources for animal agriculture remain only about half used by Nebraskans.

Nebraska agriculture made great changes during the 60's. These changes seem to be only the beginning. This is particularly true for pork production. From 1960 to 1970, Nebraska increased market hog production from 3.5 million head to 5 million head, more than a 40 percent increase (Figure 1). Cash receipts from the sale of pigs reached an all time high in 1969 and averaged 14 percent of the state's cash receipts from farm marketings in 1968, 1969 and 1970. Nebraska pork producers met the pork needs of 10 million Americans in 1970.

Steady Growth Needed

History will record 1970 as a year of excess pork production and 1971 as a year of resultant low hog prices. This is a paradox, because the American consumer needs a stable, expanding pork supply. *With only modest increases in pork consumption, our expanding population will need a 30 percent increase in pork (over 1970 levels) by 1980 (Figure 2). That is a level of production 20 percent higher than the last quarter of 1970 and the first 3 quarters of 1971.* An extended period of stable growth during the 1970's will meet the needs of the consumer and assure the price stability needed for profitable production.

The Nebraska picture is even stronger. During the 60's, Nebras-

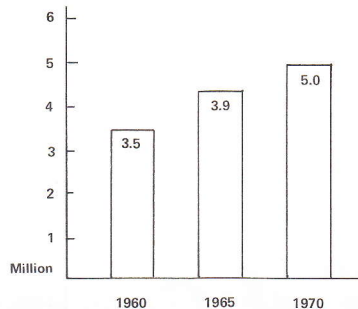


Figure 1. Nebraska fed hogs.

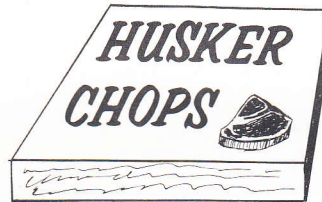


Figure 3. New food item.

ka's swine industry expanded at more than four times the national rate of expansion (Table 1). During the same period, the eastern Corn Belt decreased their number of pigs. If traditional hog areas such as the eastern Corn Belt continue to deemphasize pork production, Nebraska can continue to expand its pork production enterprise more rapidly than the nation without causing over-production.

Nebraska's opportunity for pork industry growth during the 70's is three dimensional economic growth.

1. Developing operations to process all Nebraska produced pork into retail-ready products (Figure 3).
2. Developing pork production and feeding operations to more completely convert Nebraska's feed and forage production to animal production.

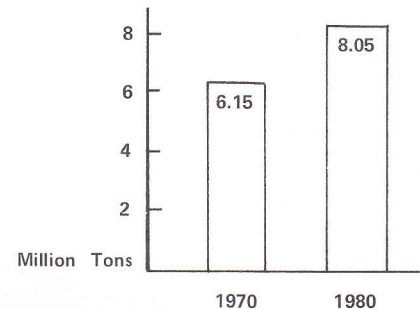


Figure 2. Nation's pork needs.

3. Developing land and water resources as new feed-producing capacity in complexes of farming, livestock feeding and meat fabrication systems (Figure 4). Fabrication is activity concerned in changing meat carcasses to retail-ready products.

Economic Development

Feeding 400 to 500,000 bushels of grain to livestock has a wealth generating capacity equal to a small industrial plant employing 100 people. According to the U.S. Chamber of Commerce, such a plant has community impacts:

- 359 more people;
- 91 school children;
- \$710,000 in personal income;
- \$229,000 in bank deposits;
- \$331,000 in retail sales;
- 3 new retail firms.

The economic impact of crop and livestock farms in rural communities is:

- 25 farms producing 300 acres of feed grain at 67 bushels per acre has the wealth generating capacity of one small industrial plant employing 100 people;

Table 1. Hog Marketings by Selected States and Regions.

	1960	1970	Change
U.S.A.	80,087	87,244	+ 8.9%
Nebraska	3,507	4,972	+41.8%
Eastern Corn Belt			
Ill., Ind., Ohio, Wisc., Mich.	26,671	25,590	- 4.1%
Southwest			
Texas, Okla., N. Mex., Ariz., Colo.	2,020	2,643	+30.8%

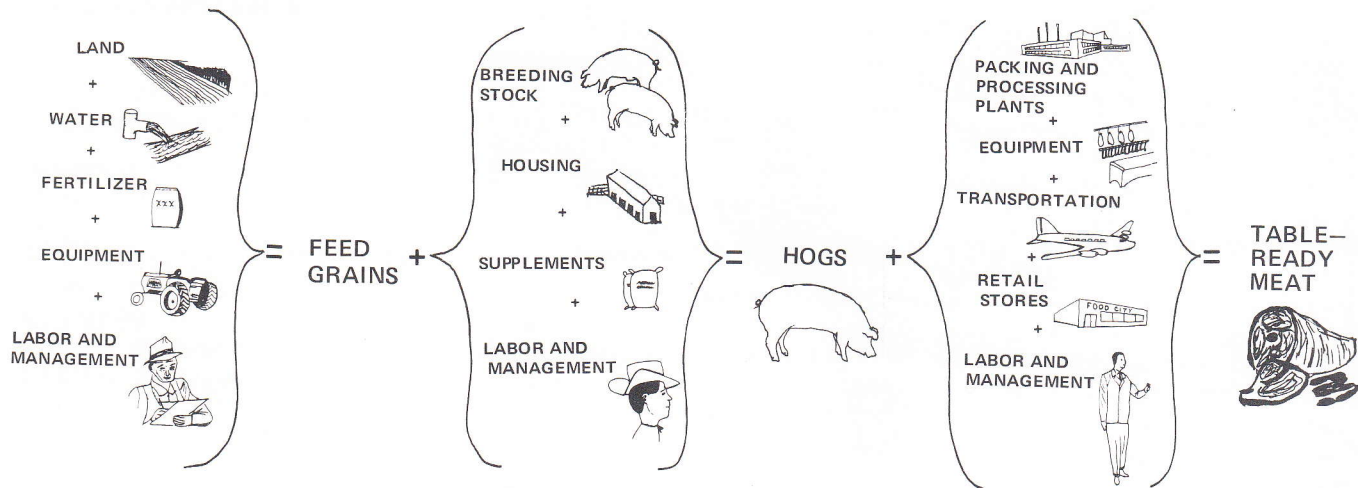


Figure 4. Value is added in each step.

feeding this grain from the 25 farms to livestock equals the wealth generating capacity of a second small industrial plant employing 100 people.

Economic development traditionally has meant new factories. Nebraska's economic base has been agriculture. One of Nebraska's best opportunities for economic development is using its grain in livestock production. The 1971 corn crop in Nebraska is estimated to be more than 460 million bushels. History says only slightly more than one-half of the crop will be fed in Nebraska.

Strengths

Nebraska has three primary strengths for development of animal agriculture in the years immediately ahead.

1. Feed represents two-thirds of the costs of livestock production. Nebraska has the greatest unprogrammed feed supply and feed producing potential in the entire United States (Table 2). During the second half of the 1960's, less than 60 percent of Nebraska-produced feed grain was used in Nebraska. From the 1970 feed grain crop, excluding wheat, between 5 and 6 million tons were shipped to other states. Each million tons of feed grain can yield one of the following:

3 million market hogs;

667,000 choice slaughter steers from 700 pound yearlings; 2.33 billion pounds of milk.

The out shipment of grain from Nebraska means that the wealth generated by livestock or industrial use is being lost to the Nebraska economy. Nebraska livestock producers have a feed price advantage over those who haul Nebraska grain elsewhere for feeding.

2. People, experience—Nebraska has been a key livestock producing and feeding state for the last 5 decades. A large reservoir of people with livestock management experience exists in Nebraska. Specialization in swine production is an opportunity for many Nebraska farmers to market their livestock skills.

3. Weather—Nebraskans tend to think of Nebraska weather as being violent. Yet, when compared to other areas of the nation where new livestock activity is being promoted,

Nebraska's weather is not a deterrent to pork production. In many cases, the weather affects the performance of the livestock producer more than it affects the performance of the livestock. Shelter is needed to protect livestock from the extremes in weather both during the winter and summer. Nebraska has extremely hot days and extremely cold days, but in most cases, minimal environmental alteration prevents significant drops in performance.

Specialization

The swine industry in the nation and in Nebraska is becoming more specialized annually.

During the 1960's, a period of rapid growth in Nebraska hog numbers, the number of farms producing hogs decreased from 52,000 to 32,000. This change in numbers of pigs and farms producing pigs resulted in nearly a tripling of the average size of swine operations.

Swine producers entering the business are starting on a larger scale than those leaving the swine business. As the average size of swine operations increases, they become a more important part of the operator's livelihood. He tends to specialize in swine production, more effectively using his skill as a livestock manager.

Table 2. Feed Grain Production and Utilization by Areas of Nebraska.^a

	Production 1,000 bu.	Utilization % fed
Northeast	85,172	97
South	45,775	32
East	146,354	50
Southeast	82,349	42
Southwest	21,356	46
North	10,779	107
Northwest	9,497	126
Central	55,554	55
State Total	456,844	59

^a Average for 1965-1969, State-Federal Division of Agricultural Statistics.

(continued on next page)

(continued from page 5)

In the cattle business, the production of feeder cattle and the fattening of market stock has traditionally been separated. The cow-calf operation depends upon roughage, grass and hay, and has largely been limited to land not suited for feed grain production. The fattening of market cattle requires large inputs of grain. These operations traditionally have been located in areas of feed grain production. This segmentation of operations in the cattle business could be called "geographic specialization".

In the swine industry such geographic specialization is not important. Both feeder pig production and feeding hogs for market require feed grains, but neither requires roughage. The resources and raw materials for these two aspects of production are not as different as they are with beef cattle.

Most swine operations are farrow to finish. However, the production of feeder pigs requires more labor but less grain and capital per unit of return than the feeding out of market stock. Because of the abundance of feed grain in Nebraska and the seasonal labor demands of corn production, grain farmers often choose to buy feeder pigs for finishing.

Nebraska currently is not able to supply the feeder pig needs of these farmers. Nebraska farmers have been importing upward of 150,000 feeder pigs annually. Since feeder pig production requires less corn but more labor than feedout operations, feeder pig production represents an opportunity for marketing livestock skills without making large commitments to grain production or capitalization. The 150,000 feeder pigs now imported could represent 75 full-time one-man specialized feeder pig operations. These family sized units would in average years pay the operator a wage comparable to that offered by Nebraska industry, in addition to a competitive rate of return on his investment.

Another opportunity not currently being exploited by Nebraskans is pork slaughter and process-

ing. In 1970 and 1971, in-state slaughter accounted for barely 60 percent of Nebraska's pork production. In addition to opportunity losses to Nebraskans, shipping hogs long distances for slaughter represents an absolute loss for the swine industry. Tissue shrinkage during hauling cannot be replaced.

The Road Ahead

The economic health of Nebraska and the well-being of its agriculturally oriented citizens during the 1970s and the 1980s depends upon the effective utilization of Nebraska's agricultural resources. The expansion of animal agriculture in Nebraska represents a major opportunity to create new wealth by using our own resources, land, water and people. Maximum use of these resources will require effective cooperation among livestock and grain producers, feed processors, bankers, packers and marketing and service agencies.

Further expansion of swine production in Nebraska, healthy, deliberate growth, is a real economic growth opportunity for the state. It will require improved marketing systems to stimulate production economics. It will require greater cooperation and openness from the financial community. It will require accelerated educational programs from the University of Nebraska both in undergraduate training and "Education for Action" Extension programs to provide technical inputs for increased specialization. It will require greater industry cooperation and coordination to most efficiently assign and use the resources available.

Summary

Nebraska has nearly unlimited opportunities for further development of its animal agriculture because it has:

1. *Feed resources*—less than 60 percent utilization during the last five years of the 60s.

2. Environmental conditions satisfactory for profitable livestock production.

3. Supporting service industries for feed manufacturing, marketing,

Fabricated Pork

R. W. Mandigo

Assoc. Professor, Animal Science

A new area of meat research is being developed at the Loeffel Meat Laboratory. This new Animal Science program is developing with the support of industry equipment suppliers. The process involves the combination of meat flaking, compression or forming, and sectioning to uniform consumer-ready meat cuts.

Many parts of the pork carcass are high value as presently used in the production of consumer meat cuts. However, certain parts of the carcass are low value due to their limited utilization value, or are primal cuts with less demand in the current marketing structure.

Many trimmings and slaughter by-products currently are used only in sausage operations. These cuts, such as cheek meat, diaphragm muscle, tongues, hearts and the many different trimmings which develop during the processing of the carcass are excellent sources of high-quality protein and are very nutritious.

Additionally the picnic and boston butt from the shoulder of the

equipment manufacturing, meat packing and processing, and educational activities.

4. People skilled in livestock production who have a long history of performance in and understanding of the livestock industry.

For continued development of pork production, Nebraska needs:

1. Financial institutions filled with enthusiasm for the growth opportunity.

2. Increased pork slaughter and processing capacity.

3. Increased feeder pig production.

4. Pork producers ready to apply sound business management principles, to meet the changes of the years ahead.

... A New Concept

carcass are readily available and need to have their value increased.

These raw materials can be flaked on a machine loaned to the Meat Laboratory which will produce very uniform flaked particles. The Urschel Laboratories' "Comitrol" or flaking machine is the first step in the new combined process. Distinct particle size can be made when frozen meat is flaked, while the flaking process will increase the emulsion properties of meat when flaked at temperatures above freezing. Thus, greater binding properties as well as distinct particle size can be obtained when various flaked meats are formulated.

The second machine in the combined process is a Bettcher Industries' "Power Press". This machine can be fitted with many different shapes or molds. The hydraulic pressure compresses the flaked meats into the desired shapes. (See *Figure 1*). This press will also form intact boneless muscles and muscle systems in a similar manner. Thus the high-value boneless meats can also be portion controlled.

The third machine in the trio is a Bettcher Industries' "Power Cleaver". The Power Cleaver permits the meat log produced in the Power Press to be sectioned into uniform, portion controlled, consumer ready meat cuts. The Power Cleaver will cut the flaked-formed product as well as many of the bone-in cuts, such as the pork loin.

These three pieces of equipment provide the Animal Science Department's meat researchers with a totally new research concept. (See *Figure 2*). The development of this new concept is expected to take from two to four years, depending on the level of support that can be generated from various sources.

Providing the consumers with a greater variety of nutritious pork products is very important. In addition, adding additional consumers of pork through economically priced formulated pork products will stimulate pork consumption.



Figure 1. Pressed and formed log.



Figure 2. Flaked, formed and sectioned chops.

Reproductive Efficiency Is Dollar Efficiency

W. T. Ahlschwede
Livestock Specialist (Swine)

Reproduction rates vary considerably among swine herds. However, few attributes of the production unit are as closely related to the level of profit as reproduction. In an industry being overwhelmed with mechanization and technology, it is interesting that mechanization has not touched the economically most critical area, reproduction. The main inputs which can alter reproductive rates are human inputs, skilled labor rather than new hardware or systems. There are two general aspects of reproduction which have direct effects on per unit costs in swine operations which farrow.

Litter size weaned and conception rate are the most easily identified and economically meaningful measures of reproduction. Each of these directly affect per pig costs. High conception rates reduce per pig costs by reducing per litter breeding herd maintenance costs. Larger litters weaned reduces per pig costs by spreading per litter costs over more pigs.

The purpose of this paper is to establish:

1. The economic costs and returns associated with conception rate and litter size at weaning, and
2. The return available to skilled labor deployed in increasing reproductive efficiency.

These objectives will be met by using artificial budgets to assign costs to reproductive failures and to provide a basis for considering alternates for improving reproduction rates.

Conception Rate

Conception rate refers to the percent of sows exposed to a boar which subsequently farrow. The cost of decreased conception rates lies in the necessity of maintaining extra females during the breeding

Table 1. Feed Needs for Breeding and Gestation for 50 Litters.

Conception rate, %	90	85	80	75	70
Litters	50	50	50	50	50
Sows	56	59	63	67	71
Feed, Ton	14	15	16	17	18

and gestation period in order to assure an adequate number of litters. Low conception rates often cause production units to operate at less than capacity. *Table 1* shows feed costs for maintaining enough sows to produce 50 litters of pigs at different conception rates.

The values shown in the table represent feed which would be fed from the time matings begin until the first litter farrowed. They apply to one season of a twice a year farrowing system. The one ton of feed increase for each 5 percent decrease in conception rates is a minimum cost. As the breeding herd increases from 56 to 71 sows, additional boar power is needed. If gilts are purchased for breeding, the salvage value of non-breeders will be less than the purchase price. As the number of females increases, more feeder space, larger pens, more sheds and more waterers are needed.

A second way to consider the economic importance of conception rate is to take a farrow-to-finish approach. If the size of the sow herd is held constant, differences in conception rate show up as differences in the number of pigs marketed. *Table 2* shows returns to management for two conception rates. These figures are based on a North Carolina Study with \$1.10 corn, \$20 market hogs, 7.1 pigs weaned per litter and moderate facilities.

The sow herd was kept at 100 females on a multiple farrowing scheme. The return to management

Table 2.

Conception rate	Return on management
75%	\$ 6,534
85%	8,835
95%	11,135

is in addition to labor costs and return on investment. The added return, about \$1,150 for each 5 percent increase in conception rate, should be considered a skilled labor bonus. In this system each additional litter was worth more than \$100 net to the manager.

Litter Size at Weaning

Litter size at weaning, taken as the average number of pigs weaned per sow farrowing is a meaningful economic measure of litter size. It is a composite of litter size at birth and survival rate until weaning. It determines what portion of the per litter costs are charged to each pig. *Table 3* shows costs charged to each pig for several litter sizes and two levels of per litter costs.

Seventy dollars per litter represents an operation using home reared replacement females and minimum farrowing facilities. One hundred dollars per litter represents fairly elaborate farrowing facilities requiring less labor and purchased females. On the litter size scale, 7 represents nearly the average litter size weaned in Nebraska. An increase of one in litter size at weaning is a reasonable goal for most producers. For a \$100 per litter operation, saving 8 pigs instead of 7 represents one free pig per litter, or a savings of \$1.79 per pig ($8 \times \$1.79 = \14.32 per litter).

Based on the North Carolina study, even larger returns can be predicted from increases in litter size if the whole operation is considered. The figures in *Table 4* are based upon a 100 sow herd, \$20 market hogs, \$1.10 corn, 240 pound market weight, 9 percent return on capital and moderate facility and labor charges. The returns to man-

Table 3. Per Pig Costs

Per litter cost	Litter size at weaning			
	6	7	8	9
\$70	\$11.67	\$10.00	\$ 8.75	\$ 7.78
\$100	16.67	14.29	12.50	11.11

agement are net returns after increased costs of larger litters (feed, medicines, etc.) have been considered.

At either conception rate, the difference between 7.1 and 8.1 pigs weaned per litter is close to \$20 per litter. The difference between this figure and the figure from Table 3 (14.29 per litter) represents the profit from feeding one pig per litter from weaning to market.

Skilled Labor Bonus

The inputs which can change conception rates from 75 percent to 85 percent and which can change litter size at weaning from 7 pigs to 8 pigs are not mechanical or strictly technical. They are improved husbandry, planning and utilization of highly skilled labor. In units where technology and mechanization have reduced labor requirements so that one man can handle two or three times as many litters, inputs of skilled husbandry still pay premiums. As shown in Table 3, the reward for increasing litter size in the more elaborate and expensive system was larger than in the system with lower costs per litter.

Studies of labor requirements between farrowing and weaning have indicated that 3-5 hours are spent per litter, depending upon the amount of mechanization (including manure disposal) employed. Small additional increments of time by a skilled swine producer at critical times during breeding and farrowing could earn large economic rewards.

Where Time Pays

1. *Observing boars "work"*—

Breeding problems can often be spotted and remedied at breeding time.

2. *Rotation of boars*—Daily rotation of boars under pasture mating schemes stimulates repeat mating and covering of all the females.

3. *Double mating*—Repeat mating under hand mating schemes can increase conception and fertilization rates.

4. *Washing sows as they enter the farrowing house*—Minimizes exposure of new-born pigs to disease causing micro-organisms.

5. *Sow ration adjustments*—Keep sows eating and drinking in the farrowing house to maintain high milk flow.

6. *With the sows at farrowing*—Assist sows having difficulty, free pigs from afterbirth, see that all pigs nurse, check heat and ventilation to prevent chilling, distribute excess pigs among litters to give better opportunity for survival, provide supplemental feeding to weak pigs.

7. *Baby pig husbandry*—Disinfecting navels, clipping needle teeth, administering iron shots.

The list of management inputs for saving baby pigs is endless. Techniques which work for one producer may not work for his neighbor. Purebred operations often must be managed differently from commercial operations.

Regardless of the type of swine operation, inputs of skilled labor can pay dividends if used in situations requiring skilled labor. Spare labor where machines can do the job. Where machines cannot do the job, use the skills available.

Table 4. Returns to Management from Increases in Litter Size at Weaning.

Conception rate	Litter size at weaning			
	6.2	7.1	8.1	9.0
75%	\$3,402	\$6,534	\$ 9,553	\$12,623
85%	5,354	8,835	12,315	15,796

'Flushing' and Reproductive Performance

D. R. Zimmerman

Associate Professor, Animal Science

Litter size is determined by the numbers of ova produced (ovulation rate), the percentage of the ova that are fertilized by spermatozoa (fertilization rate) and the percentage of the fertilized ova that survive to term (prenatal survival rate). In order for "flushing" (increased energy intake prior to breeding) to exert a favorable effect on litter size, it must first stimulate an improved performance in one or more of the developmental traits.

Ovulation Rate

The influence of feed level (energy intake) on ovulation rate is well established in the gilt. The response to flushing is dependent on the length and timing of the "flush" period and the level of energy provided.

Responsive Period for Increased Energy Intake

The ovulation response seems to result from a high energy intake during the period of major follicular development for the next ovulation. This occurs primarily during the last quarter of the estrous cycle.

High energy intake during the first half of the estrous cycle followed by low energy intake during the remainder of the cycle does not produce maximal ovulation rates. Maximal ovulation rates are produced, however, when this feeding sequence is reversed, i.e., when a high energy intake is provided during the last half of the estrous cycle following a low energy intake during the first half of the cycle. The ovulation rate produced by this feeding regimen is comparable to

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that obtained from continuous high energy feeding for a period of 3 weeks and longer.

The minimal flushing interval required to improve ovulation rate over low energy feeding has received limited study. High energy feeding for as little as 6 days prior to the next estrus will apparently increase ovulation rate, but some further improvement is obtained from flushing for 10 and 14 days.

One-day Flushing. A recent report from England has stimulated much interest because it suggested that flushing for a single day during estrus or heat would induce an increase in ovulation rate. These researchers doubled or tripled the feed intake on the first day of estrus only and produced a marked increase in ovulation rate and litter size as compared to unflushed controls.

Research at the University of Nebraska and other experiment stations has recently attempted to confirm these results, but has been unsuccessful. The timing and/or the length of the "flushing" period would not appear to be adequate under most conditions to stimulate an improvement in ovulation rate.

Level of Energy Intake

The doubling or tripling of energy intake during the responsive period (last 1-2 weeks of estrous cycle) has consistently produced significant increases in ovulation rate over basal-fed controls. This ovulation response apparently results from increased caloric intake, since it occurs following the addition of pure energy sources (sugar, starch or lard) to a basal diet fed at 3 to 4 pounds daily.

Recent research at the University of Nebraska attempted to determine the level of energy required to obtain a maximal ovulation response and whether or not the ovulation response to high energy feeding during the flushing period is conditioned by the level of energy received during the preflush period.

Diets were constructed by adding pure energy sources (corn starch

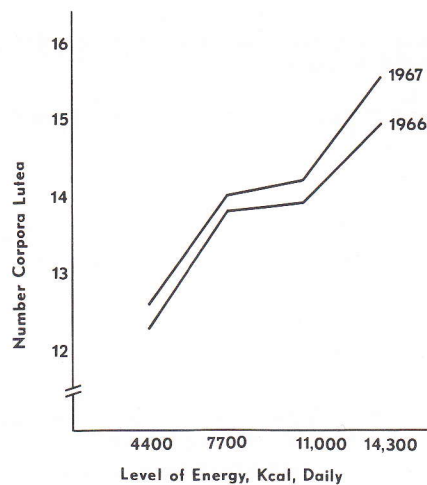


Figure 1. Influence of "flushing" level of energy on ovulation response.

and lard) to a basal diet providing 4,400 kcal daily when fed at 3 pounds daily. These diets provided daily intakes of 7,700, 11,000 and 14,300 kcal daily when fed at 5, 6.5 and 8 pounds, respectively. The ovulation responses obtained are shown in Figure 1.

Ovulation rate improved markedly as energy intake was increased from 4,400 to 7,700 kcal daily (3 to 5 pounds intake), improved only slightly in response to the next level of energy intake (7,700 to 11,000 kcal) and then showed an additional response as energy intake was increased to 14,300 kcal daily. The response to energy intake during the flush period was not conditioned by level of energy intake during the preflush period (3 vs. 5 pounds) but was dependent on the level of energy received during the flushing period.

Flushing Sows. Because of the higher ovulation rate of sows, a low ovulation rate is less likely to account for small litters in sows than it is in gilts. Consequently, much less flushing work has been done with sows.

Research at the University of Nebraska failed to obtain a significant improvement in ovulation rate in response to flushing for 2 or 3 weeks during the first or second post-weaning estrous cycle. Researchers at the University of Wisconsin (personal communication), however, have obtained significant increases in ovulation rate follow-

ing flushing. These researchers further indicate that first-litter sows (primiparous) are more responsive to flushing than are multiparous sows.

Consequence to Litter Size

The consequence to litter size of higher ovulation rates produced by high-energy feeding prior to breeding is dependent on the fertilization and prenatal survival responses to high energy feeding.

Litter size comparisons between flush and non-flush treatments in experiments where the energy intake of flushed gilts was reduced following breeding have generally favored the flush treatments. The responses have most frequently varied from small (.5 embryos) to sizeable advantages (1-2 embryos) in litter size at 25 or 40 days of gestation. Few data are available at term but the same trend is evident.

Some experiments have observed no advantage in litter size at term but many of them failed to remove the gilts from the high-energy flush diet at breeding time.

Increased Embryo Mortality?

High-energy feeding for an extended period of time has been reported by several researchers to cause increased embryo mortality. The majority of the increased mortality apparently occurs from high energy intake during the early post-breeding period (first 25 days of gestation). High energy feeding during later stages of gestation (25 day gestation to birth) does not seem to be detrimental to prenatal survival. Other investigators have failed to observe a detrimental influence of high energy feeding during the post-breeding or pre- and post-breeding periods on embryo survival.

Numerous reports are in agreement that energy intake does not influence fertilization rate.

Feed Level During Gestation

Although the data are not entirely consistent on the influence of high energy intake on prenatal survival, it appears that nothing will be gained and much may be

Sexual Development And Reproductive Performance

D. R. Zimmerman

Associate Professor, Animal Science

lost from continuing the high energy intake into gestation. High energy feeding during this period will increase feed costs without increasing litter performance and, if excessive, may cause increased embryonic mortality.

As a consequence, part or all of the increase in litter size that should accompany the higher ovulation rates produced by flushing may be lost. Following breeding, gilts should be fed approximately 4 pounds of a 14 percent protein diet properly fortified with minerals and vitamins.

Gilts should be flushed with a moderate level of energy (5-7 pounds) where it is not feasible to remove them from the flush diet at the time of breeding. Moderate levels of feeding will support high ovulation rates and can be continued into gestation with much less risk of causing increased embryo mortality.

Summary

1. The responsive period for flushing is during the last half of the estrous cycle.
2. One-day flushing during the first day of estrus is not effective but flushing for as little as 5-6 days prior to heat will stimulate an increase in ovulation rate.
3. A moderate feed intake (5-7 pounds) during the responsive period is adequate to obtain the majority of the response to flushing. Some further ovulation response may be obtained from higher feed intakes (above 8 pounds), but the response may not merit the additional cost.
4. Gilts should be removed from the flush diet at the time of breeding and fed 4 pounds of a 14 percent protein diet (3-5 pounds depending on season, housing, etc.).
5. Gilts that cannot be removed from high energy feeding at the time of breeding should be flushed with a moderate level of feeding.

Management of the breeding herd in close confinement has created and/or accentuated certain reproductive problems in the pig. The failure of, or delay in, puberty (*i.e.*, sexual development characterized by the ability to produce and release functional gametes and the willingness to mate) is one of the major problems encountered.

The failure of puberty to occur in females at the normal time results in lowered and/or delayed conception, an increased generation interval and reduced litter size in females that are mated at first estrus because of delayed puberty. These problems translate into lowered productive efficiency and reduced profit for the swine enterprise.

The environmental conditions for pigs reared in close confinement may differ in a number of ways from those encountered by field-reared pigs. The desirability of the physical environment (temperature, humidity, light, atmosphere, etc.) is dependent on the soundness of the management decisions in meeting the needs of the pigs and/or the functionality of the facilities and equipment in maintaining the environment selected.

The responsiveness of management is more critical in close confinement where the opportunity of the pigs to individually select their own subenvironment (environment within the confines of the overall environment) is severely limited.

For example, pigs closely confined in large groups on concrete have fewer ways to gain relief from high temperature. They cannot get to shade, special air currents, moist soil or move away from penmates. Consequently, management must assume the total responsibility for preventing and relieving adverse environmental conditions which may be detrimental to performance.

Limited research with pigs and more extensive research with laboratory animals suggests that intensive confinement-rearing may create other conditions which may cause delayed pubertal development. The purpose of this discussion will be to consider what is known about the influence of isolation from heterosexual contact, crowding and size of the rearing-group on sexual development and the expression of mating behavior in the pig.

Sexual Development and Mating Behavior

First estrus and ovulation is expressed in most gilts between 4½ and 8½ months of age. Average age at puberty is between 6½ and 7½ months for most breeds. Cross-bred gilts express puberty 1-3 weeks earlier than the average of their parental breeds.

Many swine producers have been unable to breed confinement-reared gilts on schedule because a sizeable proportion of them (20-80 percent) have failed to express normal estrus and mating behavior before 9-12 months of age.

Some producers have ensured the breeding of adequate numbers of females for farrowing by saving an extra number of gilts for breeding. This is a costly practice, but it may represent a good investment if this is the only way that the production plant can be kept operating at full capacity.

Others have attempted to solve the problem by allowing replacement gilts access to less confined outside pens before breeding is started. This practice has generally proven successful.

"Transport stress" and puberty. The French workers reported in 1961 that the expression of estrus tended to be grouped or synchronized when gilts around the age at puberty (200-240 lb.) were purchased in the country and trans-

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ported to the research station. They observed about 40 percent of the gilts to express estrus between 4 and 6 days after arrival at the station (Figure 1). Many swine herds-men have observed a similar "heat grouping" effect when gilts are moved and regrouped prior to the start of breeding and have used this effect to increase the percentage of gilts bred during the first week of breeding.

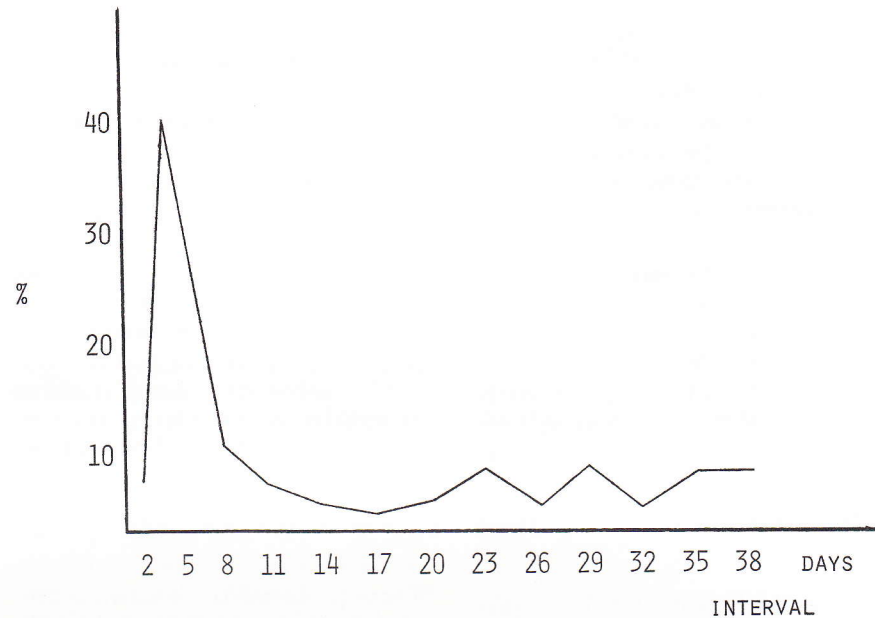
According to the French workers, the "heat grouping" response is caused by stress associated with transport rather than exposure to the boar. This is probably the main reason why movement of gilts from close confinement to less confined, outside pens prior to breeding is successful in stimulating cyclic activity.

Contact with the boar and puberty. The results from recent studies at the University of Nebraska and England suggest that exposure of gilts to the boar during development hastens the onset of the first estrus and ovulation. The results are summarized in Table 1. The timing of the first contact with the boar and the type of boar exposure provided appear to affect the response obtained. Exposure too far in advance of the time that gilts normally begin to cycle tends to decrease the magnitude of the response.

The male also hastens sexual maturation in the mouse. The odor of the male is the primary stimulus involved in the response. No information is available on the relative importance of the different boar stimuli that hasten the onset of first estrus in the pig. The French workers have shown, however, that boar odor is the most important stimulus for the induction of the standing reaction or "immobility response" in estrus females.

Only 48 percent of the females in heat showed a standing reaction in the absence of stimuli from a boar. The response increased to 80 percent when females were exposed to odor from the boar and to 90

FIGURE 1. INTERVAL BETWEEN TRANSPORT AND ONSET OF ESTRUS IN GILTS (FROM SIGNORET, 1970)



percent when females were provided with both odor and sound stimuli. Sight and tactile stimuli from the boar were required to induce the "standing reaction" in only 10 percent of the females.

It was further determined that females exhibiting a positive "standing reaction" to the riding test had markedly higher (20-30 percent) farrowing rates following A.I. than females exhibiting a negative response. The boar or stimuli from the boar aids in the accurate detection of estrus and his presence also may have a stimulatory influence on fertility.

Much remains to be learned about how the boar is able to stimulate certain reproductive phenomena in the female and how one can best utilize the "boar effect" to alter and/or improve reproductive performance.

Restricted space and mobility and sexual development. The normal expression of estrus and mating behavior is interfered with in a sizeable percentage of gilts confined to individual pens or restrained individually with tethers.

In a study conducted at Oregon State University, 28 percent of the gilts confined to individual pens as

compared to 16 percent of the gilts housed in groups of 8 to 12 expressed deviations from the normal pattern of estrus and mating behavior. In addition, 17 percent of the individually-confined vs. 6 percent of the group-confined gilts failed to mate.

Similarly, University of Illinois researchers reported that only 68 percent of the gilts that were tethered expressed estrus and were mated as compared to 92 percent of the gilts housed in groups of 5 to 7 gilts.

The developmental defect in the tethered gilts was subnormal reproductive tract development instead of abnormal patterns of estrus and mating behavior. Approximately 15 percent of the tethered gilts had infantile tracts at slaughter while all group-confined gilts showed normal development.

They also observed a higher frequency of ovulation unaccompanied by estrus in the tethered gilts (6.9 vs. 3.4 percent).

In contrast to gilts, sows showed no obvious estrus and mating behavior defects. Conception rate and litter size in mated females seemed to be unaffected by confinement of gilts to individual pens or by re-

Unidentified Growth Factors for Swine

Murray Danielson

Associate Professor, Animal Science
(Swine)

There are several sources of commercially available unidentified growth factor products. The products used in this study consist of antibiotic residues plus a combination of various unidentified growth factor sources (of fermentation origin). We conducted this study to evaluate and compare the growth rate and feed efficiency of pigs from weaning to market age when fed two different unidentified growth factor (UGF) sources.

stricting their mobility and space allowance with tethers.

In both of the above studies, gilts were not placed in individual confinement until near the time puberty normally occurs (160–236 days). Breeding was done 14 to 120 days later. Consequently, one cannot determine from these data what influence individual confinement during early development would have on sexual development and mating behavior.

The physiological age at the time of individual confinement may influence the response. Whether the interference with estrus and mating behavior induced by individual confinement is caused by stress or by the lack of important stimuli normally obtained through contact with other pigs cannot be answered at present.

The Illinois workers also com-

Table 1. Unidentified Growth Factor Study Data.

Criteria	Treatment ^a					
	1	2	3	4	5	6
Total No. Pigs	13 ^b	15 ^c	16	16	16	16
Initial wt., lbs.	21.7	21.2	21.1	21.7	21.3	21.4
Termination wts., lbs.	185.2	188.5	182.5	197.9	200.8	190.0
Average daily gain, lbs.	1.47	1.50	1.44	1.57	1.60	1.51
Feed conversion	2.97	3.04	3.00	3.08	2.99	3.04

^a 1 – Non-medicated Basal diet

2 – Diet 1 plus 3 lbs. per ton Diamond Shamrock unF-40 in starter diet and 2 lbs. per ton Diamond Shamrock unF-40 in grower and finishing diets.

3 – Diet 1 plus 2-1/2 lbs. per ton Borden's Fermacto 500 in starter, grower and finishing diets.

4 – Medicated Basal diet containing 5 lbs. per ton American Cyanamid's Aureo SP-250.

5 – Diet 4 plus 3 lbs. per ton Diamond Shamrock unF-40 in starter diet and 2 lbs. per ton Diamond Shamrock unF-40 in grower and finishing diets.

6 – Diet 4 plus 2-1/2 lbs. per ton Borden's Fermacto 500 in starter, grower and finishing diets.

^b Three pigs were removed during study because of poor performance.

^c One pig removed during study because of poor performance.

Procedure

We allotted 96 crossbred pigs averaging approximately 21 pounds

to six treatments. We fed an 18 percent protein basal corn-soy diet to all pigs the first six weeks, 16 percent protein from 7–12 weeks, and 14 percent from 13–16 weeks. The different treatments used with the above basal diets appear in *Table 1*. We maintained even distribution of gilts and barrows within each of the 12 experimental pens (two replications). A wooden-frame building with concrete floor and an attached concrete feeding apron, including a self-feeder and automatic waterer, was available for each pen. We recorded growth response and total feed intake at 14-day intervals throughout the 16-week study.

Results and Discussion

As can be observed in *Table 1*, there was little difference in the growth rate for the pigs fed Diets 1, 2, and 3. However, there was a small increase in the growth rate for the pigs fed Diet 2 over the pigs fed the basal Diet 1. The pigs fed Diet 3 gained 0.06 pound less per day than the pigs fed Diet 2, and 0.03 pound less than pigs fed basal Diet 1.

When Aureo SP-250 was added to Diets 4, 5, and 6, there was an improvement in daily gain, with the lesser gain being accounted for by the pigs fed Diet 6. The growth response of pigs fed Diets 4, 5, and 6, even though improved in each instance over Diets 1, 2, and 3, followed the same trend.

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Table 1. Age at Puberty as Influenced by Contact With the Boar.

Study	No contact	Once-daily contact started, days				
		100	125	B-165 ^a	C-165 ^b	180
Univ. Nebraska (1969)						
Age at puberty, da.	190	170	157			
Univ. Nottingham (1970)						
Cycling by 220 days,	7/12			9/12	12/12	11/12
Age at puberty, da.	204			189	172	199

^a Exposed to the same boar, once daily.

^b Exposed to two pairs of litter mate boars once daily on alternate weeks.

Cooked Full-Fat Soybeans for Growing-Finishing Swine

Murray Danielson

Associate Professor, Animal Science
(Swine)

The practice of using cooked full-fat soybeans in place of soybean meal in growing-finishing diets still remains questionable. Further work at the North Platte Station reveals what might be anti-

(continued from page 13)

The trend was that the same UGF (Diets 2 and 5) excelled by improving pig performance either in the absence or presence of Aureo SP-250. The other UGF (Diets 3 and 6) reduced the growth rate either in the absence or presence of Aureo SP-250.

Feed conversion or pounds of feed required per pound of gain for practical purposes did not differ greatly among the six treatments. However, the presence of either UGF sources with Aureo SP-250 did improve the feed conversion, whereas in the absence of Aureo SP-250 more feed was needed per pound of gain when either UGF source was present. Note, the pigs fed basal Diet 1 yielded the better feed conversion, even though it did not differ greatly from the other treatments.

Overall, the pigs fed Diet 5 did respond in providing the higher average daily gain of any of the treatment groups and had a respectable feed conversion. Pig performance for all treatments followed the same trend throughout the study; the 18, 16 and 14 percent protein basal diets having no influence.

Summary

The influence of adding Aureo SP-250 and two UGF sources separately or in combination revealed a definite increase in pig growth with one exception, that being the pigs fed Diet 2. The feed conversion was not altered to any great extent. The value of the above mentioned products could very well be justified if the cost of their addition to a diet is not prohibitive.

ipated in regards to expected pig performance when using cooked soybeans.

Procedure

We used 128 pigs in two studies (A and B) to determine the role cooked full-fat soybeans contribute when used in place of soybean meal in growing-finishing diets. Studies A and B each consisted of 64 pigs. The diet formulations appear in *Table 1*.

In Study A cooked full-fat soybeans replaced soybean meal as the source of supplemental protein. Each of the diets contained approximately 16 percent protein. Note the increase in total pounds of cooked soybeans (106 lbs.) required to equalize the total protein content of Diet 2 to 16 percent, or that found in Diet 1 containing soybean meal. Protein content of the cooked full-fat soybeans was approximately 36.5 percent versus 44 percent for the soybean meal.

In Study B we used Diets 3 and

4 as shown in *Table 1*. The diets differed in that Diet 4 was formulated with cooked full-fat soybeans by a pound for pound replacement of soybean meal found in Diet 3. Thus, Diet 4 contained approximately 14.5 percent protein compared to 16 percent protein found in Diet 3.

Eight animals, four gilts and four barrows, were used in each of the eight experimental pens for Study A and Study B. Each experimental pen was equipped with comparable shelter, self-feeders and automatic waterers. All diets were fed in meal form. Studies A and B had a duration of 84 and 98 days, respectively.

Results and Discussion

Performance data are shown in *Table 2*. Growth rate of the pigs in Study A fed Diet 2 (cooked full-fat soybeans) was 0.09 lb. per head per day greater than the pigs fed Diet 1 (soybean meal). Feed conversion was improved, as 0.47 pound less feed was required per pound of

Table 1. Cooked Full-Fat Soybean Study Diets.

Ingredients	Diets			
	Study A		Study B	
	1	2	3	4
Corn	75.0	69.8	73.3	73.3
Soybean meal (44%)	21.2	.....	20.5	.....
Cooked full-fat soybeans	.....	26.5	.....	20.5
Alfalfa hay	.....	.....	2.5	2.5
Ground limestone	0.4	0.4	0.5	0.5
Dicalcium phosphate	1.8	1.7	1.6	1.6
Salt, iodized	0.5	0.5	0.5	0.5
Trace minerals ¹	0.075	0.075	0.075	0.075
Vitamin premix ²	1.025	1.025	1.025	1.025
Total	100.00	100.00	100.00	100.00

¹ Calcium Carbonate Company, swine, 20% zinc.

² Contributed the following amounts per pound of complete diet: Vitamin A, 1500 IU; Vitamin D, 200 IU; riboflavin, 1.0 mg.; niacin, 8.0 mg.; calcium pantothenate, 4.5 mg.; choline chloride, 100 mg.; Vitamin B₁₂, 10 mcg.

Table 2. Performance Data.

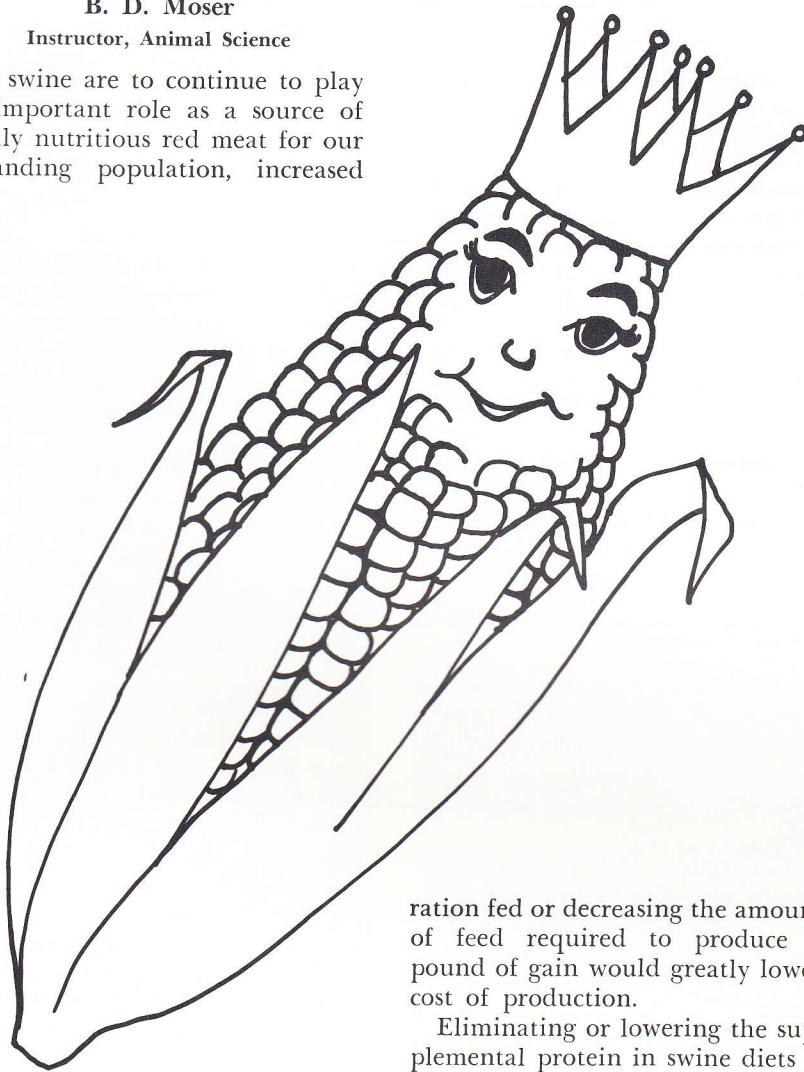
Item	Diets			
	Study A		Study B	
	1	2	3	4
No. of pigs	32	32	32	32
Avg. initial wt., lbs.	68.4	68.4	54.8	54.2
Avg. final wt., lbs.	202.9	210.9	212.3	223.2
Days on study	84	84	98	98
Avg. daily gain, lbs.	1.60	1.69	1.61	1.73
Feed/lbs. gain	3.78	3.31	3.52	3.32

High Lysine Corn Superior Feed Grain

B. D. Moser

Instructor, Animal Science

If swine are to continue to play an important role as a source of highly nutritious red meat for our expanding population, increased



efficiency of production is mandatory.

Since 60 to 70 percent of the total cost of producing swine is feed, then lowering the cost of the

ration fed or decreasing the amount of feed required to produce a pound of gain would greatly lower cost of production.

Eliminating or lowering the supplemental protein in swine diets is one way of reducing the cost per pig marketed. The development and utilization of high-lysine corn in swine diets provides a way to lower the amount of supplemental protein required.

gain than was required by the pigs fed soybean meal.

In Study B, the pigs fed Diet 4, containing cooked soybeans, showed an increased growth response over the pigs fed soybean meal of 0.12 pound per head per day. Feed required per pound of gain was reduced 0.20 pound.

Summary

From the data presented on each

of the studies reported herein, a pound for pound replacement of cooked full-fat soybeans for soybean meal would be recommended. At this point, if the protein source is in question (cooked full-fat soybeans versus soybean meal) it would be advisable to compare the actual cost of each diet and relate this cost to the expected performance of the animals.

What is High-Lysine Corn?

The opaque-2, high-lysine, varieties of corn contain a mutant gene which has markedly changed the amino-acid pattern of corn protein and has substantially increased the lysine content as compared to normal corn.

Research at Purdue has attributed this change to a reduction in the ratio of zein to glutelin proteins in the corn as well as an increase in the lysine content of the acid- and alcohol-soluble (zein) fractions.

Glutelin is the higher quality protein of corn while zein is of low quality. Therefore, lowering the ratio between the two proteins would constitute a higher quality protein for corn, since the content of some of the essential amino acids, such as lysine and tryptophan, have been increased.

Since lysine is the first limiting amino acid in corn, protein supplementation must be enough to bring the ration up to the lysine requirement.

With the increased lysine content of opaque-2 corn, it appears quite probable that comparable gains and feed conversions can be obtained from swine using opaque-2 corn with reduced levels of supplemental protein, thus lowering cost of production.

The protein and amino acid content of normal and high-lysine corn analyzed at Purdue in 1966 are shown in *Table 1*. The first two limiting amino acids (lysine and tryptophan) are markedly increased in the high-lysine corn. The lysine requirement for finishing pigs is about 0.50 percent. Therefore, the lysine requirement could be met from high-lysine corn (0.49 percent lysine) with little or no supplemental protein.

What About Performance?

The goal of pork production is to achieve maximum performance the most economical way. There-

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fore any type of new or different feeding regime must result in a performance that is equal to or better, or at least more economical, than the one presently being used. High-lysine corn provides a different feeding regime which appears quite favorable as far as performance is concerned.

Research from several different stations has indicated that high-lysine corn can be used effectively in all phases of a swine feeding program.

Gestation

Research at Purdue indicates that a diet (9.7 percent protein and 0.37 percent lysine) containing high-lysine corn with no supplemental protein appears quite adequate for gestating gilts (Table 2). This diet was compared to normal corn with no supplemental protein (8.8 percent protein) and to normal corn supplemented with soybean meal at levels of 12, 16 and 20 percent protein.

In this study there was essentially no difference for any of the treatments in number of live pigs born or number of pigs weaned per litter. Slower preweaning gains of pigs from sows fed normal corn (no supplemental protein) were observed, while the high-lysine corn diet (no supplemental protein) compared favorably with normal corn-soybean meal diets for this trait.

Baby Pig

The baby pig is in a rapid state of protein production, therefore the protein and lysine content of the diet becomes critical. Research

Table 1. Composition of Normal and Opaque-2 Corn.^a

	Normal Corn	Opaque-2 Corn
	%	%
Protein	8.86	11.94
Dry Matter	91.88	87.10
Amino Acids		
Lysine	.24	.49
Tryptophan	.09	.15
Methionine	.15	.16
Arginine	.46	.79
Threonine	.32	.38
Histidine	.27	.40
Isoleucine	.31	.37
Leucine	1.10	.97
Valine	.42	.57
Phenylalanine	.45	.51
Aspartic Acid	.61	1.16
Serine	.45	.50
Glutamic Acid	1.89	2.17
Proline	.88	1.00
Clycine	.36	.56
Alanine	.72	.75
Cystine	.14	.20
Tyrosine	.39	.45

^a Pickett, Purdue, 1966.

at Nebraska indicates that the amount of supplemental protein required by early-weaned baby pigs can be reduced because of the increased lysine content of high-lysine corn.

The results from a study conducted at Nebraska in which high-lysine corn was compared to normal corn at 3 levels of protein (12, 16 and 20 percent) are shown in Table 3. In this study high-lysine corn produced faster gains and better feed conversion than normal corn at all levels of protein, but especially at 12 percent protein.

The nutritional value of high-lysine corn for the baby pig is clearly shown by the comparisons presented in Table 4. When baby pigs were fed a stress diet of 12

percent protein, the high-lysine corn produced an 81 percent improvement in average daily gain and a 37 percent improvement in feed/gain ratio. At the required level of 20 percent protein, the percent improvement of gain and feed/gain was 2 percent and 13 percent, respectively.

This same response for the two corns across the three levels of protein for average daily gain is graphically illustrated in Figure 1. Since high-lysine corn produced faster gains than normal corn at all three levels of protein, it appears that a lower level of supplemental protein is required when using high-lysine corn.

As illustrated, high-lysine corn supplemented with soybean meal at 18 percent protein should produce an average daily gain of .72 pound per day compared to a .74 pound per day for normal corn-soybean meal diet of 20 percent protein.

It has been established that in order to obtain maximum gains from pigs of this weight a normal corn-soybean meal diet must be balanced to 20 percent protein. Therefore, when using high-lysine corn, with its superior amino acid content, the same gains can be obtained with 18 percent protein.

Since baby pig diets contain such a high level of supplemental protein, lowering the added protein content of the diet 2 percent would reduce the cost of production.

Growing-Finishing

The largest percent of the feed consumed by a market pig is during the growing-finishing phase. Therefore, any improvement in performance in this phase, through increased gains and feed conversions or the lowering of supplemental protein, would greatly reduce the cost of producing that pig.

Research at Purdue, Illinois, Nebraska and South Dakota indicates that high-lysine corn is used very efficiently by growing-finishing swine.

Results from a finishing study conducted at Purdue are shown in Table 5. The pigs averaged approx-

Table 2. Effect on Dietary Protein Quality and Quantity During Gestation on Reproduction Performance and Progeny Development^a (Illinois).

Protein, %	Corn	Opaque-2 Corn	Corn-Soybean Meal		
	8.8	9.7	12	16	20
No. of gilts started	54	54	53	54	54
Farrowing percent	76	73	70	64	73
No. of live pigs born per litter	7.3	7.5	7.6	8.1	8.1
No. of pigs weaned per litter	6.2	6.9	6.9	7.5	7.3
Litter wt. live pigs at birth, lb.	19.8	20.8	21.3	22.7	22.8
Litter wt. at 21 days, lb ^b	61.8	75.5	75.8	81.0	75.5

^a Baker, et al., 1970. Illinois Pork Industry Day, p. 15.

^b Significant ($P < .05$) treatment difference.

Table 3. Effect of Normal, High Lysine Corn and Protein Level on Performance of the Baby Pig.^a (Nebr. Exp. 71406).

	Normal Corn ^{b,d} % Protein			High-Lysine Corn ^{c,d} % Protein		
	12	16	20	12	16	20
No. of pigs	16	14	15	15	16	15
Initial wt., lb.	8.8	9.3	8.7	8.8	8.9	9.1
Final wt., lb.	16.6	29.9	34.5	22.8	31.2	35.5
Total gain, lb.	7.8	20.6	25.8	14.0	22.3	26.4
Avg. daily gain, lb. ^{e,f}	.22	.59	.74	.40	.64	.76
Feed intake, lb. ^{e,f}	.98	1.31	1.53	1.09	1.32	1.37
Feed/gain ^e	4.45	2.23	2.07	2.82	2.07	1.81

^a All pigs were on test for 35 days.

^b Lysine content for normal corn 12, 0.56; 16, 0.86; 20, 1.17.

^c Lysine content for high lysine corn 12, 0.72; 16, 0.99; 20, 1.27.

^d Significantly different ($P < .01$) for gain, feed/gain and feed intake.

^e Linear effect significant ($P < .01$).

^f Quadratic effect significant ($P < .01$).

^g Quadratic effect significant ($P < .05$).

imately 130 pounds at the start and the trial was for three weeks.

Pigs fed the high-lysine corn diet (no supplemental protein) gained significantly faster than those fed a diet of identical formulation using normal corn and also faster than those fed a normal corn-soybean meal diet of equal nitrogen content. Feed conversion was also poorer for pigs fed the normal corn diets as compared to those fed the high-lysine corn diet.

Normal corn plus soybean meal which provided 1.8 percent more crude protein than the high-lysine corn diet resulted in only slightly faster gains and required slightly more feed to produce a pound of gain. Therefore, these results indicate that high-lysine corn which contains 11.2 percent protein and 0.48 percent lysine is adequate to support normal gains and feed conversions in finishing pigs (130 pounds—market) with no additional supplemental protein.

Similar results were also obtained by Illinois with finishing pigs from 110 to 200 pounds (Table 6). A high-lysine corn-soybean meal diet balanced to 11 percent protein produced slightly faster gains (1.60 pounds per day) and considerably less feed was required per pound of gain (2.70) than a normal corn-soybean meal diet of 12 percent protein (1.50 pounds per day and 3.57, respectively). Also when high-lysine corn was supplemented with lysine to a level equivalent to that of the normal corn-soybean meal diet, average daily gains were the same and 40 pounds less feed was

required to produce 100 pounds of gain.

Research at South Dakota and Nebraska using high-lysine corn in both the growing and finishing phases show similar results as that discussed above for the finishing phase.

The results of the South Dakota trial are presented in Table 7. Pigs receiving the normal corn diet (16–14 percent protein) and high-lysine corn (16–14 percent protein) produced similar average daily gains of 1.83 and 1.81 pounds respectively. Feed required per pound of gain was also similar 3.20 and 3.20 for the normal and high-lysine corn diets, respectively.

Table 4. Percent Improvement in Average Daily Gain and Feed Conversion of Pigs fed High Lysine Corn vs. Normal Corn.^a

Level of protein	Percent improvement	
	Avg. daily gain	Feed/gain
	%	%
12	81	37
16	9	7
20	2	13

^a Based on results of Nebraska Exp. 71406 with baby pigs from 9 to 35 lbs. body weight.

Pigs receiving the normal corn (12–10 percent protein) gained only 1.30 pounds per day as compared to pigs gaining 1.70 pounds per day when fed high-lysine corn at the same low protein levels. Also, the group receiving normal corn required 70 pounds more feed per 100 pounds of gain than the high-lysine corn group.

In addition, the high-lysine corn diets fed at the 12–10 percent protein regime resulted in gains only 0.1 pound less per day than pigs fed the 4 percent higher protein regime of normal or high-lysine corn, indicating the superior protein quality of the high-lysine corn.

A growing-finishing study with high-lysine corn was conducted recently at Nebraska. In this trial a normal corn-soybean meal, 14 percent protein diet (treatment A),

(continued on next page)

Table 5. Performance of Finishing pigs fed Opaque-2 Corn vs. Normal Corn (3 week trial). (Purdue)^a

	Opaque-2 Corn	Normal Corn	Normal Corn +SBM	Normal Corn +SBM
Protein level %	11.2	8.9	11.2	13.0
Lysine level, %	0.48	0.23	0.38	0.48
Initial wt., lb.	131	131	130	133
Avg., daily gain, lb.	2.27	1.50 ^b	1.94 ^b	2.39
Feed/gain	3.59	4.71 ^c	3.74	3.65

^a Pickett, R. A. Opaque-2 Corn in Swine Nutrition. 1966. Proc. High-Lysine Corn Conference, p. 19.

^b Significantly less ($P < .01$) than other two treatments.

^c Significantly more ($P < .05$) than other three treatments.

Table 6. Performance of Pigs Fed Normal Corn, Opaque-2 Corn Supplemented With Soybean Meal and Lysine (Illinois^a).

	Normal Corn +SBM	Opaque-2 +SBM	Opaque-2	Opaque-2 +Lysine
Calculated values, %				
Crude protein	12.0	11.0	9.3	9.3
Lysine	0.44	0.45	0.34	0.49
Avg. daily gain, lb. ^b	1.50	1.60	1.36	1.54
Avg. daily feed, lb. ^b	5.36	4.33	4.96	4.87
Feed/pound of gain ^b	3.57	2.70	3.65	3.16

^a Jensen, et al., 1969. Illinois Pork Industry Day, p. 15.

^b Each figure represents an average of two groups of nine pigs each from 110 pounds to 200 pounds.

(continued from page 17)

was compared to several other diets using high-lysine corn. The treatments are described in *Table 8*.

Treatments B, C and E did not produce gains and feed conversions equivalent to those produced with treatment A, which would indicate that the lysine content of these diets was too low to support normal growth in either the growing and/or finishing phase.

However, treatment F (diet A to 100 pounds, then diet C) which used high-lysine corn-soybean meal (10 percent protein) from 100 pounds to market, produced equal gains but required 40 pounds more feed to produce 100 pounds of gain when compared to the normal corn-soybean meal diet of 14 percent protein for both phases.

The most interesting results in this trial were when normal corn and high-lysine corn were compared at the same protein level of 14 percent protein (treatment A and D, respectively). The high-lysine corn diet produced 0.2 pound per day faster gains than normal corn (1.4 vs 1.2 pounds), and required 50 pounds less feed to produce 100 pounds of gain.

Therefore, when using a 14 percent protein high-lysine corn diet for both the growing and finishing phase, one could expect faster gains and less feed required per pound of gain as compared to normal corn at the same level of protein. It appears, therefore, with high-lysine corn, one could feed 12 percent protein and equal the performance

Table 7. Effect of Feeding Opaque-2 Corn on Average Daily Gain, Feed Conversion and Carcass Characteristics. (South Dakota State University)^a

Protein, % ^{b,c}	Normal ^e 16-14	High-Lysine Corn 16-14	Normal 12-10	High-Lysine Corn 12-10
No. of pigs	12	12	11	12
Initial wt., lb.	42	41	43	41
Final wt., lb.	210	209	207	211
Avg. daily gain, lb.	1.8	1.8	1.3	1.7
Avg. Feed/lb. Gain	3.2	3.2	4.1	3.4
Loin eye area, sq. in. ^d	5.0	5.4	3.9	5.2
Backfat thickness, in. ^d	1.2	1.1	1.2	1.2
Lean Cuts, % ^d	48.2	49.0	45.6	48.4

^a Gilster, K. E. and R. Wahlstrom, 1970. A.S. Series 70-41. p. 46.

^b Rations were reduced in protein when lot averaged approximately 110 lbs.

^c Calculated lysine for the respective diets were 0.79-0.63, 0.93-0.78, 0.48-0.32, 0.63-0.49.

^d Eleven pigs except for high-lysine corn 12-10 which had 12.

obtained with a normal corn diet of 14 percent protein.

In summary, it appears that because of the nutritionally superior value of high-lysine corn a 2 percent lower protein level will support equal performance to normal corn for all phases of a swine feeding program at the presently required protein levels.

Carcass Merit

Table 7 presents the carcass data from the South Dakota trial. Pigs fed the low protein, normal corn diets (12-10 percent protein) had significantly smaller loin eye areas and a lower percent lean cuts than pigs fed the other diets. The low protein, high-lysine corn diets (12-10 percent protein) produced loin eye area and percent lean cuts similar to those produced with the 16-14 percent protein diets, indicating that the low protein high-lysine corn diet was adequate for maximum muscle production by the pig.

Nebraska research shows little

difference in backfat thickness and percent ham and loin due to the diets compared (see *Table 8*). The results clearly indicate that lowering the protein content of the diet from 14 to 10 percent at 100 pounds body weight will not adversely affect carcass composition when high lysine corn is used as the feed grain.

What About Yield?

Research has indicated that high-lysine corn is a superior feed grain for swine during all phases of a feeding program. However, the biggest question confronting the future of high-lysine corn is that of yields and test weight.

Conflicting results have been reported concerning yields. Some unfavorable reports indicate reduction in yields as much as 30 percent lower than normal corn varieties. Others report that high-lysine corn has equaled normal corn in yields and in some cases produced slightly higher yields. The favorable reports about yields have come from the Illinois, Indiana and Iowa areas, where apparently the high-lysine varieties now being used were developed for those areas.

In Nebraska lower yields have been reported, which would indicate that there has not been a variety developed which is adapted for this area. At the present, in Nebraska, yield, not nutritive value seems to be the big question about high-lysine corn.

Some corn breeders think that getting comparable yields is just a matter of time and generations in an effective breeding program.

Table 8. High Lysine Corn vs. Normal Corn for Growing-Finishing Swine (Nebr. Expt. 71408)

	Treatments ^a					
	A	B	C	D	E	F
No. of pigs	13	13	14	14	14	14
Initial wt., lb.	38.0	38.9	38.0	39.0	36.5	37.5
Final wt., lb.	173.0	79.5	118.0	190.5	142.0	174.0
Avg. daily gain, lb. ^b	1.2	0.3	0.7	1.4	0.9	1.2
Feed/gain	3.8	6.4	4.0	3.3	4.6	4.2
Backfat, in. ^c	1.2	.....	.....	1.2	.....	1.1
Ham-loin, % ^c	43.8	.....	.....	42.4	.....	43.0

^a A = Normal Corn + SBM

B = High-Lysine Corn 14% protein; Lysine 0.61

C = High-Lysine Corn + SBM 8% protein; Lysine 0.38

D = High-Lysine Corn + SBM 10% protein; Lysine 0.52

E = Diet A to 100 pound then B 14% protein; Lysine 0.81

F = Diet A to 100 pound then C

^b Approximately 116 days on test.

^c 10 pigs from Treatments A, D, F slaughtered for carcass data.

High Lysine Corn For Swine . . . An Economic Analysis

Larry L. Bitney
Extension Economist
(Farm Management)

What is high-lysine corn worth? As pointed out in the preceding article by Moser, several feeding trials have shown that increases in feed efficiency and average daily gains are possible when high-lysine corn is substituted for normal corn in swine finishing rations.

Other experiments have shown that rations containing high-lysine corn can be formulated at a lower protein level and will still produce gains as efficiently as higher protein rations which contain normal corn.

Summary

Research indicates that high-lysine corn is a nutritionally superior feed grain for all phases of a swine feeding program. Because of its increased lysine content, lower supplemental protein is required to balance swine diets to meet protein requirements.

When high lysine corn is used as the feed grain, a diet which is approximately 2 percent lower in protein will produce performance that is equal to a normal corn-SBM diet balanced at the presently required dietary protein levels.

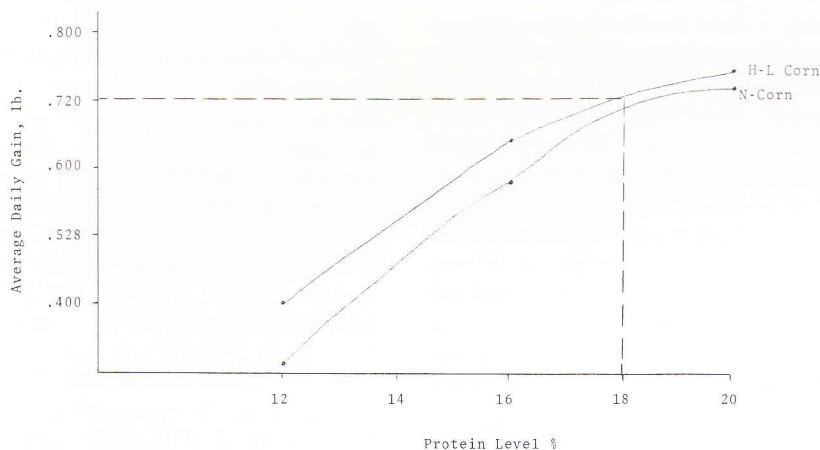


FIGURE 1. Average Daily Gain of Baby Pigs fed High-Lysine and Normal Corn at Different Protein Levels

Table 1. Comparative Cost per ton of a 14% Normal Corn Diet and a 12% High-Lysine Corn Diet.

Price/lb.	Feedstuff	Normal Corn		High-Lys Corn	
		14%	Cost	12%	Cost
2c/lb.	Normal Corn (8.9%)	1676	\$33.52	.....
2c/lb.	High-Lysine corn (10.0%)	.....		1805	\$36.10
4.5c/lb.	Soybean Meal (49.0%)	249	11.21	122	5.49
1c/lb.	Ground Limestone	19	.19	17	.17
5c/lb.	Dicalcium Phosphate	25	1.25	25	1.25
1c/lb.	Salt	10	.10	10	.10
10c/lb.	Trace Mineral	1	.10	1	.10
25c/lb.	Vit. Ab Premix	20	5.00	20	5.00
	TOTAL:		\$51.37 ^a		\$48.21 ^a
			Difference = \$3.16/ton		

^a Ingredient cost only, cost of mixing not included.

But—how do these benefits from feeding high-lysine corn compare with the costs?

What does high-lysine corn cost? Its use as a feed grain is so new that it does not have an established market price. Reports on yields of high-lysine corn range from “about the same” as normal corn in Illinois and Indiana to as much as 30 percent less in Nebraska. As varieties of high-lysine corn are developed for this area we would expect this difference to narrow. Yet, the cost of producing high-lysine corn will likely be the same as that of normal corn, with the possible exception of seed cost. Thus, we are not sure what the cost of high-lysine corn is.

We have found ourselves in this same situation with many new

developments in agriculture. We don't have all the information we need to make a positive analysis of a new crop, machine, livestock housing system, etc.

In the case of high-lysine corn, we have an indication of how it will perform as a feed grain with swine, but we do not know for sure how much of a premium we will have to pay for it, or how much of a yield decrease we should be willing to accept if we grow it. But, with the information we have, we *can* estimate how much of a premium we *could* pay for high-lysine corn, or how much of a yield decrease we *could* realize before high-lysine corn becomes less profitable than normal corn as a swine feed grain.

The value of high-lysine corn in relation to normal corn depends upon how it is used in a swine finishing ration. Two feeding methods, or strategies, are used in this article. They are:

1. “Strategy 1,” lower the protein content of the ration containing high-lysine corn, while maintaining equal feed efficiency. The basis for this evaluation was: a 14 percent protein finishing ration containing normal corn (Table 1); A 12 percent protein finishing ration containing high-lysine corn (Table 1). These rations are as

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sumed to produce equal performance in terms of average daily gain and feed efficiency.

2. "Strategy 2," replace normal corn pound-for-pound with high-lysine corn and realize an increase in feed efficiency.

The basis for this evaluation was: a 14 percent protein finishing ration containing normal corn; (Table 1). The same ration, only with high-lysine corn substituted pound-for-pound for normal corn. (The high-lysine corn ration will contain slightly over 14 percent protein, as the high-lysine corn contains more protein than normal corn. Another possible strategy would be that of formulating a 14 percent ration with high-lysine corn, allowing some reduction in the soybean meal required).

Estimated gains in efficiency for the ration containing high-lysine corn were: An increase in average daily gain of 0.2 pounds per head per day, and a decrease of 0.5 pound of feed per pound of gain.

This comparison is based on a gain of 120 pounds (100 lb.-220 lb.). The results are shown in Figure 1.

How to Use Figure 1

The two lines in Figure 1 represent an optimistic and a conservative estimate of the value of high-lysine corn in swine finishing rations.

"Strategy 1", the lower line, represents the conservative estimate. As mentioned above, equal performance with the 14 percent normal and 12 percent high-lysine corn rations was assumed, but instances of improved performance with a lower protein high-lysine corn ration can be cited.

"Strategy 2", the upper line, represents a more optimistic estimate, although instances of increases in efficiency due to high lysine corn above those assumed here can be cited.

To use Figure 1, find the price of normal corn which you wish to use on the horizontal axis. Draw a line vertically from this point. (As

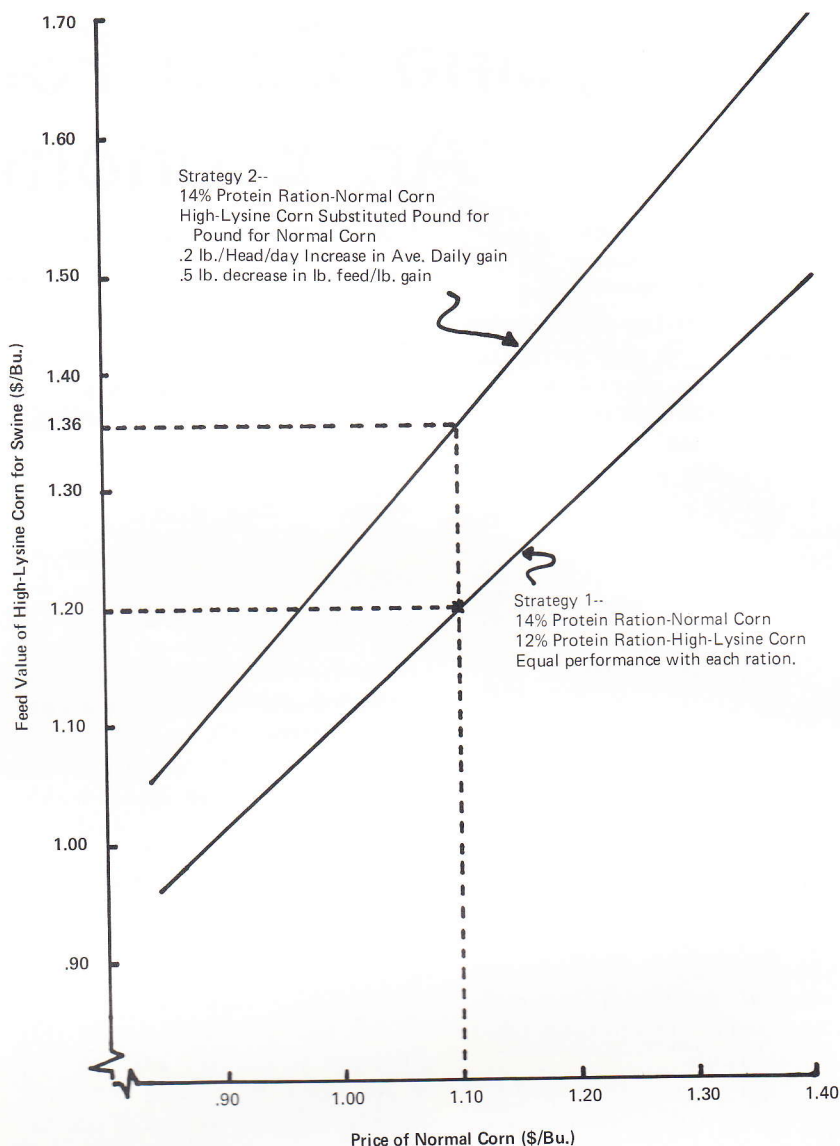


Figure 1. Feed value of high lysine corn in swine finishing rations, based on price of normal corn.

we have done for the \$1.10 price of normal corn in Figure 1.) Now, draw a line to the left axis from the points where your vertical line crossed the "Strategy 1" and "Strategy 2" lines.

This gives you a conservative estimate and an optimistic estimate of the value of high-lysine corn, relative to the price of normal corn with which you started. As shown in Figure 1, if the price of normal corn is \$1.10 per bushel, high-lysine corn is worth at least \$1.20 and possibly \$1.36 per bushel in a swine finishing ration. The value which you choose reflects your own optimism or pessimism regarding high-lysine corn.

Strategy 1—Lower Protein Level In Ration Containing High-Lysine Corn

In this case, equal gains and feed consumption were assumed. Thus, the advantage of high-lysine corn is realized because less soybean meal is required for the 12 percent protein ration. We have seen in Figure 1 that if normal corn is worth \$1.10 per bushel, then high-lysine corn is worth \$1.20 per bushel when this strategy is used.

Yield Difference

If production costs are equal for high-lysine and normal corn, we could also interpret this difference in value in terms of yield. Using

this approach, the high-lysine corn would have to make 92 percent of the yield of normal corn in order for it to be profitable to grow high-lysine corn as a feed grain for hogs. Thus, if we could expect a 100 bushels per acre yield of normal corn, we would have to get at least 92 bushels per acre of high-lysine corn to break even.

Effect of Soybean Meal Price

Since the differing amounts of soybean meal used in the two rations cause much of the difference in the value of normal vs. high-lysine corn, how do changes in the cost of soybean meal affect this relationship?

Based on the rations shown in *Table 1*, a \$5.00 per ton increase in soybean meal price increases the value of high-lysine corn 2¢ per bushel, relative to normal corn. The values in *Table 1* and *Figure 1* are based on \$90 per ton soybean meal. An increase in the price of soybean meal to \$95 per ton would increase the value of high-lysine corn obtained from the "Strategy 1" line in *Figure 1* by 2¢ per bushel.

Strategy 2—Normal Corn Replaced Pound-for-Pound With High-Lysine Corn

In this case, the ration containing high-lysine corn improves the estimated average daily gain from 1.6 to 1.8 pounds per head per day and the feed required per pound of gain is decreased from 3.8 to 3.3. *Figure 1* shows that using high-lysine corn in this manner makes it worth more, relative to normal corn. If normal corn is \$1.10 per bushel, high-lysine is worth \$1.36 per bushel.

Yield Difference

The break-even yield level for high-lysine corn when using this strategy is 81 percent. Thus, if we could grow 100 bushels of normal corn per acre, we would need a yield of at least 81 bushels per acre of high-lysine corn for it to be a competitive alternative.

Feed Processing

Since less feed is required by the hogs fed the ration containing high-

lysine corn, a savings is also realized in feed processing cost. If the feed processing cost is \$5.00 per ton, and we take this into account in our comparison, it increases the value of high-lysine corn by 0.2¢ per bushel in relation to normal corn.

Overhead Costs

Since the hogs on the high-lysine corn ration will gain faster, they will occupy the hog feeding facility less time, take less labor, less electricity, etc. The increase in daily gain from 1.6 to 1.8 on a gain of 120 pounds (100 pounds to 220 pounds) gets the hogs to market seven days earlier than those fed the normal corn ration.

Overhead costs in an automated swine facility might be about 3½¢ per head per day. This gives the hogs on the high-lysine corn ration a 25¢ per head advantage. On a per bushel of corn basis, this gives high-lysine corn an additional 4.7¢ per bushel advantage over normal corn. This can be added to the value of high-lysine corn obtained in *Figure 1* for "Strategy 2".

A producer who does not have an alternative use for his housing facilities or labor should not figure this much of an advantage due to overhead costs, but this advantage will apply to many producers.

Summary

The value of high-lysine corn, relative to normal corn, depends upon how it is used in a swine feeding program. For the feeding strategies budgeted here, high-lysine corn is worth from \$1.20 to \$1.36 per bushel when normal corn is priced at \$1.10 per bushel. When growing high-lysine corn for hog feed, yields may drop as low as 81–92 percent of normal corn yields and high-lysine corn will still remain competitive as a feed grain for swine rations. At present, Nebraska corn farmers are no doubt reluctant to grow high-lysine corn for sale, as they face a probable yield reduction, and a premium for high-lysine corn has not been established.

Thus, if a hog producer wants to feed high-lysine corn, he must grow

Another Look At Antibiotics For G-F Swine

E. R. Peo, Jr.

Professor, Swine Nutrition

Last year we reported that growing-finishing swine fed diets containing the antibiotic Bacitracin gained slower than pigs fed diets without antibiotic supplementation. On the other hand, pigs fed diets with chlortetracycline (Aureomycin) gained faster and more efficiently than those on the unsupplemented control diet.

The reason for the depression in gains of pigs fed Bacitracin was not known but appeared to be related to reduced feed intake. The diet containing Bacitracin seemed rather unpalatable to the pigs from the very beginning of the experiment.

Although Bacitracin has not been widely accepted as a consistently effective antibiotic for growth promotion in swine, cost plus reports of positive growth responses from the field suggested the need for further evaluation of Bacitracin. If the appetite depression is due to the Bacitracin or its carrier, the form could be changed and the antibiotic could perhaps have a useful role in swine feeding programs.

We conducted an experiment with 72 growing-finishing swine to

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it himself, or contract with someone to grow it for him.

From this analysis, we see that growing and feeding high-lysine corn will likely be profitable even if yields of high-lysine corn are somewhat lower than those of normal corn.

As adapted varieties of high-lysine corn become available in Nebraska, and if marketing premiums are established, high-lysine corn should offer both corn and hog producers an opportunity to increase their profits.

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determine the effect of levels and source of antibiotic on gains and feed conversion. The pigs were housed in a modified-open front growing-finishing unit which was 50 percent slatted floor. The study was from March to June 1971.

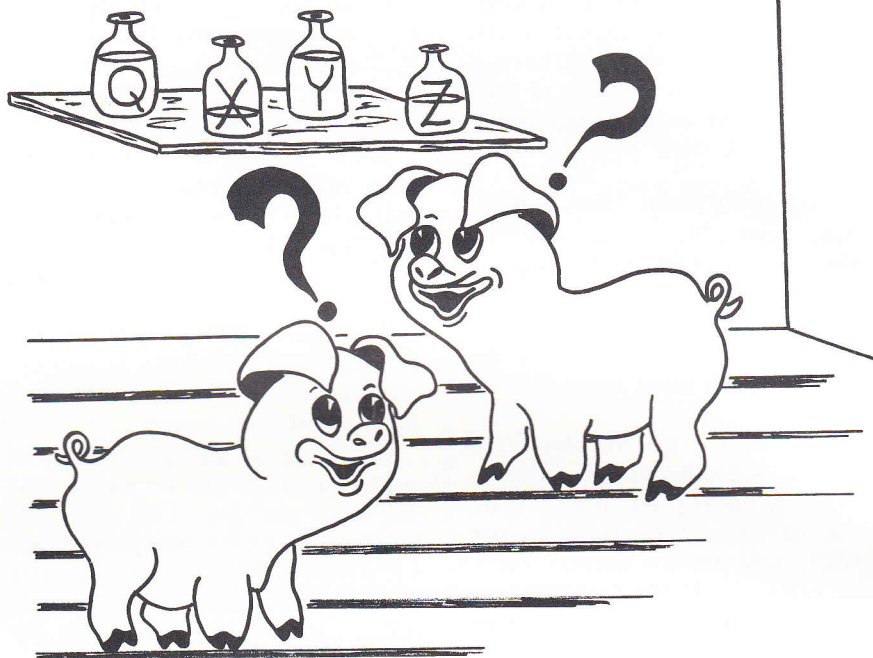
The experimental diets consisted of a 14 percent protein milo-soybean meal diet supplemented with (a) no antibiotic, (b) 20 or 40 grams/ton of Bacitracin methylene disalicylate (BAC-MD), (c) 20 or 40 grams/ton of Aureomycin (chlortetracycline) and (d) 40 grams/ton plain Bacitracin (same as used in the 1970 study, but dispersed on a different carrier.) The results are shown in *Table 1*.

Pigs fed diets containing antibiotics gained faster and generally more efficiently than those not fed antibiotics. This finding provides further and continuing support for the growth promotant value of low dietary levels of antibiotics.

The greatest gain response (9 percent improvement over the control) was obtained with BAC-MD fed at a level of 40 grams/ton. Aureomycin fed at levels of 20 and 40 grams/ton and plain Bacitracin at the 40 gram level produced similar gain and feed conversion responses.

These results are contrary to those obtained in our 1970 experiment. Feed intake was not reduced in pigs fed diets containing plain Bacitracin or BAC-MD, as was observed in the 1970 study. Thus, pig gain in the 1971 study was not limited by feed intake as appeared to be the case in 1970.

The reason for differences in feed intake between the two trials may



have been palatability of the carrier (antibiotics are dispersed on carriers for inclusion in rations) since the carrier for Bacitracin was different in the current experiment as compared to 1970.

Form of Bacitracin (plain vs. BAC-MD) does not appear to be a factor affecting diet palatability.

Other factors involved which might account for the difference in pig response to the Bacitracin between the 1970 and 1971 trials besides the carrier for Bacitracin or form (BAC-MD) are (1) initial weight of the pigs (55 lbs. in 1970; 31 lbs. in 1971), (2) time of year (fall-1970; spring-1971), (3) pre-

vious antibiotic program and (4) diet (corn-soybean meal-1970; milo-soybean meal-1971).

The pigs did not respond particularly well to the 20 gram/ton level of BAC-MD but made a significant improvement in gain when the level of BAC-MD was increased to 40 grams/ton.

Antibiotics play an important role in modern swine feeding programs. They will continue to do so as long as they are used properly, withdrawn from the ration at correct intervals before the pigs are sent to slaughter and are not considered as a "substitute for good swine management."

Table 1. Effect of Antibiotics on G-F Swine Raised on Partially-Slatted Floors.^a

	Treatments ^b					
	No Antibiotic	20 gms/ton BAC-MD ^c	40 gms/ton BAC-MD ^c	20 gms/ton AUREO ^d	40 gms/ton AUREO ^d	40 gms/ton BAC ^e
No. pens/treatment	2	2	2	2	2	2
No. pigs/pen	6	6	6	6	6	6
Initial wt., lb.	31.0	30.9	30.8	30.5	30.7	31.2
Final wt., lb.	154.6	154.3	162.5	155.6	157.2	156.8
Av. daily gain, lb. ^f	1.44	1.46 ^g	1.57 ^g	1.49	1.50	1.50
Av. daily feed intake, lb.	5.76	5.95	5.75	5.32	5.69	5.90
Gain/feed ratio	0.25	0.25	0.27	0.28	0.26	0.25

^a 50% slatted floor research unit. D x Y x H crossbred pigs. Mar-June 1971. Duration of test 84 days.

^b 14% milo-soybean meal diets

^c Bacitracin methylene disalicylate supplied by S. B. Penick & Co., New York.

^d Aureomycin supplied by American Cyanamid Co., Princeton, New Jersey.

^e Bacitracin supplied by Dawes Laboratories, Inc., Chicago.

^f No antibiotic vs. antibiotic sig. ($P < .10$).

^g 20 vs. 40 gm/ton Bacitracin MD sig. ($P < .05$).

Confinement Housing Research

By R. D. Fritschen

Assoc. Prof. An. Sci. and
District Swine Spec.

The type of confinement system that most nearly allows the growing-finishing pig to express its genetic ability to perform is the goal of everyone contemplating this type of production.

The industry, before research data had been generated, assumed that buildings described as "environmentally controlled" or "total controlled environment" represented the optimum.

More recently, as a result of research, producers learned that several different concepts in housing were comparable when using animal performance as a response criteria. It has also been shown that profitability among swine enterprises is a function of management and not necessarily system type.

Last year we reported on a fall-winter study conducted in 1969. This year we are reporting on a winter study that was begun October 28, 1970, and ended February 13, 1971. We focused this study on the winter months, since this period is considered the most limiting for production.

Four hundred-eighty pigs were used in this study, designed to compare: (1) Open versus enclosed housing in a one and two unit system, and (2) the effect of 25, 50, 75 or 100 percent slatted floor (three pens of each in all buildings).

We allotted 10 pigs per pen, based on weight and sex. We analyzed the data for gain and feed efficiency as phase one (from 24 lbs. to 100 lbs. or from Oct. 28 to Dec. 22) and phase two (from 101 lbs. to approximately 200 lbs. or from Dec. 22 to Feb. 13).

Buildings A and B are modified open-front (MOF) units completely under roof, but capable of being completely open or closed by raising or lowering panels on the south side of the building. The panels on the south side of buildings A and

B were lowered during the entire test.

Building E differs from A and B in that it is only partially under roof and provides little protection. This unit is referred to as an open-front (OF) unit.

These three units, as well as the environmentally regulated units, have a door at the rear of each pen that may be opened for ventilation. They are not insulated and have no mechanical ventilation.

Pigs in building A were provided 1,000 watts of heat per pen with a quartz-tube infra-red heater. Pigs also had the benefit of the same heat when moved to building E. Pigs in unit B were provided with one 7,200 BTU catalytic heater per pen.

Buildings C, D and F are environmentally regulated (ER) units, completely enclosed, heated, insulated and mechanically ventilated. The temperature in the three ER units ranged from 60-65 degrees during the study.

Units A and C are designed to provide four square feet per pig up to about 100 pounds. Pigs are then moved to units E and F which provide slightly over eight square

feet per pig. This constitutes the two-unit production concept in both the open and closed system. Units B and D allow slightly over eight square feet per pig for the entire study. These two units represent the one-unit concept in the MOF and ER systems. Average daily gain and feed efficiency were determined at two-week intervals.

Phase I

Table 1 compares average daily gain by building and percent slatted floor for Phase I. While the pigs in unit A outgained those in the other three units during Phase I, none of the differences were statistically significant ($P < .05$ or greater). The means for percent slats were also non-significant. This compares closely with data from earlier tests where the effect of slatted floor on growth rate was nearly nil.

Table 2 compares feed per pound of gain during Phase I. Even though it was late fall or early winter the pigs in unit A, the MOF building, required less feed per unit gain than those in the other three units. This difference was highly significant ($p < .01$).

While the difference in feed per unit gain between unit B and D

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Table 1. Effect of Percent Slats and Housing System on Average Daily Gain, Phase I (24 lbs.—107.8 lbs.)^a

Bldg.	Percent slats				
	100	75	50	25	Av.
A (MOF-2 unit)	1.52	1.54	1.61	1.61	1.57 ^b
C (ER-2 unit)	1.52	1.50	1.45	1.47	1.48 ^c
B (MOF-1 unit)	1.56	1.47	1.54	1.50	1.52 ^b
D (ER-1 unit)	1.54	1.47	1.54	1.52	1.52 ^c
Av.	1.54	1.50	1.54	1.52	

^a Oct. 28-Dec. 22, 1970.

^b ^c Building means (A versus B and C versus D) differ significantly ($P < .10$).

Table 2. Effect of Percent Slats and Housing System on Feed/Gain, Phase I 24 lbs.—107.8 lbs.)^a

Bldg.	Percent slats				
	100	75	50	25	Av.
A (MOF-2 unit)	2.42	2.42	2.39	2.38	2.40 ^b
C (ER-2 unit)	2.50	2.47	2.50	2.46	2.48
B (MOF-2 unit)	2.57	2.57	2.47	2.47	2.52 ^b
D (ER-1 unit)	2.54	2.52	2.45	2.40	2.48
Av.	2.51	2.50	2.45	2.43 ^c	

^a Oct. 28-Dec. 22, 1970.

^b Building means (A versus B) differ significantly ($P < .01$).

^c Linear effect of slats significant ($P < .01$).

(continued from page 23)

was only one half as great as that between unit A and C, this variation was also highly significant ($P < .01$).

The beneficial influence of building A upon feed per unit of gain is noteworthy since it is characterized by a lower degree of environmental control than its counterpart, unit C.

The difference in feed required per unit of gain between units A and B is quite marked. Since the two units are quite similar except for size (unit A allows 4 sq. ft. per pig), it appears that area in excess of the pig's requirement may be a restrictive influence upon feed efficiency in this type of building during lower ambient temperatures.

The feed requirement per unit gain for units C and D was identical, thus it appears that space has less influence on feed efficiency during this production phase in this type of building.

The effect of percent slatted floor upon feed efficiency again showed that as the amount of slatted floor increased the feed requirement per unit of gain also increased in a linear manner and this increase was highly significant ($P < .01$). This agrees with earlier experiments where this same response was recorded.

Phase 2

The Phase 2 data for average daily gain are summarized in *Table 3*.

The pigs from units A and C went into units E and F respectively on Dec. 22, 1971, officially the first day of winter.

While the pigs from unit A were gaining faster and more efficiently

Table 3. Effect of Percent Slats and Housing System on Average Daily Gain, Phase II (107.8 lbs.—200.2 lbs.)^a

Bldg.	Percent slats				
	100	75	50	25	Av.
E (OF—2 unit)	1.19	1.06	1.19	1.14	1.14 ^b
F (ER—2 unit)	1.69	1.72	1.80	1.72	1.73 ^c
B (MOF—1 unit)	1.63	1.52	1.65	1.65	1.61 ^b
D (ER—1 unit)	1.61	1.54	1.61	1.69	1.61 ^c
Av.	1.53	1.46	1.56	1.55	

^a Dec. 22, 1970—Feb. 13, 1971.

^b Building means (E versus B) differ significantly ($P < .01$).

^c Building means (F versus D) differ significantly ($P < .01$).

than those in the other three units during Phase 1, they reversed their position during Phase 2. The average daily gain for unit E was perhaps a direct response to the limited protection that the building provided.

The differences in gain between units E and B were highly significant ($P < .01$) as were the differences between units F and D.

The latter comparison suggests that the two-unit system in the totally enclosed system support better gain than the one-unit system. This is not in total agreement with an earlier test where the reverse was the case. However, in the earlier test the experiment was designed differently, thus a direct comparison would not apply.

The difference in gain between units B and E is due primarily to building design and has little to do with the one or two unit concept. The difference does emphasize the importance of being able to close down the open side of a building in winter to prevent direct drafts and to maintain temperatures. Again, as in *Table 1* (Phase 1), there was no difference in gain between the modified open-front unit B and the totally enclosed unit D. There was no pattern to the effect of slats on gain during Phase 2.

The effect of housing systems and slat percent on feed efficiency during Phase 2 is shown in *Table 4*.

The high feed requirement per unit gain for unit E is probably a response by the pig to the extreme cold temperatures or chill factor and lack of adequate protection. During sub-freezing weather the slats in all pens in unit E froze over, making them non-functional until we had a general thaw or abrupt warm-up in temperature. In addition, the liquid wastes in the pit froze solid and did not thaw out until late spring—well after the pigs had gone to market.

The difference in feed efficiency between units E and B indicate that the modified open-front type system has a high degree of merit over the open-front or open-front-outside apron unit during severe weather. Two pigs died in unit E; one from exposure to sub-freezing temperatures and the other from complications from rectal prolapse.

It is interesting to note that the difference in feed efficiency between units B and D slightly favors the modified open-front system. This suggests that pigs, from 100 pounds to market weight, can adjust to a fairly wide range of temperatures and may actually be stimulated within a certain temperature range as long as they are maintained in a draft-free and relatively dry system.

The effect of slatted floor percent on feed efficiency was again highly significant ($P < .01$) and increased in a linear manner with percent slatted floor.

Health Aspects

Table 5 indicates the effect of percent slats and building or system type on pneumonia and leg condemnation at slaughter.

Table 4. Effect of Percent Slats and Housing System on Feed/Gain, Phase II (107.8 lbs.—200.2 lbs.)^a

Bldg.	Percent slats				
	100	75	50	25	Av.
E (OF—2 unit)	5.13	5.18	4.96	5.18	5.11 ^b
F (ER—2 unit)	3.81	3.74	3.72	3.76	3.76
B (MOF—1 unit)	3.88	3.92	3.65	3.77	3.80 ^b
D (ER—1 unit)	3.88	3.89	3.89	3.65	3.82
Av.	4.17	4.18	4.05	4.09 ^c	

^a Dec. 22, 1970—Feb. 13, 1971.

^b Building means (E versus B) differ significantly ($P < .01$).

^c Linear effect of slats significant ($P < .01$).

Table 5. Relationship Between Housing System, Percent Slats & Pneumonia^a

Bldg.	Percent Slats				Total
	100	75	50	25	
B (MOF-1 unit)	1	2	2	3	8
D (ER-1 unit)	-	2	1	-	3
C-F (ER-2 unit)	4 (1) ^b	4	-	1	9 (1)
A-E (OF-2 unit)	1 (3)	- (5)	1 (4)	2 (2)	4 (14)
Total	6	8	4	6	

^a Oct. 28, 1970-Feb. 13, 1971.

^b () Indicates number of animals with legs condemned at slaughter due to arthritis.

Table 6. Effect of Percent Slats and Housing System on Atrophic Rhinitis.^{a,b}

Bldg.	Percent Slats				Total
	100	75	50	25	
B (MOF-1 unit)	4	5	2	4	15
D (ER-1 unit)	3	2	7	3	15
C-F (ER-2 unit)	3	5	10	6	24
A-E (OF-2 unit)	3	2	1	3	9
Total	13	14	20	16	

^a Oct. 28, 1970-Feb. 13, 1971.

^b Internal deviation $\geq .6$ MM.

Table 7. Utility Cost Per Unit/System

	Bldg. A-E ^a two unit MOF & OF	Bldg. C-F two unit ER	Bldg. B ^b one unit MOF	Bldg. D one unit ER
Propane	-----	1068	2249	1931
Electricity	26,517	1120	-----	3535
Cost (\$)				
Propane @ 13c/gal.	-----	\$139.23	\$292.37	\$251.03
Electricity @ 2c/KW	\$530.34	22.40	-----	70.70
Total	\$530.34	\$161.63	\$292.37	\$321.73
Cost/pig	\$ 4.42	\$ 1.35	\$ 2.44	\$ 2.68
Cost/pig/day	\$.0405	.0124	.0224	.0246

^a Used 1 quartz-tube (2000 watt) radiant heater for each two pens.

^b Used 1 catalytic heater (7200 BTU) per pen.

There was not a clear pattern influencing the incidence of pneumonia. It must be noted however that pigs in the A-E two-unit system had less than one-half as many cases of pneumonia as the C-F two-unit system. This would suggest that prolonged exposure to cold temperatures is not the sole prerequisite for pneumonia or respiratory problems.

The leg condemnations at slaughter, attributed to arthritis, were almost exclusively confined to unit E. A further indictment against this type of building in cold weather was the problem of rectal prolapse. Seventeen pigs from unit E had to be treated for this condition. There were 6, 3 and 8 cases of rectal prolapse on the 75, 50 and 25 percent slatted floors respectively. There were no cases of rectal prolapse

among pigs finished on 100 percent slats.

The effect of housing system and percent slatted floor on atrophic rhinitis or turbinate atrophy is shown in *Table 6*.

There was no difference in this trait between the one-unit systems B and D. However, there were 24 cases of turbinate atrophy in the totally enclosed two-unit system (C-F) as compared to only 9 in the A-E system. The effect of percent slatted floor on turbinate atrophy was without pattern, but this condition increased among pigs on 50 percent slatted floors. However, all of this increase came from the 50 percent slatted floors in the C-F units.

Utility Costs

Table 7 indicates the utility cost

by building system for both phases combined. The catalytic (unit B) and quartz-tube infra-red heaters (units A-E) were used during nearly all of the test.

The two-unit modified open-front (A-E) system which used the infra-red quartz tube heaters had the greatest utility usage.

The two-unit enclosed (C-F) system had the lowest utility usage. However, most of the reduction in utility usage occurred during Phase 1 in unit C. This may be because there is a smaller area to heat plus the greater insulation value in the walls of unit C (sandwich wall concrete tilt-up) as compared to units D and F (concrete block with insulation poured in).

The cost of operating the catalytic heaters in unit B was slightly less than the total utility cost of unit D. When the average daily gain and feed: gain from phase one and two are pooled, there is no difference in performance between pigs reared in units B and D.

Summary

1. The modified open-front systems, in general, supported equal or better production than the environmentally regulated system.

2. The open-front outside apron or open-front unit only partially under roof (unit E) does not support an acceptable level of performance during the winter when managed as described.

3. The two-unit totally enclosed system supported better performance than the one-unit system. However, some of the health measurements in the two-unit totally enclosed system were below those of some of the other systems. This could indicate that rapid gain is a stress in itself.

4. Slats in Nebraska must be under roof to be functional on a year around basis.

5. As the amount of slatted floor is increased, the feed required per unit of gain increases.

6. Pigs housed in cold buildings with inadequate protection may develop an unusually high level of arthritis. In addition, housing that encourages piling in cold weather may cause rectal prolapse.

Respiratory Diseases and Interactions

Norman R. Underdahl
Professor, Veterinary Science

For the swine industry to remain competitive with other meats, pork producers must increase production while decreasing unit cost. Currently, rapid changes in swine husbandry with increased numbers in total confinement has influenced the problems associated with pork production. To stay competitive the industry must improve all phases of production.

Goals for efficient swine production have been presented (Table 1). The goals as listed are ambitious, but many swine producers have achieved some of these objectives. However, the national average is far below these standards.

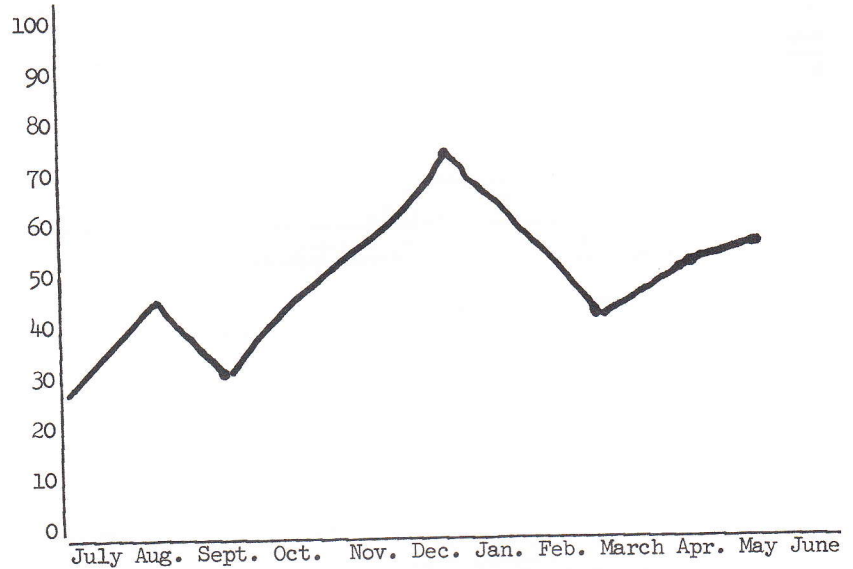
Table 1. Goals for the Swine Industry

- | | |
|----|--------------------------------------|
| 1. | 80-90% conception rate |
| 2. | 10 live pigs per litter |
| 3. | 3 lb. pigs at birth |
| 4. | Reduce deaths of baby pigs below 15% |
| 5. | 48 lb. pigs at 8 weeks |
| 6. | Weaning to market 1.65 lb. per day |
| 7. | 3.3 lb. feed per pound of gain. |

There are a number of environmental conditions which can greatly influence swine production. These environmental conditions, frequently referred to as "stress factors," include temperature changes, chilling, humidity, disease, parasites, nutrition, crowding, moving, or anything which might upset the normal routine of the animal.

If pigs are infected during a period of stress, the disease will be enhanced. Consequently, a larger number of pigs will be affected and the period required for recovery may be extended.

Figure 1. Incidence of Pneumonia in Market Pigs Examined at Slaughter



Respiratory diseases of swine account for a considerable economic loss to the swine industry. A one year study conducted at a midwestern packing plant showed that, depending upon the month, 30 to 70 percent of the market pigs had some form of pneumonia; pneumonia peaked at about 70 percent during December (Figure 1).

Enzootic Pneumonia

Mycoplasmal or enzootic pneumonia (EP) (formerly called virus pneumonia of pigs VPP) is the important respiratory disease of pigs and accounts for most of the pneumonia seen in market weight pigs.

Economic losses due to EP are through reduced gains and increased feed requirement. It takes EP infected pigs approximately 30 extra days and 200 additional pounds of feed to reach market weight. EP appears to occur only in pigs and the infection is spread from pig to pig contact.

Enzootic pneumonia is a chronic disease, with the pigs generally infected shortly after birth. The lesions can persist for several months and a number of pigs become carriers perpetuating the disease. There is an apparent low-grade immunity, but colostrum immunity will not prevent infection in the baby pigs.

The causative agent of EP has been shown to be a mycoplasma

(*Mycoplasma hyopneumoniae*). This organism is difficult to isolate but can be grown on artificial medium. When the bacterial culture is inoculated into pigs it causes a mild disease with little coughing or sneezing. Under field conditions, stress and secondary invaders can intensify the disease with coughing and sneezing, rough hair coat and reduced growth rate.

Serological and fluorescent antibody tests have been developed for diagnosing EP, but as yet an effective treatment has not been found.

Swine Influenza

Swine influenza is another respiratory disease which sometimes is confused with EP. Influenza is a more explosive disease and all or most of the pigs in a pen will be sick at one time. The pigs will be listless, off-feed and have an increased temperature. Generally the sickness will only last a few days and if there are no complications the pigs will soon recover.

Parasites

Parasites that invade the lung can intensify respiratory problems. The intestinal roundworms (*Ascaris*) have in their life cycle a stage during which the larvae migrate through the liver and lungs. If this migration occurs during a respiratory infection then the disease becomes more severe. That is,

in EP the larval migration can increase the extent of the lesions in the lung 10-fold and the growth rate is reduced correspondingly.

In an experimental influenza infection, the death rate was 50 percent in the combined *Ascaris* and influenza infection, while none of the pigs with a parasite or virus-only infection died. With increased area of the lung involved the number of secondary bacterial invaders may be increased, resulting in a higher mortality or an extended period for recovery. Lungworm infestations in pigs also enhance the respiratory diseases.

Atrophic Rhinitis

Atrophic rhinitis, a disease in which the nasal turbinates are destroyed, allows unfiltered air into lungs and this can be a predisposing factor to pneumonia. Rhinitis has been the largest single reason for nonaccreditation in the specific pathogen-free (SPF) program.

There is some controversy about the etiology; in one report rhinitis was produced by varying the calcium-phosphorus ration of the feed. *Bordetella bronchiseptica* has been shown to cause a form of rhinitis; and *Hemophilus* and *Pasteurella* have been reported as the cause of some rhinitis. Other reports indicate a viral infection complicated by bacteria may be responsible.

A sulfa treatment was reported to be effective in freeing herds of rhinitis caused by *Bordetella* but later reports indicate that 80 percent of the *Bordetella* isolated were resistant to the sulfa drug. Many feel that atrophic rhinitis may be a complex disease in which infectious agents, nutrition, and management are all involved.

For efficient swine production a producer must control as many problems as possible. Through management practices, adequate shelter and nutrition must be provided, stress factors reduced, and disease must be eliminated or brought under control. With reduction of the problems of swine production together with a meat type animal, pork should remain competitive with other meats.

Regulatory Aspects of Livestock Waste Control

Steven L. Pilcher
Nebraska Dept. of
Environmental Control

Nebraska is proud and jealous of its environment. We have an abundance of fertile land, clean fresh air, and pure water in a combination which can be matched with few other states.

Nebraska first indicated concern over degradation of our environment in 1957 with the passage of the Water Pollution Control Act, which was later amended in 1967 to make the law more inclusive and give the regulatory agency broader power.

This amendment also required the state to adopt and enforce water quality standards to be used as a guide to determine pollution, together with compliance dates whereby various waste sources will be controlled.

Nebraska became increasingly aware of the threat to the environment, and the 1971 session of the Nebraska Legislature passed the Environmental Protection Act which creates a Department of Environmental Control and an Environmental Control Council responsible for the control of pollution of any air, water, or land of the state. It is this Act that is presently used as the basis for environmental control in Nebraska.

The Environmental Protection Act is an attempt to consolidate the responsibility of environmental control within one agency. The basic policy of the Environmental Protection Act is simply to maintain our environment in such a manner that it will be a good place to live.

Control Council

This Act establishes an Environmental Control Council, consisting of 16 members representing all walks of life, including the livestock industry and the crop production industry. These representatives

are appointed by the Governor, and as a Council are not given a "free hand" in dealing with pollution but rather given specific duties and powers.

The Environmental Protection Act specifically declares certain activities to be unlawful. Two of those unlawful acts which affect livestock operations include:

1. To cause pollution of any air, water, or land of the state or to place or cause to be placed any wastes in a location where they are likely to cause pollution of any air, water, or land of the state; or

2. To discharge any wastes into any air, water, or land of the state which reduce the quality of such air, water, or land below the air, water, or land quality standards established therefore by the Council. Any such action is hereby declared to be a public nuisance.

The Act also establishes a procedure for administration and enforcement. The enforcement procedure is very specific and includes provisions for a hearing at which time the department staff will present its evidence and the alleged violator is given an opportunity to present his defense.

The basic requirement for livestock waste control can be best summed up in a few words: All livestock waste must be retained on the owner's or operator's property and must be disposed of in a manner which is not going to cause pollution of our environment.

Applies to All

This requirement applies to all livestock operations regardless of the class or number of livestock involved and applies equally to all types of livestock facilities whether they be open lots, total confinement or anything in between.

The precautions which must be taken to control the waste material will vary in each situation, but

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must result in the control of all waste material.

For open lot areas, it is necessary to control the runoff which can be expected from a 10-year, 24-hour storm. This is the amount of rainfall which can be expected during a 24-hour period once in 10 years.

For confinement units, the liquid manure storage facilities must have a capacity to store all the waste material produced over a 120-day period.

It should be pointed out that deadlines have been established for not only livestock waste but all other types of waste as well.

The Environmental Protection Act and Water Quality Standards make no distinction as to the persons involved, type of waste, or source; but rather their concern is with the effect on Nebraska's environment.

The Water Quality Standards specify that livestock waste will be effectively controlled no later than 31 December 1972, with earlier compliance where necessary. The owner or operator of any livestock operation which is found to be in violation of the Environmental Protection Act will be asked to take immediate steps to correct the problem instead of waiting for the compliance date.

Approval System

In an effort to meet the 31 December 1972 goal, the Department of Environmental Control has set up an approval system for livestock waste control facilities.

Under this system, waste control facilities can be approved if, through either natural or constructed control facilities all runoff from the feeding area is contained on the owner's property. Upon the submission of sufficient information on a data sheet provided by the Department, a certificate of approval for the control facilities will be issued.

A procedure leading to this approval has been established using the Cooperative Extension Service, Soil Conservation Service, and consulting engineers. The responsi-

Management of Swine Wastes

E. A. Olson

Extension Agricultural Engineer

The preceding article has dealt with the regulatory aspects of livestock waste control to prevent water pollution. At this time, Nebraska air regulations have not been adopted. However, they will be adopted in the *near future* and should be given due consideration by the producer.

Until air regulations are adopted, the producer should concern himself with management steps that can be taken to keep odors under control to prevent nuisance suits from developing because of offensive swine waste odors.

When a new swine facility is being planned, several items need to be considered so as to reduce the potential danger of odor problems. These include site selection, location and distance from urban, commercial or residential areas and county zoning.

Space and facilities for manure disposal must be provided to obtain approval for new developments.

Further discussion on these items is provided in EC 71-795 "Waste Management for Feedlots." Copies are available through your local County Extension office.

bility of the Cooperative Extension Service is to inform livestock operators of the requirements as well as the procedure to be followed in correcting a problem, while the Soil Conservation Service and consulting engineers will provide the technical assistance necessary in the design of waste control facilities.

To date, approximately 200 livestock waste control facilities have received this approval.

Summary

In summary, we feel that with the excellent cooperation from the livestock industry, Nebraska has taken a realistic approach to the problem of livestock waste control and great strides are being made toward the ultimate goal of a cleaner environment.

Oxidation ditches equipped with the paddle wheel or other aerating devices are effective means for holding swine odors to a low level inside of buildings and also in the swine production area. Some producers are using them to control odors and help reduce solids in swine wastes. Others have tried them and report that because of maintenance problems and high operating costs they are no longer using the equipment.

To assure success, it takes a combination of well engineered equipment and good management. Further information on these systems is available in EC 70-789 "Oxidation Ditches for Swine Wastes" available in County Extension offices.

As was pointed out in the previous article, water pollution laws have been passed and it is the responsibility of the swine producer to have his "house in order" by December 31, 1972.

Questions have been asked regarding penalties or fines for the individual who does not comply. Such questions imply that the producer does not want to abide by the state laws and tends to identify him as one who is not concerned with being a law-abiding citizen.

The producer with outside swine lots may not have a potential water pollution problem. However, if he does, technical assistance from the local SCS office is available to design the waste management systems. When controls are built according to SCS standards, cost-sharing is generally available through local ASCS offices. To assure that funds can be had, contact, at the time of planning, should be made with the county ASCS office.

Certain basic steps generally are needed to control waste-runoff from open lots:

1. Outside runoff can be kept out of the lots by a diversion terrace.
2. Runoff from the lot can be collected in a settling pond known as a debris basin.
3. Solids carried in the lot run-

off are allowed to settle out in the debris basin.

4. Liquid flows from debris basin into a holding pond.
5. Disposal of liquids from the holding pond by spreading on cropland is the final step.

Some open lots may not require all of the items listed above. Possibly, a simple diversion above the lot may correct the problem. However, a producer should get technical help from SCS in designing complete facilities for cost-sharing and also to obtain approval of the Department of Environmental Control.

Producers should be aware of the fact that concreted open lots will produce greater runoff, since rainfall will not be absorbed by a dry soil covered with a manure pack.

Manure management problems are somewhat different for the producer with hogs confined in buildings. These facilities usually include a slotted floor which allows solid and liquid manure to drop into a holding pit beneath the floor.

If space is not provided in the building, additional manure storage with a combined capacity of 120 days will be needed. This is to provide adequate storage so liquid waste will not need to be spread on cropland when the ground is frozen. Manure spread on frozen ground may be carried off the fields by rain or melting snow and flow into a watercourse, causing pollution.

In new buildings, sufficient storage can be provided in the building manure pit or additional outside space made available, depending on local conditions.

For existing buildings, the 120 day storage requirement may create a need for additional storage outside of the building. Additional manure storage outside of a building may be a lagoon or a below ground manure tank.

With lagoons, odors are quite likely to be a problem unless the lagoon is built with capacity to provide for aerobic conditions. However, aerobic lagoons are quite large in size and therefore expensive. Un-

Odors in Swine Housing

Wayne F. Fisher

Assistant Prof. of Ag. Eng. and
Area Agricultural Engineer

Problems related to odors created by raising animals in close confinement are drawing much more attention than in past years. Each day finds an increasing interest in maintaining an air environment which will meet today's social and ecological standards.

dersized lagoons generally create undesirable odor problems because of anaerobic conditions.

See your SCS representative for design of your lagoon.

Below ground manure storages are more costly, but help control odors and also conserve nutrients in animal wastes for application to cropland.

Field disposal of manure from below-ground manure tanks, from lagoons or from holding ponds can be accomplished with a liquid manure wagon (honey wagon) for the smaller producer. However, larger producers are finding they can save labor by pumping wastes through a small pipeline to the field. The gated-pipe technique of spreading has been used successfully by both irrigators and non-irrigators. Manure sprinklers have also been used.

When manure is spread on cropland, local weather conditions, primarily wind direction, should be noted. Avoid spreading if winds will carry odors to local neighbors or other populated areas. Odors can carry for over a mile, depending on the size of the facility. Disking or plowing fields promptly after spreading will help control odors. Some honey-wagons are equipped with injectors to place manure below the soil surface to help eliminate odors. Limited information is available in this technique, but it is believed that this method may be practical for the smaller producer with limited wastes.

Each swine producer will need to decide which system is most economical and practical for his operation to help prevent air or water pollution.

We usually can wait for food and water until some of satisfactory quality is available. For all practical purposes, however, we must live in and use the atmosphere which surrounds us.

Swine Odor Research at the Northeast Station

I have studied odor measurement and control at the University of Nebraska Northeast Station. This research is aimed at providing more favorable atmospheric conditions within the buildings on the station as well as developing recommendations for swine raisers.

At present, opinions differ as to the actual health effects of gases generated by the decomposition of swine wastes. I am making no attempt to relate levels of gases to animal performance. The problems related to the identification and measurement of levels of gases under production conditions has caused a large share of the past difficulty in evaluating gas effects.

Measurement of Gases in Swine Environments

Flame ionization detection and gas chromatography are considered as acceptable methods of identifying and measuring the more complex gases. These are highly technical methods involving complicated equipment. Using the equipment at an actual production site is not feasible. Transporting of atmospheric samples from the site to the equipment is difficult.

There is however a group of simpler gases, classed as fixed gases, which are almost always present in conjunction with the more complex gases. These gases are carbon dioxide, methane, ammonia and hydrogen sulfide.

Fixed gases can be detected and measured with reasonable confidence with simple color indication equipment. This principle is being used in the Northeast Station studies.

Small blocks, paper or tubes im-

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pregnated with reactant chemicals are used where gas levels are to be measured. Color change is observed in a given period of time or by a given volume of air passage. This color change allows one to evaluate the level of gases present.

Even though exact levels of the fixed gases are not determined, relative concentrations between locations and systems may be established. This allows one to evaluate management systems or equipment on an odor basis without depending on human response, and complex equipment is not involved.

Management of Odor Problems

Four environmental areas should be considered when relating to animal odors: the actual environment within enclosed buildings, the production site, property of others adjacent to the production site, and those living near the disposal area and its access route.

At present, my odor control studies have been limited to measuring and reducing odor levels within the enclosed buildings. We have placed exhaust fans over the manure pit annexes to draw heavy gases from the pit areas of buildings D and F. *Figure 1* and *2* show a fan and the fan housing design. The double door opening allows access to the pit's drain plug or would allow withdrawal by a honey wagon system.

If a manure pit is not allowed to fill completely, a large share of the heavy gases will remain below the slatted floor. Thus concentrations of gases within the building will be kept lower. A ventilation system which draws air from beneath the slatted floor can remove these heavy gases from an enclosed building. *Table 1* shows the results of a study conducted at the University of Nebraska Northeast Station this past summer.

I took measurements under the pit fan housings on the totally enclosed building D, as well as at floor level in the work alley. I also took measurements at floor level in the alley of the modified open front building B, as a comparison. The

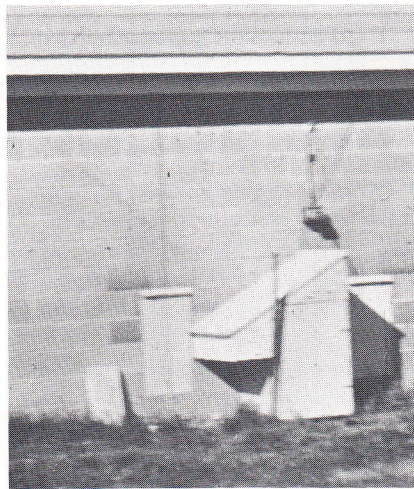


Figure 1. Dog house from distance.

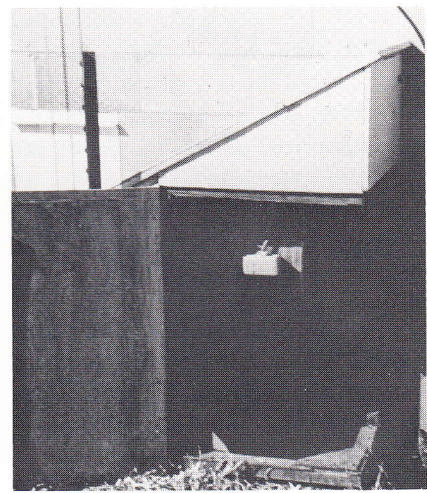


Figure 2. Dog house open.

measurement of hydrogen sulfide is representative of mercaptans and other sulfides. The measurement of ammonia is representative of the amines.

When pit ventilation is used it should be supplemented with a limited amount of wall exhaust to remove lighter weight gases from the building.

The ventilation inlet system of the enclosed buildings at the Northeast Station have been modified and managed so as to improve odor conditions. Uniform location of air inlets provides fresh air to all areas of the building. Proper sized inlet openings in relation to fan capacity creates both pressure differentials and inlet velocity. A manometer is used to measure these pressure differentials. The inlet baffles are adjusted to cause a pressure differential of .03 to .05 inches of water.

When the static pressure inside a building is slightly lower than outside pressure, equal volumes of air will enter at each inlet. The pressure differential also creates an inlet velocity.

Negative pressure and inlet velocity have been found to closely follow the relationship shown in *Figure 3*. The velocity causes air circulation which mixes the fresh air with the gaseous air. Without this mixing action, fresh air entering may move directly to fans and gaseous odors may accumulate below the fresh air even with high levels of ventilation.

The air entering ventilation in-

lets should be directed to create a circulation pattern which will cause tempered fresh air to be supplied to sleeping areas or animals' heads, then move along the floor to the pit. A circulation pattern that is reversed will move gases from the pits to areas where odors are not wanted.

Odor Reduction Methods

At present the only production proven method of odor reduction is the oxidation ditch system. Air is introduced into the fluid and circulation prevents the solids from settling out of the fluid. The resulting aerobic bacterial action will not produce the offensive odors present under anaerobic conditions. Operators interested in using oxidation systems should carefully consider the economics and reliability of any system they are considering.

Other means of odor reduction under investigation or trial by the industry are: chemicals, burning of emissions, absorption by water and adsorption to a surface.

Chemical treatments fall into three categories; those that mask the odors, those that counteract odors and those that sterilize the wastes. Common chlorine solutions have been reported to be quite effective in preventing bacterial action in swine wastes. Lime and chlorine have both been used effectively on floor surfaces.

The effectiveness of counteractants depends largely on trial and error. If the proper chemical is

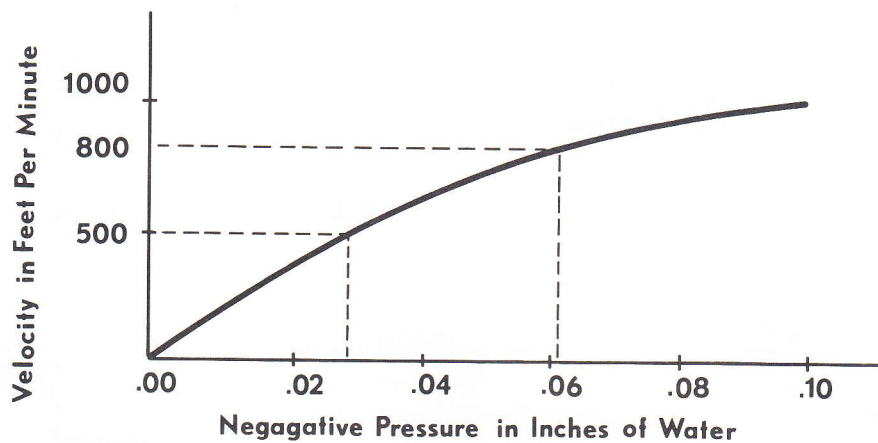


Figure 3. Characteristics of air flow through slot openings without excessive friction losses.

introduced in relation to the odors present, then the odors virtually disappear.

Masking chemicals superimpose what is hopefully a pleasant odor over the disagreeable odor. Complaints have been reported where an individual's response to the masking agent has been negative. The practicality or economic feasibility of using chemicals has not been proven under production conditions.

Burning by high temperature flame and adsorption to charcoal filters are methods proven successful to eliminate organic odors in industrial applications. The economic feasibility of these methods for swine operations is questionable under ordinary production situations.

We are conducting a preliminary investigation of the absorption principle at the Northeast Station. A dilution of 2½ parts fresh water for each part swine waste produced is being sprayed over pits in a comparison with no spray. The experiment has not been under way for a sufficient length of time to offer any evaluation.

Table 1. Indicator Levels of Fixed Gases (Parts per Million)

Location	Season averages at locations	
	Hydrogen Sulfide	Ammonia
Alley modified open front bldg. (B)	0.13	0.00
Alley enclosed bldg. (D)	0.21	0.01
Pit exhaust Enclosed bldg. (D) North side	3.41	.6
Pit exhaust Enclosed bldg. (D) South side	2.62	.6