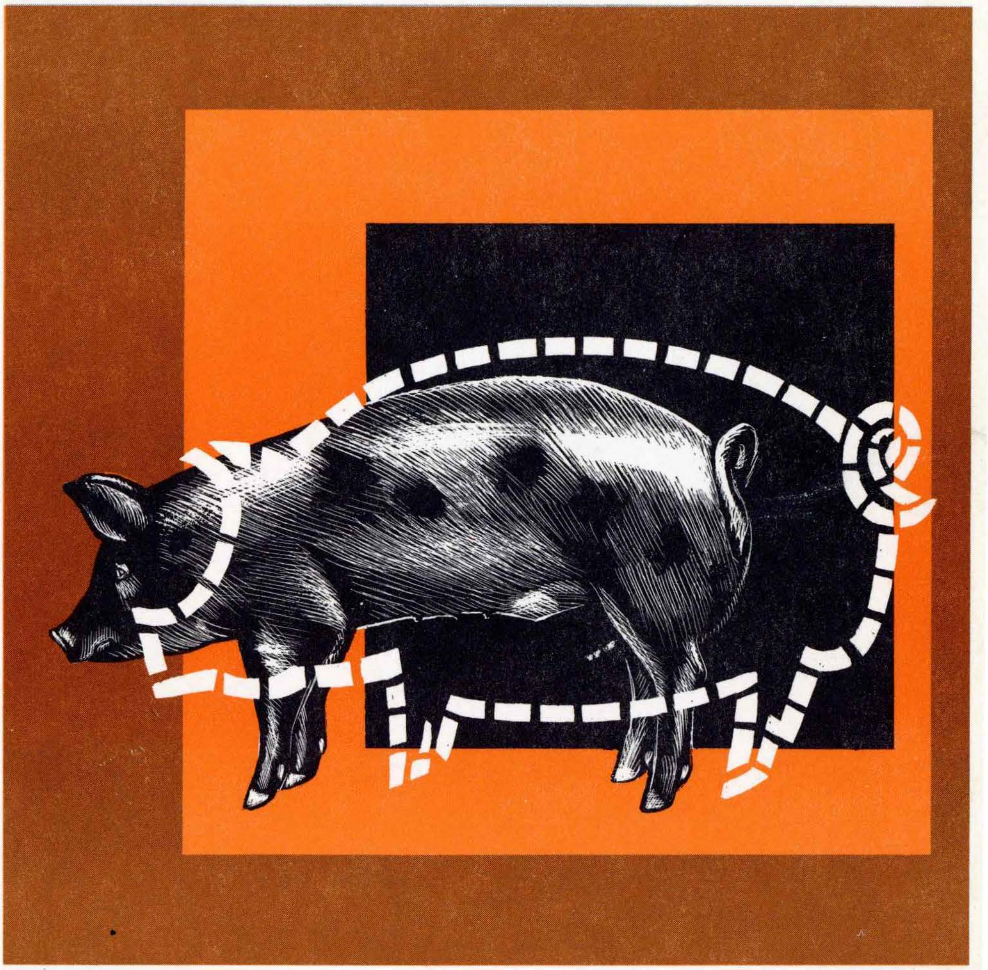
agricultural research: IMPACT ON SWINE



Special Report 72

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IOWA STATE UNIVERSITY of Science and Technology
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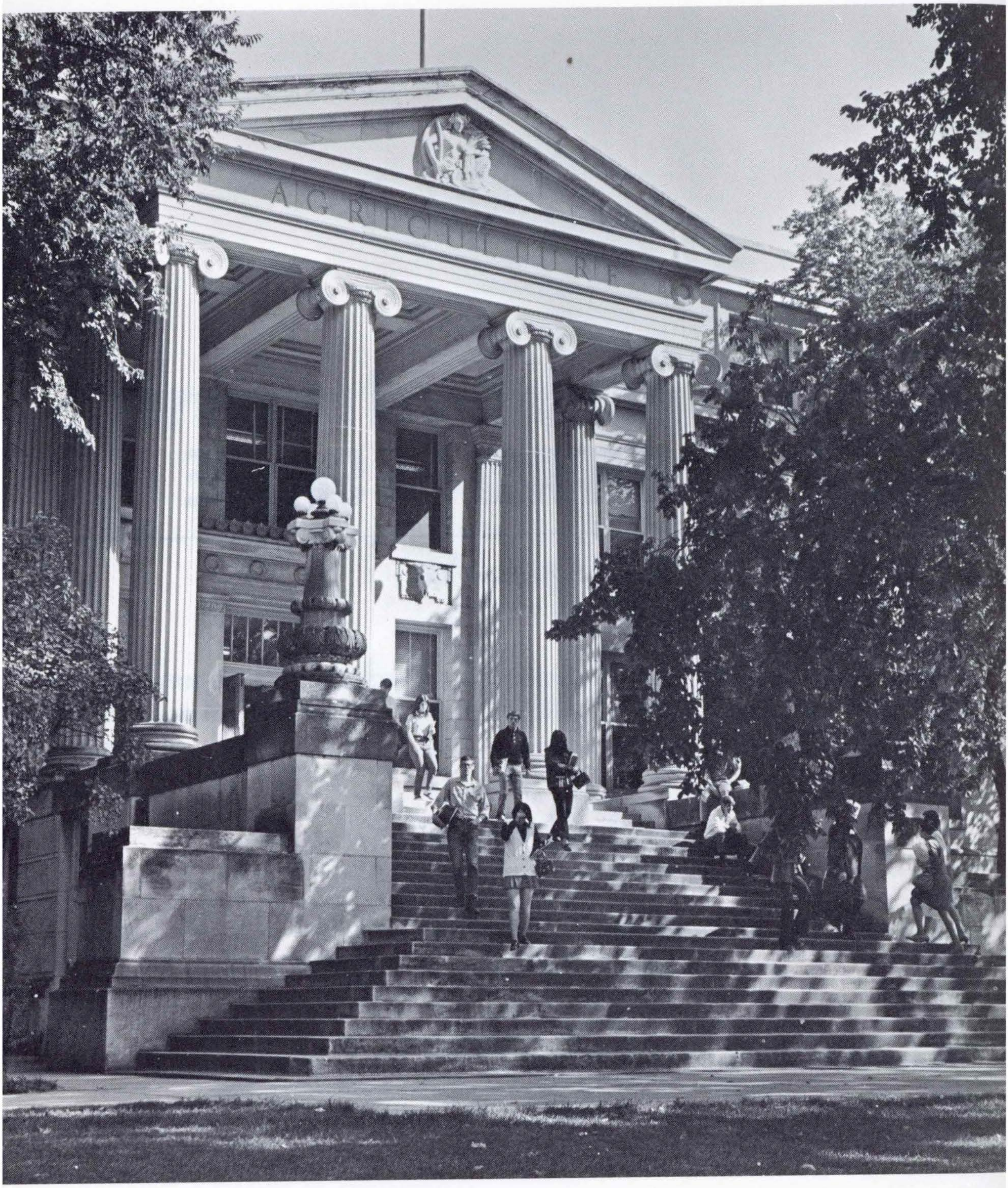

AGRICULTURE

What Is the Iowa Agriculture and Home Economics Experiment Station?

The Iowa Agriculture and Home Economics Experiment Station is the research branch of Iowa State University's College of Agriculture. The Experiment Station is an organization of agricultural scientists working cooperatively through independent subject departments, not only to solve the problems of today, but also to anticipate and meet the demands of tomorrow. Research is conducted at the Experiment Station and its 22 research areas and outlying experimental farms.

The ultimate goal of the Iowa Agriculture and Home Economics Experiment Station, in its simplest and broadest terms, is to conduct research that will contribute to a better Iowa, a better nation, and a better world.

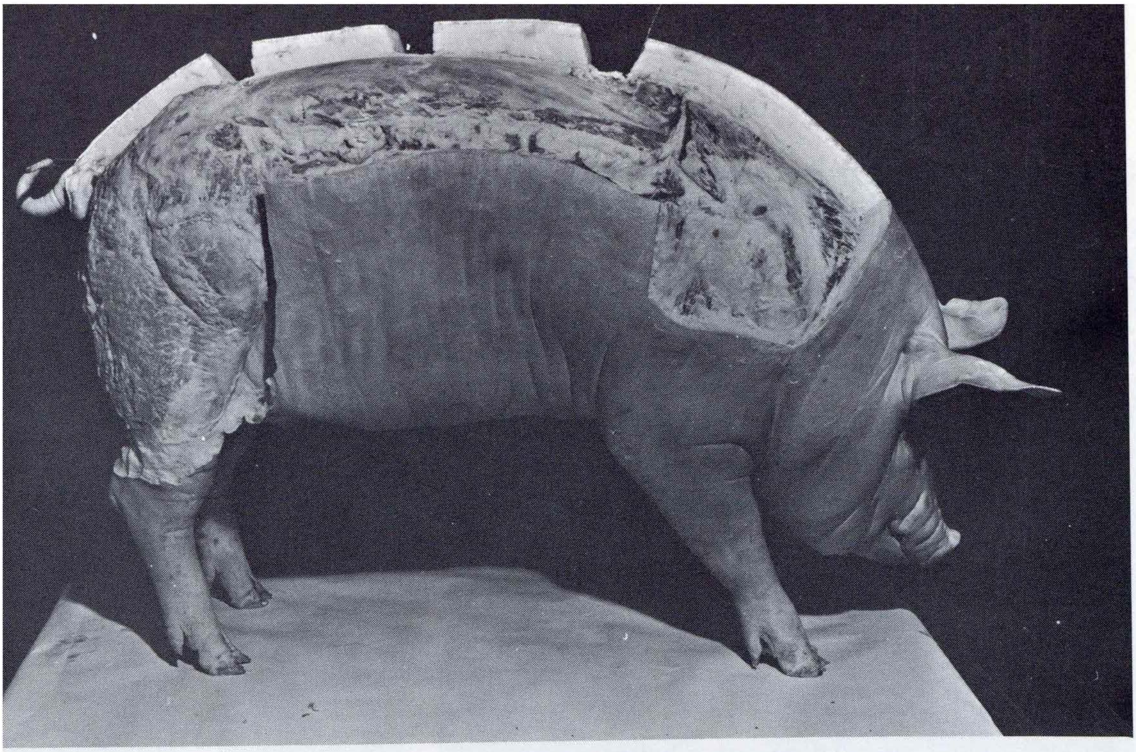
Better to work in. Better to live in.

This encompasses research that will contribute to individual, economic, and social progress.

More than 300 such research projects are currently under way at the Iowa Experiment Station. They cover such diverse areas as improving efficiency and production to meet the needs of our population, finding new uses for present crops, revitalizing our rural communities, safeguarding our natural resources, analyzing the consequences of alternative courses of action for the future, establishing foundations for new industry through the discovery of new products and processes, and improving marketing procedures.

About 550 scientists, specialists, graduate students, and administrative personnel work part or full time at the Experiment Station to accomplish these goals. Graduate students are guided and supervised by experienced Station scientists. They earn M.S. and Ph.D. degrees and prepare themselves as the scientists of tomorrow by conducting research to solve pressing scientific and social problems today.

Let's look at some of the areas the Experiment Station has investigated, is investigating, or plans to explore in the future. It's of concern to us all, not only because we all pay the taxes that support research, but because we all reap the benefits.



Iowa State University researchers often go "whole hog," frozen that is, in studying carcass traits.

PORK PRODUCTION:
THEN, NOW, AND TOMORROW

Swine research—from crossbreeding to the farrowing crate to the backfat probe—has left its mark on both the hog itself and the entire swine industry.

Feed efficiency, for example, has improved about 25 percent during the past 20 years. The pork producer of the early 1950's fed his animals about 400 to 420 pounds of feed to produce 100 pounds of live animal. Today, he can produce 100 pounds liveweight gain with only 300 pounds of feed: a 3-to-1 feed efficiency ratio!

The basic metabolism of the hog itself has changed vastly, too. A few years ago, the hog's food energy largely produced fat; today, much more of it becomes lean meat. In 1956, for example, only about 32 percent of the average hog carcass was ham and loin—the more expensive lean meat cuts that consumers prefer. The packer cut about 42 pounds of fat off the average carcass. In 1971 the average hog produced about 44 percent ham and loin—an increase in lean-pork yield per hog by the equivalent of half a ham and a third of a loin per animal. And the same size carcass that yielded 42 pounds of fat in 1956 has only 26 pounds of fat today.

Hog raising also is quite different from 20 years ago. Raising the hog in confinement facilities where his environment can be controlled improves gains and saves more than 10 percent in feed requirements. But more important are the big labor savers that hog production in confinement has ushered in—such things as mechanized feeders and automatic waterers. With a mechanized confinement hog setup, a farmer can now raise a hog to market weight with less than an hour of direct labor.

The Pig: Vital Part of Iowa's Economy

When the first pioneers settled in Iowa, swine came with them. The pork industry has been a vital part of Iowa's economy ever since. Today, Iowa is the nation's No. 1 pork-producing state. Iowa has nearly one-fourth of all the hogs in the United States and markets around 20 million each year. About 30 percent of the state's cash farm income comes from swine production.

Pork production—and even the pig itself—has changed tremendously over the years. Today's modern hog farm is a far cry from the pigsty of yesterday. So is the modern hog, compared with his ancestors of just a few years ago. The Iowa Agriculture and Home Economics Experiment Station has set the pace in the revolution in production efficiency and product quality.

Crossbreeding: First Big Change—and Controversy

Farmers raised a lot of *mongrel* stock in the early days. Around the turn of the century, agricultural experiment stations across the United States began to stress the culture of good, progressive pure lines of major-breed seed stock to improve quality and quantity of production.

Breeding and feeding purebred stock was emphasized until about 1930. About this time, corn breeders discovered the potential of heterosis, or "hybrid vigor" —the increased growth and production rate of the offspring of a cross of two pure lines.

This stimulated scientists at the Iowa Experiment Station to cross purebred lines of swine in controlled experiments. The results: larger and heavier litters farrowed, lower death rate of pigs, greater sow milk production, and faster pig growth rates.

The Extension Service began to recommend that commercial producers raise crossbred rather than purebred pigs as a result of these research findings. This turned out to be a correct —but extremely unpopular—step for Iowa State University.

Many purebred breeders across the state felt that their very livelihoods were threatened. Some breed associations considered the crossbreeding research a betrayal of the purebred industry.

Crossbreeding research continued in the face of the criticism, however. Farmers who raised crossbred market hogs soon discovered that they could produce about 20 percent more pork per litter. Crossbreeding of commercial pigs became widespread, and by 1950, most commercial feeder pigs in Iowa were crosses.

Three-Breed Cross

Early crossbreeding was strictly for market hog production. The Experiment Station pioneered research in the three-way or three-breed cross, with emphasis on mothering ability of the dam.

A crossbred sow, when bred to a third breed of boar, will farrow more pigs than will a purebred sow. Research showed that the pigs from the three-way cross have a higher survival rate than either first-generation crossbreds or purebreds.

For example, survival rate of crossbred pigs is about 7 percent higher than that of the purebred lines of either parent. But pigs from a three-way cross—a crossbred mother mated to a boar of a third breed—have about a 14-percent higher survival rate than do any of the purebred lines that make up the cross.

The higher survival rate of pigs from a three-way cross stems from heterosis expressed through the "maternal performance" of the mother. The result: about 40 percent more weight per litter at 5 months age from a three-way cross.

A current three-way cross study involves four of the major swine breeds: Chester Whites, Yorkshires, Durocs, and Hampshires. Researchers hope to learn which breeds or combinations of breeds are best for maternal and paternal performance in a three-way cross.

All possible crosses will be made among the boars and gilts of the four breeds in the first phase of the study. Then the various combinations of crossbred gilts will be bred back to test sires to determine which crossbred gilt combination seems the most desirable in terms of maternal performance—litter size farrowed, pig preweaning mortality, and growth rate.

Purebred and crossbred boars also will be evaluated to determine which breed or breed combination makes the best sire for different crossbred combinations. The sire's role has not been examined in about 15 years. The boar of 15 years ago—and the environment in which he was raised—is quite different from that of today.

A static three-way cross may be common in the future. A producer may maintain a herd of high-quality, performance-tested crossbred sows, all from the same parent breeds. Parent breeds used to produce these crossbred gilts would be superior in litter size produced and maternal performance. Replacement gilts for the sow herds may be obtained from planned matings within the herd or from commercial firms that specialize in providing superior crossbred females with superior mothering ability for use in three-way crosses. The crossbred gilts and sows will be mated to purebred boars of a third breed.

Superior characteristics unique to each breed can be exploited to greater advantage in such a system. For example, reproductive traits of the three-way-cross offspring could be ignored because they will be used only for market production. The sire could be selected purely on the basis of outstanding production and carcass traits, such as growth rate and percentage of lean meat. Mothering ability of the three-way-cross gilts would not be important because they would never be bred.

What about the purebred breeders? Have crossbreeding and the advent of the three-way cross hurt them? What role will the purebred producer play in the future?

Crossbreeding hasn't hurt the quality purebred man at all—and neither should the increasing popularity of the three-way cross. Separate, unique breeds of good, pure stock must always be maintained to produce the faster growing crosses. The demand for quality lines of pure breeding stock will be just as high in the future as in the past.

The Farrowing Crate: A Step Toward Modern Production

A significant breakthrough in efficiency of swine production came with the modern farrowing crate in the 1950's. Much of the testing and development of the farrowing crate was done at the Iowa Experiment Station.

The principle of the farrowing crate is simple: A restraining frame around the sow confines her and prevents her from lying on the baby pigs. But the implications of this innovation

Development of the farrowing crate gave swine production a big boost in efficiency.

go far beyond the number of baby pigs saved.

The farrowing crate set a whole new trend to efficiency in swine production. It laid the groundwork for the subsequent shift to confinement swine housing and, consequently, to a tremendous increase in production efficiency.

Before the farrowing crate, the swine producer or his employee had to be on the scene at farrowing time, or risk losing valuable baby pigs. The farrowing crate eliminated this requirement and in doing so, saved a lot of time, labor, expense, and sleepless nights.

The farrowing crate also increased the efficiency of space utilization. With the sows restrained in about half the space required otherwise, confinement rearing of hogs became practical. Thus, the trend was set to move hogs off the pasture and into controlled, efficient confinement facilities.

Antibiotics: A Chance Discovery

Scours and enteric diseases have traditionally been a major problem in swine production. Antibiotics to prevent these enteric diseases were discovered—almost by chance—by researchers at the Iowa Experiment Station.

Scientists were determining the vitamin B-12 content of various substances by feeding them to pigs when scours broke out in the experiment. But some of the pigs—those being fed penicillin mold residues—didn't scour. The researchers noticed this and wondered why.

What they discovered turned out far more important than a new source of vitamin B-12: *Streptomyces aureofacien* mold was controlling the scour organisms, protecting the baby pigs.

The antibiotics were fairly easy to cultivate commercially. Today, antibiotics are used as preventive medicine in practically all hog rations, particularly early in life when pigs are more susceptible to internal diseases.

Vitamin B-12—The Missing Factor

Meat protein contains vitamin B-12, an essential vitamin for hog growth and development. Soybean protein—otherwise just as nutritious as meat protein and far easier to handle—lacks that one essential vitamin. So, hog producers before the early 1950's had to include tankage or meat meal in swine rations.

Swine nutritionists began studying vitamin B-12 at the Iowa Experiment Station in the early 1950's. They found that a high concentration of vitamin B-12 was left as a residue of antibiotic production. By feeding the vitamin B-12 residue along with the antibiotics, the hog feeder could eliminate tankage from his rations. This radically altered the feeding of swine as well as of poultry. Now, by adding a combination antibiotic and vitamin B-12 supplement, the hog producer can use soybean meal as the only protein supplement in his hog rations. This has vastly simplified swine feeding and permitted mechanization and better utilization of time and labor.

The Backfat Probe—Key to Selection for Meatiness

The backfat probe, developed at the Iowa Agriculture and Home Economics Experiment Station, was another innovation that helped set the trend for today's improved hog.

Just 20 or 30 years ago, the hog was our primary source of fats. The dominant philosophy of swine breeders then—as it had been for thousands of years—was to produce a hog as fat as possible. The average pig then was obligingly plump and jowly, providing a good supply of lard and fat for cooking and industrial use, as well as meat.

Not too many years ago, the hog was our primary source of fats.

People's tastes in pork began to change in the early 1950's. As the housewife became more calorie conscious, she demanded a leaner, meatier piece of pork. But one almost essential tool for a selective breeding program to give her the more-lean, less-fat product she demanded was still missing: a means to measure the amount of fat on a live breeding animal.

The original backfat probe was developed at the Iowa Experiment Station to fill this need. Nothing more than a narrow ruler, the backfat probe opened the way for scientific breeding

The backfat probe pioneered scientific breeding.

programs. Since most hog fat is uniformly distributed outside the lean meat, the ruler could easily be pushed through an incision in the skin and fat until it hit the solid muscle. The breeder could then read the measurement of the thickness of fat cover from the side of the blade.

This simple tool made the swine testing station possible. For the first time, live hogs from different breeding herds could be brought together and compared for meatiness under controlled test conditions. Because the backfat probe accurately and objectively measured how much fat each hog actually carried, it opened the door to scientific, selective swine breeding. Breeders could now select the leaner hogs and discard the fatter ones from their breeding herds.

The simple mechanical probe originally developed at Iowa State University has become quite sophisticated through the years. Iowa State University research has led the way in the improvement of this simple yet essential tool.

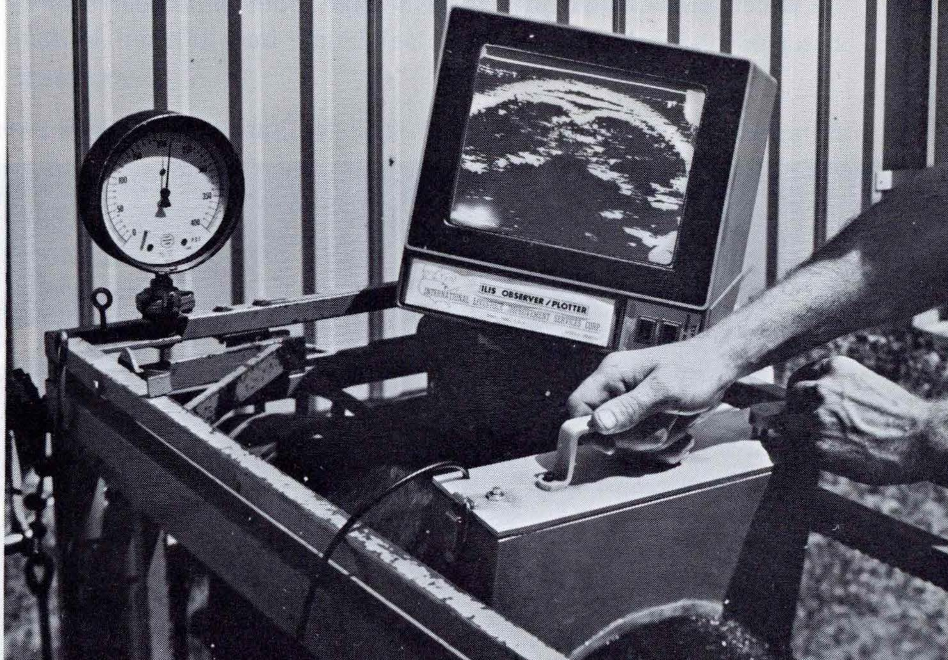
An electrical probe was later tested. A needle with positive and negative electrical poles was inserted through the skin of the hog's back. It would register the uniform fat layer on the hog's back. The underlying lean meat had a higher level of electrical conductivity. The point where this changed was recorded for more accurate backfat measurement.

Ultrasonic Probe

The ultrasonic probe was first used to study the growth of abnormal tissues—such as cancer—in the human body. It works much like radar. Ultrasound, or short sound waves, are beamed into the body. The sound waves penetrate through homogeneous tissue, such as fat, but when they strike a different type of tissue—such as lean meat or bone—they bounce back and are recorded.

The Iowa Station was first to apply this unique measuring device to swine measurement. They found that a "photo" could be made by tracing the reflected sound waves. This not only gives a breeder an accurate measure of an animal's backfat, but also traces the size and shape of the loin eye portion of the live animal. In other words, the breeder can measure almost exactly the loin portion of different animals simply by analyzing the photos from the reflected sound waves.

Ultrasonic instruments permit the automatic display of fat layers and loin eye area.



Boar Testing Stations

The concept of comparing performance of live boars at central testing stations originated at Iowa State University during the mid-1950's. Today, most major pork producing states operate live boar testing stations.

Boar testing stations measure and demonstrate both carcass and production characteristics of live male animals. In the Iowa programs, four or five male pigs from the same sire—one or two barrows, the others intact—are placed in a small pen and fed a high-energy ration of corn and soybean meal from about 60 pounds up to a terminal weight of around 220 pounds. The barrow is then slaughtered to provide carcass data. Three indicators of performance are measured: average daily gain and backfat thickness for each pig, and feed efficiency for the entire pen. Values for the three characteristics are combined in an index of evaluation. The breeding value of a sire is thus measured through the performance of his offspring. Individual performance of the young boars provides an estimate of each one's potential value as a breeding animal.

Another type of evaluation, littermate testing, is popular in other areas. Two pigs from a litter, both either barrows or

The Iowa Swine Testing Station.

gilts, are started at about 50 pounds and taken to market weight, then slaughtered. Carcass data, as well as growth rate and feed efficiency, for the two are combined in an index. The breeding potential of farm-reared littermates may then be estimated.

Iowa research suggests that live boar performance testing is more valuable than littermate testing.

Central boar testing began at the Experiment Station's swine research farm. The first permanent boar testing station was built and managed by the Iowa Swine Producers Association. Since then, four other swine testing stations have been established across the state.

Boars were tested on concrete floors in small pens for the first time in the initial swine testing programs. Until then, breeders thought that a good breeding boar had to be raised on pasture with plenty of exercise. Boars raised indoors on concrete, it was popularly believed, would not be effective for breeding programs because they would have weak feet and legs, grow obese, and lack libido, or sexual drive.

The fallacy was disproved by the first boar testing program. Boars were confined in small pens and fed a high-energy ration. Some grew 2-1/2 pounds per day, probed less than an inch of backfat, had sound feet and legs, and grew to be good breeders.

More important, the first boar testing station demonstrated the importance of measuring performance. Breeders could easily compare performance records of various animals tested. Performance-tested boars went into breeding herds and soon proved their value.

Producers began to believe in performance testing and performance records. Many established on-the-farm performance-testing programs of their own. They gathered more and better information about their herds. Commercial producers began to demand performance records on the breeding animals they purchased.

This impetus to test on the farm, rather than relying entirely on results gained from the boar-testing stations, was the major contribution of performance-testing research. All boars evaluated through the testing stations in Iowa in an entire year, for example, would only provide about 2 percent of the boars needed for breeding in the Iowa swine industry.

Performance testing also provides a benchmark by which to measure improvement within the industry. Performance of the animals that go through the testing stations has steadily risen over the years. This is a reflection of the improvement of the average genetic merit of herds across the state.

Linear Programming Applied

''Linear programming'' provides a means to determine the cheapest and most practical balanced hog ration. Experiment Station research pioneered the application of linear programming to hog-ration formulation.

In linear programming, the farmer looks at the cost of each of the different ingredients he can use in a balanced ration and at the feasibility of substituting products. He can formulate alternative rations, all similar in nutritional value, by using different ingredients.

The producer can then substitute feedstuffs in his rations as prices fluctuate, to provide the cheapest feed. For example, sometimes it may be more feasible to use corn; at other times sorghum, oats, or barley may be a more economical substitute. The producer saves money, without sacrificing quality of ration.

Combating Trichinosis

Trichinosis, a parasitic disease acquired by consuming uncooked or improperly cooked pork, has been an enemy of the United States swine industry for nearly a century.

Trichina, a nematode worm that invades the muscle tissue of swine, man, and other animals, causes the disease. Today, trichina incidence among hogs in the U.S. is very low—about 1/8 of 1 percent—but even that isn't low enough for us to disregard the health and economic hazard.

Very few animals die of trichinosis, and only occasionally is the disease transmitted to humans. But the disease is extremely costly to the swine industry—mainly because it gives pork a bad image and hurts its market potential.

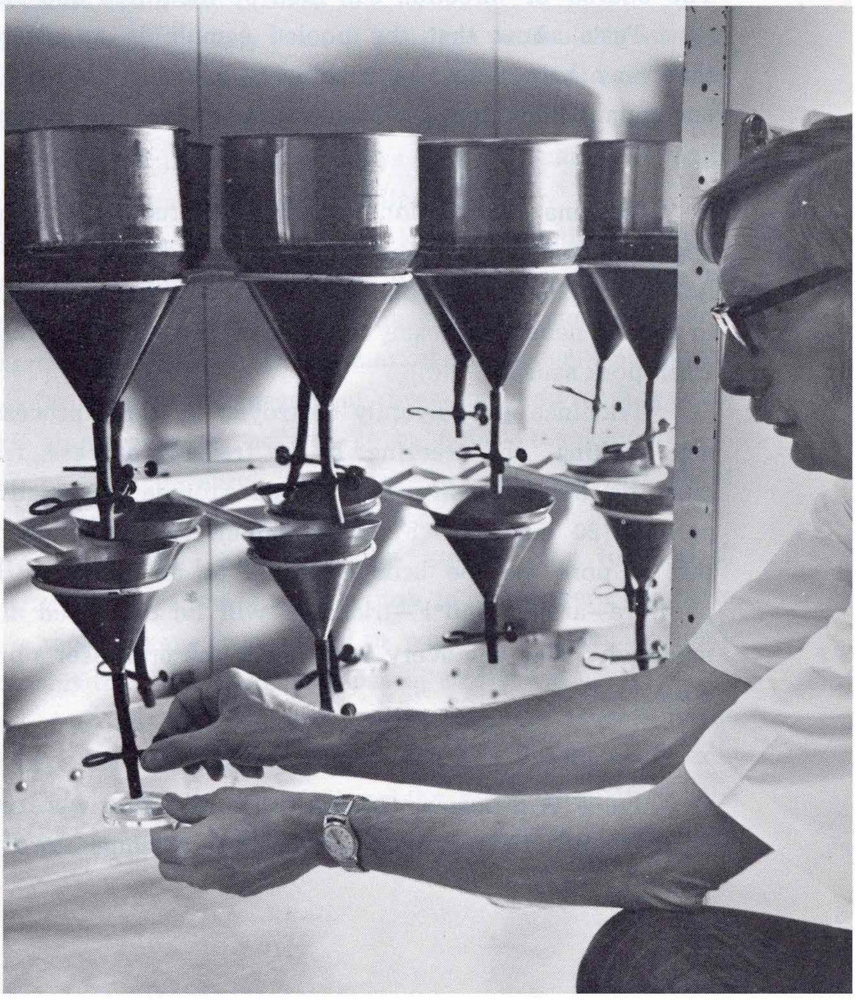
The possibility of trichina infestation hurts pork's export value, too. European countries placed embargoes on U.S. pork in the past because trichinosis was a common disease here then. Many embargoes are still in force today.

Domestic consumption of pork is also lower because of the unfavorable image. Grandmother's stern warning to ''Cook pork until all the pink is gone'' to kill trichinae often makes pork a drier, tougher, less juicy and flavorful product, less appealing to the homemaker.

The extra cost of processing all pork products that might be consumed raw, required by the U.S. Department of Agriculture, also hurts the swine industry.

Pooled-Sample Method of Detection: An effective method to detect and eliminate trichinae in swine was developed by the

Pooled-sample method: an effective technique to detect trichinae in swine.



Veterinary Medical Research Institute at Iowa State University.

Trichina worms, although found in muscle tissues of infected animals, are more numerous in the diaphragm. In the pooled-sample method, animals are identified by source and divided into lots of 20. Portions of the diaphragm tissue of each of the 20 hogs are ground together and placed in a solution that will identify trichinae, if present, in about 10 to 12 hours. If any trichinae are found in the pooled sample, all 20 carcasses of the lot can be held and tested individually. The infected carcass is identified and processed so that all trichinae are killed. The other carcasses are released for normal processing. The test does not interfere with the work flow of the packing plant. Results are available within the normal 24-hour chilling period for swine carcasses.

Infected animals can be traced back to the farm where they originated through the pooled-sample method of testing. The source of infection can then be identified and eliminated.

Tests show that the pooled sample is an effective tool that may help eradicate trichinosis and the hidden costs that accompany the disease sometime in the not too distant future.

Trichina Destruction: Trichina destruction is required in any pork product that might be consumed raw or without sufficient cooking. This applies to cured hams, for example, but not to meats never purposely consumed raw (bacon, pork chops, fresh pork sausage, etc.).

Trichinae are currently destroyed by three processes: curing, cooking, and freezing. In the freezing process, fresh pork must be held in controlled freezer storage for relatively long periods (20 days at 5°F, for example). Research now indicates that if pork can be brought down to an extremely low temperature—around -40°F—trichinae will be destroyed almost immediately. This discovery may lower the processor's production costs.

170°F Will Destroy Trichinae: Homemakers were once warned that pork products must be cooked to a temperature of 185°F to insure destruction of any possible trichinae. Experiment Station research has shown, however, that if pork is cooked to an internal temperature of 170°F, all trichinae that may be present will be destroyed.

PSS: A Problem That Must Be Overcome

The obese hog of the 1940's and early 1950's was the result of literally thousands of years of selective breeding for an animal that carried as much fat as possible. Twenty years ago, the consumer's preference reversed completely, and breeders started developing a hog with as little fat as possible. The trend is likely to continue.

But breeders ran into some problems in genetically reversing in 20 years a trend set for more than 2,000 years. They've found that, like man, many of the modern meaty hogs are plagued by stress. The over-all stress problem is termed "porcine stress syndrome" (PSS).

Some extremely meaty lines of hogs are particularly susceptible to PSS. They are unable to adapt to excitement or stress conditions. When they become excited or frightened, they may drop over dead, as in a stroke. Stress also may cause a "pale, soft, exudative" carcass condition, called PSE.

PSS is not associated with any known infectious disease. No treatment is known at this time. It seems to be a shocklike reaction to a departure from the routine, and the condition seems to be increasing, especially among market-sized hogs. PSS deaths occur on farms where management, breeding, and feeding practices are above average, as well as on poorly managed farms. A survey of Iowa purebred swine breeders revealed that about a third had lost pigs to stresslike symptoms.

Stress-susceptible hogs may die on the way to market. Deaths sometimes follow a sudden rise in atmospheric temperature or a rapid change from a cold to warm environment. Fighting is perhaps the most common cause of stress deaths.

PSS may be due to a hormonal deficiency. Muscle tissue taken from hogs immediately after death has a high lactic acid content. This indicates that perhaps the blood circulatory system fails under stress conditions. When an animal comes under stress, adrenalin, the "fight or flight" hormone, is ordinarily released into the bloodstream. Adrenalin causes the blood vessels to dilate, or enlarge, so that blood can carry nutrients to individual body cells and remove waste products. But an adrenalin deficiency could mean that the blood vessels would not dilate, and blood would "pool." This may be responsible for the buildup of lactic acid and waste products in the muscle, indicating that the blood doesn't circulate fast enough to supply oxygen to the cells. Death could result by what amounts to a heart attack.

If PSS is actually caused by a hormonal imbalance, then perhaps the deficient hormones can be produced synthetically. If so, the condition may be alleviated or controlled through hormonal feed additives.

Or, selective breeding for PSS-resistant lines may eventually eliminate the problem. Research at the Experiment Station indicates that the condition is genetically controlled. Some lines of heavily muscled pigs are able to adapt to stress conditions with no bad effects, but other lines, no more muscular, are not able to adapt.

The swine breeder has no way to determine, while his hogs are still alive, which ones may be susceptible to PSS. The only positive way to tell if an animal is stress-prone is to kill it and examine the carcass, and this is not practical in a breeding program.

Visible traits or live measurements that will help a producer identify the PSS-prone hog are being sought in a current Experiment Station project.

A herd of 36 sows thought to be susceptible to stress has been established at the Station. The sows are all mothers or littermates of pigs that have died of stress. They are being bred to stress-susceptible boars. The researchers hope to learn more about the genetic aspects of the PSS problem, as well as to search for stress indicators in the live animals.

A condition similar to swine PSS sometimes is found among heavily muscled athletes, such as weight-lifters. Doctors in heart research at the University of Iowa's medical school are working cooperatively with the Experiment Station swine researchers.

Information gathered concerning the swine PSS condition may help determine causes for human heart attacks.

MMA: A Puzzling and Costly Disease Complex

MMA (mastitis-metritis-agalactia) disease complex is one of the most costly problems of Iowa pork producers. MMA complex hits about 15 percent of all sows farrowing in Iowa. The incidence is much higher in many herds.

MMA causes a sow's milk production to decline or even cease. As a result, many pigs die from starvation and enteritis (inflammation of the intestinal tract). In Iowa, when a sow has MMA, about 15 percent of each litter of pigs will die before weaning. Surviving pigs often are runty and more susceptible to other diseases.

The actual cause of MMA is not known. The Experiment Station's swine nutrition research group and the Veterinary Medical Research Institute are cooperatively studying the complex to determine its cause.

No set patterns can be associated with MMA. Some research suggests that MMA may be inherited, but this has not been proved. Such factors as diet, management, breed, or season seem to have little influence on the rate of MMA infection. It occurs under the best management conditions and the poorest. Stress conditions of confinement and farrowing may contribute. Although MMA appears in sows on pasture, most cases are in confinement-raised hogs. MMA often appears contagious, but it cannot be reproduced with regularity in the laboratory.

A hormonal imbalance, followed by a bacterial infection of the uterus and udder, may contribute to MMA. Blood constituents are being studied to determine if the MMA complex is associated with a metabolic or homonal deficiency.

U.S. per capita consumption of pork is increasing.

PORK PRODUCT QUALITY

The entire swine industry exists for one purpose—to market a quality product at a profit. Thus, some of the more valuable contributions of the Iowa Agriculture and Home Economics Experiment Station have been in pork-product quality research. Effects of research studies on things like consumer preferences, desired meat characteristics, quality standards, pork processing methods, and trichina destruction are perhaps not so visible as the shift to confinement housing or alteration of the hog's body conformation. But they are just as significant.

Pork Consumption Is Increasing

Pork consumption in the U.S. recently took an upward swing—an encouraging trend for producers.

In 1900, U.S. pork consumption was about 72 pounds per person annually. Demand for pork fluctuated over the following years, but remained at about that level until 1944, when it reached a record high of 79.5 pounds.

In the late 1950's, however, consumption dropped. By 1966, consumption was only 58 pounds per person. Total demand for pork remained fairly constant during the low years because the decline in per-capita consumption was offset by population increase.

Long-run changes in pork demand and hog supply were examined by Experiment Station researchers in the Center for Agricultural and Economic Development. The computer analysis study pointed out reasons for the decline in pork's popularity.

Pork purchases dropped as consumers' preferences for two other meats—beef and chicken—increased. Demand for beef and chicken was found to increase as per capita income rose. The supply of beef and chicken also increased during that period.

Demand for pork per person, however, declined slightly with rising incomes. Increased consumption of other meats left less room in the consumer's diet for more pork.

Surveys also pointed out other reasons for changes in meat preference. As people engage in occupations that require less physical labor, they eat less pork. Also, pork quality had not improved as dramatically as beef and chicken quality. Consumer concern about the relation of fat to cholesterol and heart disease probably contributed to the decline.

But pork consumption began to climb again in the late 1960's. In 1967, consumption was more than 64 pounds per person. In 1971, the average American ate nearly 73 pounds of pork—the highest consumption level since 1944!

Why the increase in pork consumption? Higher beef prices and lower pork prices, for one thing. Pork's improved quality, for another. Consumers are learning that today's leaner hogs produce a better pork roast or ham than did the overfat hog of a few years back.

Animal-less Meat for Research

Meat will be grown outside the animal's body in unique muscle-tissue culture research at the Experiment Station. Scientists hope to use the animal-less meat to study muscle-cell growth in a controlled environment. If they can learn more about what regulates muscle growth, perhaps methods to influence the growth rate or alter the fat-and-lean ratio of animal carcasses can be developed.

Tissue culture itself is not new. For medical research, animal and human body cells have been grown since before the turn of the century in sterile dishes containing nutrients essential to growth. Muscle cells, however, have not been grown by tissue culture for meat-science research.

Leg muscle cells will be taken from chick and pig embryos, cultured, nourished, and grown completely in the laboratory. Protein synthesis and muscle fiber development can thus be studied in a controlled environment.

Muscle makes up more than half of the animal's carcass. The largest solid constituent of muscle is protein. Proteins, consumed by humans in meats, contain the amino acids necessary to support life. Excess caloric intake leads to obesity, and consumers are concerned about the possible relationship of fat to atherosclerosis, or heart and circulatory problems. If scientists can learn to manipulate the muscle-fat ratio to produce a leaner animal with less fat, it could have both economic and health implications.

No Blood Vessels: Muscle tissue raised outside the body will have neither blood nor blood vessels. Normal blood functions—carrying nutrients to the individual body cells and waste products away—will be performed by the researchers. Nourishment will be through a nutrient medium added directly to the cell culture. The growth media will have to be changed constantly as carbon dioxide and other waste byproducts accumulate.

Characteristics of Cultured Meat: Would muscle tissue grown in this manner be different from ''normal'' meat? Yes and no, the scientists speculate.

Cultured muscle tissue should be more uniform than regular meat tissue because the scientists can regulate or control its texture. For example, regular muscle tissues from different parts of the body have different cell characteristics. The cultured muscle tissue, though, should be more consistent in fiber size and diameter. Cultured muscle may provide a more uniform medium for controlled experiments than regular meat.

Of course, cultured meat would not be attached to bone. It won't have fat, so it should contain a much higher percentage of protein.

Would cultured meat have a taste? No one knows yet. But pure protein is bland, almost tasteless. Flavors that characterize meats—pork, chicken, beef—come largely from fat deposits rather than from muscle protein. Since the cultured meat won't produce fat, it will probably lack the flavor characteristics of meat animals.

Assembly-Line Meat Production Not Likely: Technically, mass production of muscle tissue outside the animal's body is entirely feasible. Assembly-line meat synthesis, though, isn't too likely in the near future. The ISU researchers seek means to improve the product quality of livestock, not a substitute for the meat-producing animal.

Limited *Specialized Markets Possible:* Limited special markets for this type of product could some day emerge, though, if efficient production techniques are developed.

Perhaps some meat could be custom-grown to fit specialized individual diets for hospital patients. Or perhaps it could provide special high-protein diets for people who do not consume meat because of religious or ethical reasons.

Consumer Preference Research

Webster County, Iowa, was selected as a test area for Experiment Station consumer preference research because the socioeconomic pattern of the area was considered fairly representative of the United States. A 3-year study there investigated why consumers accept or reject pork products. Homemakers' preferences were measured at the meat counter. Families' preferences were measured when meat was served at the table.

The relative importance of four quality characteristics was measured: (1) amount of bone, (2) color, (3) freshness, and (4) fat content. Freshness clearly stood out as most important, and amount of bone as least important, for all meat products. The amount of fat was considered more important than color for pork products.

Factors by which quality is measured were found nearly the same for all socioeconomic groups studied. One exception, however, was the amount of fat on pork. Fat content of pork was considered less desirable by higher income households having a higher level of education. Among individuals, the middle-aged group was more concerned with the fat content of pork than were either the young or the old.

Opinions on satisfaction at the table were also collected for five attributes: (1) tenderness, (2) proportion of fat to lean, (3) taste, (4) ease of preparation, and (5) shrinkage.

Taste was found the most important characteristic for all meat products, and ease of preparation was least important. Shrinkage and fat content were considered more important for

The average consumer is more concerned with quality than price.

pork than for poultry or beef. Income level and social standing generally had little influence on relative percentage of beef or pork that a household consumed.

The role of price changes, advertising, and in-store promotion in changing purchase habits also was studied. Lower income households were generally more responsive to these variables. The higher income households, the extremely poor, and the aged were less flexible in purchasing habits.

For years, pork promoters had assumed the consumer was more concerned with the price—rather than quality—of a product. The Webster County study showed the reverse to be true. The average shopper considers quality of product before looking at price. This finding has influenced the direction of pork promotion and merchandising and emphasized the livestock producer's role in product quality.

Why Not Grade Pork Cuts?

Virtually every part of the hog carcass serves a different purpose. A pork carcass loses its identity in the processing plant. It is completely disassembled, and individual parts become different pork products, such as cured ham, or boston butt roast, smoked pork chops, or pork lunch meat. Since different products have different requirements, it would be almost impossible to establish standard government grades for pork comparable to the grades of beef or lamb carcasses.

Grades and standards present another problem. For example, how does one establish standards to grade spareribs? Right now, there are none. The Experiment Station is studying consumer preferences, to determine exactly what the public wants in various pork cuts. Amounts of fat and lean, processing defects, carcass damage, trimming, "watery" pork, and loin eye size are just a few factors that must be considered.

"IQ" Pork Promotion

The feasibility of identifying superior pork products was tested in a recent Experiment Station research project.

Pork products have traditionally been sold as a commodity, with a specific weight group the only criterion for selection. A pork loin, for example, that weighs 12 pounds generally is packaged, shipped, and sold to the retailer simply as a "12-14 pound loin," regardless of factors such as amount of fat trim or quality of processing. The retailer then sells the loin as a roast or as pork chops to the consumer—once again only as a commodity, with no regard to product quality.

Superior quality specifications were established for pork loins in an Iowa State research project. Superior loins were designated "Iowa Quality," abbreviated IQ. Products that met IQ standards could then be used as a packer's own superior house brand to indicate its higher quality.

The program successfully stimulated many packers to establish house brands. But it also pointed out a vital problem area for pork. To promote a superior quality product, the retailer must be assured of a steady, consistent supply of that product.

The hog market is subject to severe fluctuations, in both quantity and quality of pork offered. Often, packers cannot get a steady supply of the superior quality products and thus cannot meet the demands of consumers. The image of pork products then suffers—and so does the image of the retailer, the packer, and the entire pork industry!

Soft, Watery Pork

Soft, watery, almost colorless pork is often found in carcasses of well-muscled, growthy pigs. The PSE (pale, soft, exudative) condition is unappealing to the consumer. PSE may have cost the swine industry millions of dollars through lowered consumer purchases.

No one knows for sure what triggers the condition. It is associated with the PSS, or sudden death syndrome, that affects the modern, muscular hogs. The soft pork condition is seldom observed among hogs that carry an abundance of fat and minimum of lean muscle.

In their search for the cause of the soft pork condition, scientists at the Experiment Station are studying the total body mechanism of the hog. The condition seems heritable. Perhaps breeders can some day select for heavily muscled animals that do not carry the watery pork condition.

Color Quality

A desirable, fresh, well-colored product in the supermarket display case results in higher pork consumption. Maintaining a desirable color in pork products has always been a problem.

Fresh meats will hold their color if the retailer follows two good business practices. Research shows that maintaining the temperature of the display case at around 32°F preserves fresh meat color. A high level of sanitation is also essential in color preservation. Deterioration of meat color is very closely related to bacterial activity.

Color is an even bigger problem with cured meat products, such as ham. The pinkish-red color of cured meats fades very rapidly and may even change to a brownish color. Scientists have found that the color change is a light-catalyzed reaction.

Now they are trying to find what color pigments are involved with color change in cured meats and to determine how to stabilize the desirable pink cured-meat color.

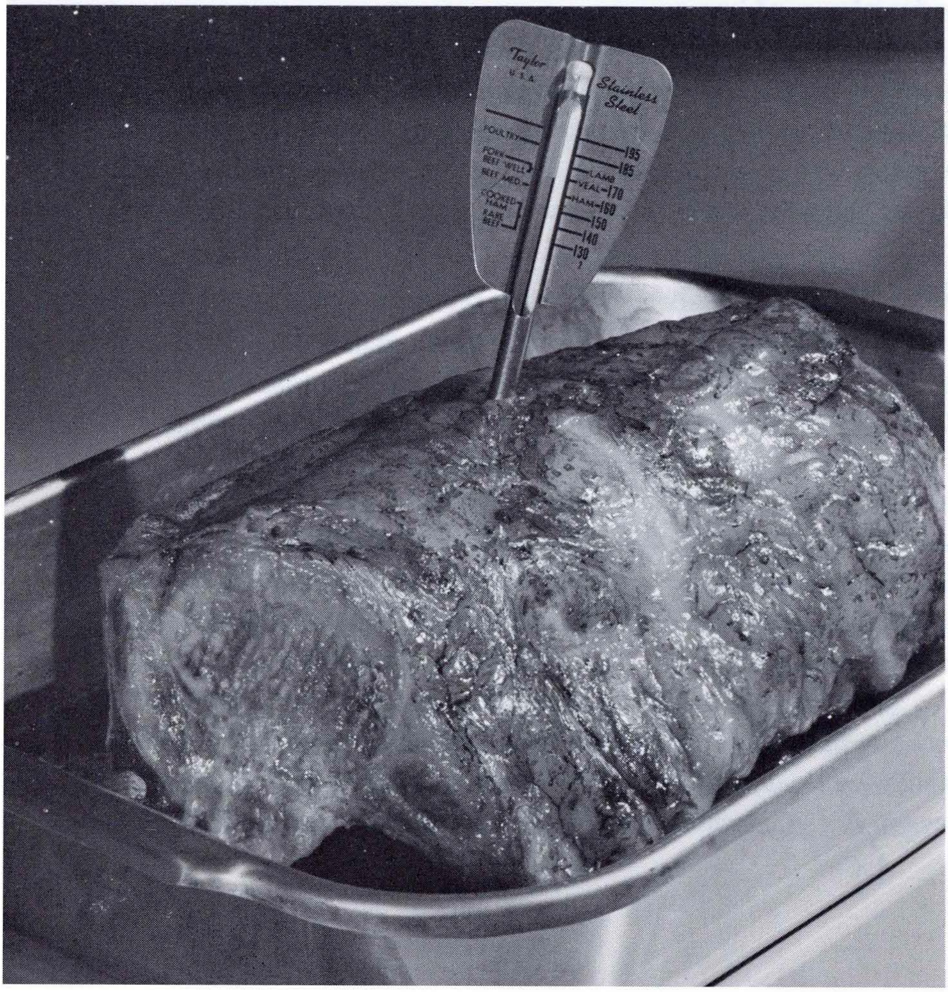
Lowered Temperature for Pork Cooking

The rules for pork cooking were recently changed by Experiment Station research supported by the National Live Stock and Meat Board.

For years homemakers had cooked pork products to a final internal temperature of 185°F. But this recommended procedure deserved critical evaluation as a result of improvements in household ranges and production of leaner, meatier hogs.

Recommendations for the final internal temperature for cooked pork were updated after years of research in Experi-

Photo courtesy of National Live Stock and Meat Board



ment Station food science laboratories. Extremely high cooking temperatures, researchers found, are not necessary to kill trichinae. In fact, overcooking assures only that a pork roast will shrink and be dry through and through!

Hundreds of pork cuts were cooked and submitted to taste panels for flavor, tenderness, and juiciness evaluation. Meat was cooked at various oven temperatures and to final internal temperatures of 165°F, 170°F, 175°F, 180°F, and 185°F. Rib and loin roasts of every type—small and large, frozen and thawed—as well as different sizes of fresh hams with and without bones were tested over years.

The research showed that the consumer will have a more acceptable product if she cooks pork to an internal temperature of only 170°F. A pork roast cooked to 170°F will be tender and more juicy and flavorful than one cooked to a higher internal temperature, yet still be perfectly safe from any danger of trichinae. The 15°F lowered temperature means that pork now can be cooked in less time and with less fuel consumption. More important, though, pork cooked to 170°F can be served while juicy and succulent, rather than cooked until dry. Since cooking losses are less, more pork can be served at the table.

The National Live Stock and Meat Board, which provides meat information to consumer and meat industry alike, changed its recommendations for both final internal temperature and cooking time per pound. The Meat Board gave this information to manufacturers of meat thermometers. Previously, 185°F was marked on meat thermometers as the proper internal temperature for pork roasts. Now new meat thermometers have 170°F marked as the proper final internal temperature for pork. Also, the Meat Board made this information available to the armed forces, who are the nation's largest single purchaser of meat thermometers and are large consumers of pork. The recommended cooking temperature was changed from 185°F to 170°F, both in armed-forces cooking manuals and on their meat thermometers.

News of the new recommended cooking temperature was disseminated through a number of additional channels. The American Meat Institute, for example, arranged for the scientist who supervised the research to address a meeting of influential food editors in New York. Consequently, the new recommendation found its way into many women's magazines. The news was also sent to home economics teachers across the United States and disseminated through various Extension Service activities. Literally millions of consumers will thus be exposed to juicier, more flavorful pork products, improving their perception of pork.

The shortened cooking time also means more convenience—something for which homemakers are constantly searching.

The discovery may have far-reaching effects on the pork industry. The new recommendations present a more favorable image of pork to the public, which could mean increased consumption of pork and pork products.

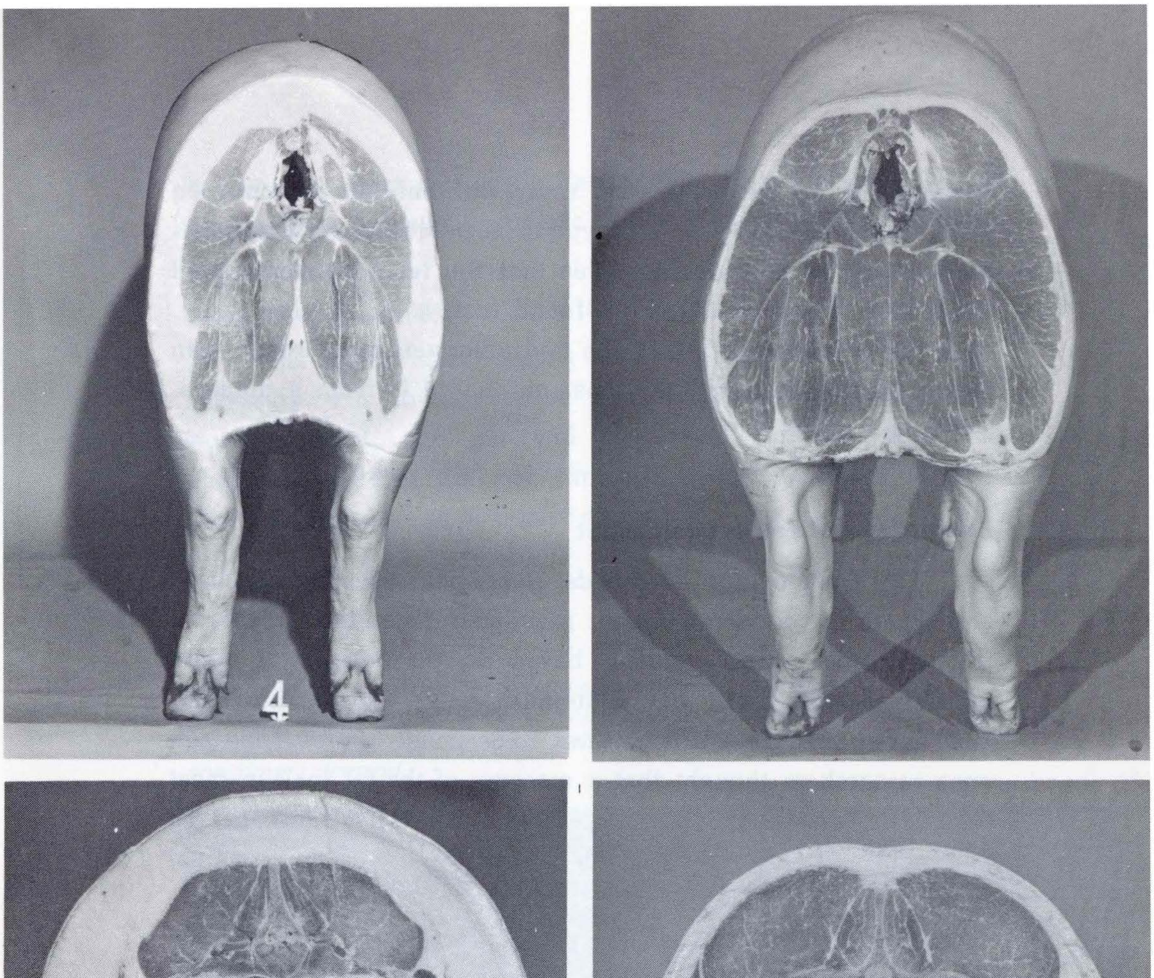
Other Meat Quality Research

Questions about the quality of pork, particularly pork from the new lean types of hogs, began to be asked in the late 1950's. Was the meat from the leaner hogs as good as meat from the old-fashioned ones? Was it as juicy and as tender? Did the consumer actually get a better bargain from meat purchases? What about the external fat on pork cuts? Fat within the lean meat?

Iowa Experiment Station and U.S. Department of Agriculture food science researchers worked cooperatively to find answers to these and other questions.

Lean-Type Hogs Give Consumers More Edible Meat: Pork loins and cured hams from hogs with backfat thickness ranging from 1.1 to 2.3 inches were purchased from an Iowa meat packer. The fat and lean meat from pork chops, pork roasts, and cured hams was separated and weighed, before and after cooking.

A negative correlation was found between backfat thickness and percentage of lean meat: As the backfat thickness increases, the percentage of lean meat in the various meat cuts decreases, regardless of fat trim. For example, a hog with a backfat thickness of 1.1 produces a pork rib roast with 65 percent lean meat and only about 12 percent fat. But a hog with a backfat mea-



Which carcass would you prefer? Lean-type hogs give consumers more meat per dollar.

surement of 2.3 produces a rib roast with only 45 percent lean meat and 25 percent fat. This type of negative correlation exists even though meat packers agree that the fat cover around all roasts should be trimmed to one-fourth inch.

So, regardless of trim, the consumer gets more edible lean meat and less fat when the meat purchased is from a modern, lean hog.

Percentage of Fat in Lean Meat

The Composition of Foods Handbook, used by dietitians and others in food preparation, previously listed the fat content of pork cuts as 25 percent, based on the analysis of entire untrimmed pork cuts. Fat content of only the lean, however, had never been determined. Iowa Experiment Station food science researchers thought that a measure of the fat in lean meat would be far more useful, since the packer trims much of the external fat, and the consumer ordinarily leaves any external fat on his plate.

Researchers measured the percentage of fat in raw and in cooked pork chops, pork roasts, and cured hams. They learned that the actual fat content of lean pork is only about 5 to 6 percent. No correlation was found between the amount of fat within the lean (marbling) and backfat thickness of the live animal.

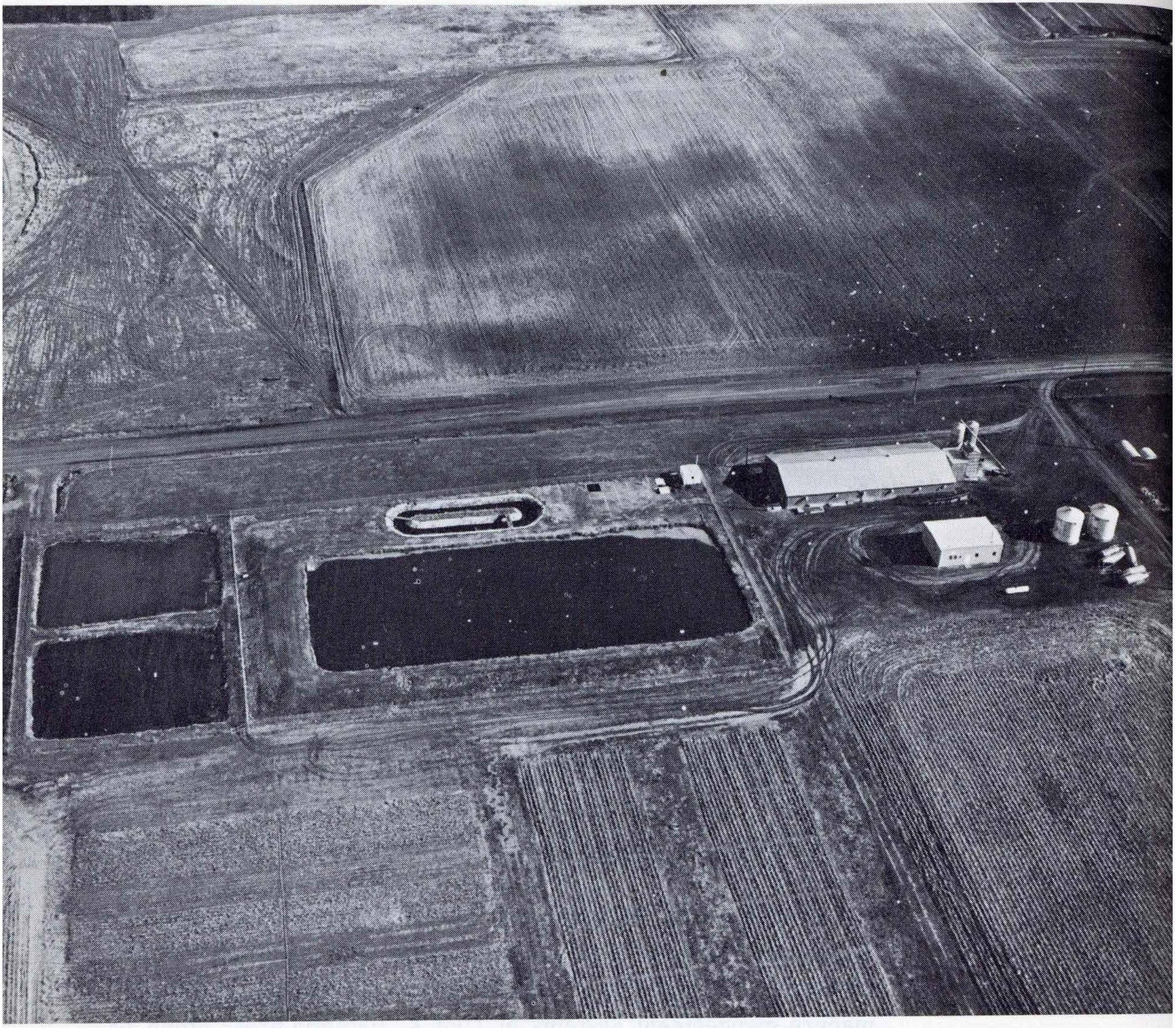
Pork products are often unjustly maligned today, despite tremendous improvements in product quality. Results of pork quality research at the Iowa Agriculture and Home Economics Experiment Station provide evidence that should reverse this trend and improve the image of a fine Iowa product.

Bacon Processing: Bacon processing has always been an art. But researchers are trying to combine this art with science at the Experiment Station. They are searching for means to process and cure bacon in a few hours rather than days, yet have the product retain the quality that consumers expect and deserve.

Rapid Chilling: Mechanical refrigeration is no longer necessary in the processing of pork carcasses. Researchers have learned that meat can easily be brought down to extremely low temperatures by using cryogenic materials, such as liquid nitrogen or carbon dioxide. ''Rapid chilling'' of meat products is accomplished in a matter of minutes.

This means that chilling a carcass overnight is no longer necessary. An animal can be slaughtered, chilled with a cryogenic material, and cut and processed within a few hours. Shortened holding time of carcasses can mean more efficient use of facilities, such as cooler space.

More efficient methods for processing and curing bacon are being sought by scientists. Their goal is to shorten curing time from days to hours, yet maintain the quality consumers demand.



Unit K, at Iowa State University's Swine Nutrition Farm near Ames, is a prototype for waste management studies.

easy. Anaerobic decomposition, however, produces some odorous byproducts, including hydrogen sulfide and ammonia. These gases are partly responsible for the smells that often make a hog farmer unpopular with his neighbors.

Anaerobic decomposition is being studied at Unit K. Wastes flushed from the hog house go into a large anaerobic lagoon for decomposition. Then the lagoon effluent is recirculated for flushing again. If properly managed, and not too heavily loaded, the anaerobic bacteria can consume the manure fairly quickly, and little odor will result. The system is simple and easily managed.

During the low temperatures of winter, however, anaerobic manure decomposition practically ceases. Manure accumulates, and when the spring thaw comes, the anaerobic bacteria population increases tremendously. The bacteria decompose a huge amount of manure, giving off large amounts of odorous byproducts.

If the lagoon is properly designed and managed, bacterial activity soon stabilizes, and most odors disappear. But if improperly designed and managed, the lagoon becomes overloaded, and decomposition practically ceases. The producer has a foul-smelling manure-storage pit.

Aerobic Decomposition: Less Odor, but Harder to Manage

Aerobic bacteria, as the name implies, live and multiply only in the *presence* of free oxygen. When aerobic bacteria consume organic matter, they produce nearly odorless byproducts. But an aerobic manure treatment system is harder to manage and more expensive to operate than an anaerobic system.

The flushing water from the hog house is discharged into an oval concrete oxidation ditch in the aerobic system. A large, turning paddle wheel continually mixes air into the waste, exposing bacteria to increased amounts of oxygen and keeping the liquid circulating. Treated effluent from the oxidation ditch is pumped back into the flushing tanks and flushed through the manure gutters again.

The paddle wheel makes the aerobic oxidation ditch work. The compact system saves space by substituting power injection of oxygen for the larger surface area needed for regular aerobic decomposition. If the paddle wheel stops, though, *anaerobic* bacteria take over the job of manure decomposition, and the odorous byproducts are discharged into the air.

The oxidation ditch and paddle wheel combination, or some variation of it, has been used for some time in city sewage treatment plants, but has only recently been used for animal waste treatment. A similar oxidation ditch is being tested for cattle manure decomposition at the Experiment Station's Allee Farm near Newell.

Anaerobic-Aerobic System

A combination anaerobic-aerobic decomposition system is being tested in another experiment. The manure-carrying effluent is first discharged into a large anaerobic lagoon. The solids settle to the deep portion for anaerobic decomposition, and the liquid portion is transferred to the oxidation ditch for aerobic decomposition before being recirculated through the flushing system.

Application of Excess Effluent to the Land

Any waste treatment or management system, no matter how efficient, produces excess materials that must ultimately be discharged somewhere. Neither anaerobic nor aerobic treatment removes enough nutrient material from the manure to make the effluent safe to discharge into streams. While decomposing organic matter, bacteria will quickly strip available oxygen from the water. The oxygen is denied to aquatic animals, including fish, which may then suffocate.

Another problem is that the plant nutrient elements—nitrogen, phosphorus, and potassium (N, P, and K)—are not removed by bacterial decomposition. These elements can stimulate eutrophication, or excessive algal growth, in our streams and lakes. Not only is the algal growth unsightly, but it lends a foul smell to the water, and the decay of dying algae may strip available oxygen from the water.

One of the oldest waste disposal methods—and in many instances the least polluting—is to apply the material to the land. At Unit K, a sprinkler irrigation system is used to apply treated effluent to adjacent grassland. Scientists are irrigating corn with swine manure effluent by sprinklers.

Aerobic soil bacteria finish the decomposition of the organic matter. If the effluent is applied too thickly, however, anaerobic bacteria may take over the decomposition.

N, P, and K in the effluent can be utilized by the growing plants, and may to some extent reduce the need for additional fertilizers. If applied in excess, however, the plant nutrients, particularly nitrogen, can sometimes move into ground water. This danger is greater in a loose, well-drained soil.

Water Hyacinths for Lagoons

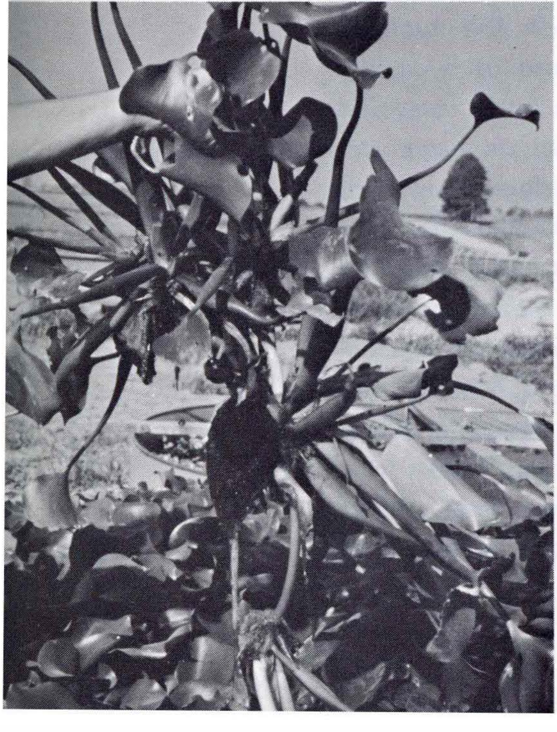
Water hyacinths may some day be used to remove plant nutrients and organic matter from swine manure lagoons, Experiment Station research indicates. The tropical aquatic plants normally float on the surface of water, unattached to soil, and absorb nutrients from the water itself.

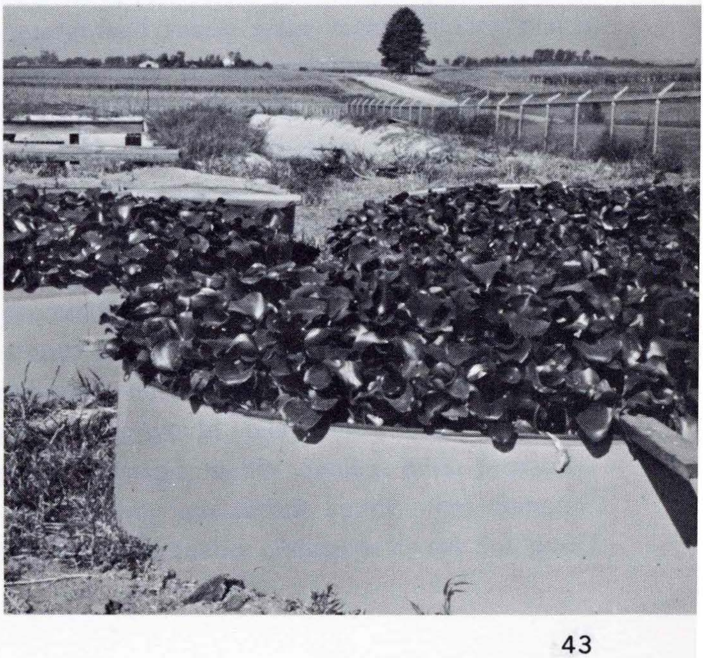
Water hyacinths have removed enough organic matter and N, P, and K from manure-carrying lagoon water to render it safe enough to discharge into surface waters with no fear of pollution in Experiment Station research.

The plants grow rapidly and are easy to harvest. They also increase evaporation from the lagoon's surface, easing disposal problems.

Finding a use for the harvested hyacinths—up to 84 tons per acre—may be a problem. Their normal moisture content is

Water hyacinths will purify manure-carrying lagoon water so that it is safe enough to discharge into surface waters.





around 94 percent, so most of that 84 tons per acre is water. The high moisture causes them to spoil soon after harvest.

Hyacinths may have some potential as a livestock roughage. Mixed with corn refuse, the hyacinths have made an acceptable silage in Experiment Station research. Or possibly they could be plowed into the soil to increase humus matter or left on the surface to halt soil erosion.

Water hyacinths are a major problem in the southern U.S. and in some tropical regions because they grow thickly and clog up waterways. The researchers don't believe this could be a problem in Iowa, though, because the plant is an annual that multiplies by runners rather than seeds. The plant is very susceptible to cold weather and cannot survive a typical Iowa winter.

Present results encourage ISU researchers to think that application by irrigation of decomposed effluent offers more practical possibilities for final waste disposal than using water hyacinths.

MARKETING RESEARCH

What direction will the swine industry take in the future? Economic researchers at the Agriculture and Home Economics Experiment Station are trying to find answers to this question in a hog-subsector study.

Changes taking place in the hog industry, and particularly in production and marketing, are being studied. For example:

—What will be the most economical production method in the future? Will confinement systems increase, lowering production costs? If so, will confinement be practical under all conditions?

—What will be the relationship between feeder pig production and hog raising? Today, most hog producers raise their own feeder pigs. Will this trend continue in the future, or will the pork industry, like the beef industry, change to a system where one specialized operator raises feeder pigs and another specialist buys and feeds them out?

—How will the guaranteed yearly wage influence the packing industry? What consequent effect will it have on hog production? Will the guaranteed yearly wage mean packing plants will have to preschedule hog slaughter to maintain a uniform kill year round and maximize efficiency of labor use? Would this mean an increase in contract marketing of hogs to assure the steady supply demanded?

—If contract pork marketing becomes common, what effect will this have on the industry as a whole? Would a contract price set before production benefit the individual hog raiser? Would this allow better planning and utilization of farm labor? Or, would hog production be so radically changed that a completely new type of producer would emerge?

—Will the public demand higher quality pork products? If so, how will future hog producers supply that demand? Should strict meat grades and quality standards be set for pork?

If so, by what criteria? Would the packer pay an incentive for high-quality pigs on the open market, or would he contract with specialized producers?

Experiment Station researchers feel that it is absolutely necessary to measure these and similar trends and determine, as closely as possible, what the future holds for the swine industry.

The individual livestock producer, armed with this information, can react to trends and take advantage of production systems available. If not, the pork industry could possibly shift to another part of the nation—as did the broiler industry a few years ago.

The Iowa producer can take advantage of trends for the future as well as producers anywhere else. First, however, he must have the necessary information. Providing this information is one of the purposes of the Experiment Station economic research.

What Is the Best Way to Market?

Today, several marketing options are available to the producer. He can sell live to a packing plant. He can sell on the carcass grade-and-yield basis. He can sell to a terminal. How should the producer market to maximize his profits?

Returns for both high-quality and low-quality hogs were studied for different marketing systems in an Experiment Station research project.

Packing plants have different systems of carcass evaluation. But different packing plants across Iowa paid about the same prices for animals sold on a carcass-quality basis. When hogs were sold live, however, packing plants varied considerably in their payments.

The producer of high-quality hogs generally profits more if he sells on a grade-and-yield basis, the study showed. The producer of poor-quality hogs, on the other hand, profits more by selling in lots of live animals.

Producers often assume that the terminal markets set the trends for price changes. The study showed the opposite to be true. Packing plants reacted more to changes in the wholesale price of pork than did the terminal markets at Omaha and

Sioux City. When wholesale prices fluctuated, the packing plants raised or lowered prices accordingly. Terminal markets also fluctuated prices—but not nearly so rapidly or radically.

Terminal Markets: The First System

Livestock production in the United States developed as a pioneer and frontier industry. Terminal livestock markets, such as the classic Chicago market, developed as a link between the midwestern livestock producing areas and the urban consumers, mostly on the East Coast.

The huge centralized markets were accessible to rail and water transportation. They were surrounded by other elements of the meat industry: packers, processors, wholesalers. The terminal markets brought assembly-line efficiency to animal slaughter and meat processing. The giant terminal markets at Chicago, Omaha, Sioux City, and St. Joseph drew immigrants to America and drew East Coast workers to the interior of the country. Cities grew up around them.

Terminal Markets Stimulated Cooperative Marketing

The remoteness of the producer from the terminal markets, and the difficulty of transporting his animals, stimulated the first cooperative marketing systems. As cattle raising gave way to more general farming, and as swine and dairy production became more important, the problems of the individual, small producer grew. Small farmers often had less than economical shipping units. The man with just a few hogs or a dozen steers either had to sell to a local livestock buyer, at his prices (the buyer then sent larger units to the terminals) or had to pay high shipping costs.

In the early 1900's, farmers began to band together to ship and sell their livestock in lots. Often, several neighbors would group their small shipments together to make up a full carload. By doing so, they found that they could reduce their transportation and marketing costs and get a better price at the market. Cooperative shipping organizations were formed, some of which were the basis for farmers' organizations, such as the Grange and the Farmers' Union.

Decline of Terminal Markets

In the years after World War I, the giant terminal markets began to decline. Packing plants began to move away from the terminals and into the interior of the Midwest, to the areas where the livestock were actually produced. Several factors influenced this livestock market decentralization.

Increased technology was one factor. Specialized slaughter plants were found more efficient than the huge multi-species plants. A packer could specialize in hogs or cattle and structure his entire operation to this one commodity.

Agricultural production intensified. Different areas could now produce enough livestock to justify a packing plant in those particular areas, as farming operations became larger and more efficient.

Transportation changes were perhaps the most important factor. Trucks and automobiles became more common. Farm-to-market roads were built and improved. Farmers could now take their animals to an area market rather than depend on rail or water transportation to the terminal market.

Terminal markets were by no means replaced. They remained important, just as they are today. But decentralization, a move to local markets, now challenged the huge terminals. The traditional systems of livestock marketing and pricing were changed.

As producers began to raise higher quality hogs, they started looking for a better marketing system that would adequately reward them for producing a superior product. Collective marketing in lots was not practical under these conditions.

The pricing system itself was changed. When the majority of a product, such as hogs, moves through a terminal market each day, then that market becomes a place where supply and demand forces meet to establish prices. With producers selling more and more to small, decentralized plants in the producing areas, however, supply and demand were less well matched, and it was more difficult to determine a clear price level. Often, farmers found a wide variation between terminal market prices and interior market prices. Market news became increasingly important to the farmer.

Market News Research

Accurate, up-to-date information is important to any agricultural activity. It is particularly vital to farm marketing. Experiment Station researchers over the years have examined the flow of farm market news to farmers across the state.

Radio Market News

The Experiment Station, through the Journalism Department, sponsored an initial research project on radio market news in 1954. Six hundred farmers, from every county in the state, were randomly selected and personally interviewed to determine how radio market news could better serve them.

Data collected from this intensive study pointed out constructive changes that would enable radio stations to provide better market news services for farm audiences.

Researchers found that 43 percent of the farmers selling hogs, and a high proportion of farmers selling other commodities, listened to radio market news during midmorning when prices at the marketplaces were being established, if such a report was available. As a result, some stations that had not previously broadcast midmorning reports initiated them.

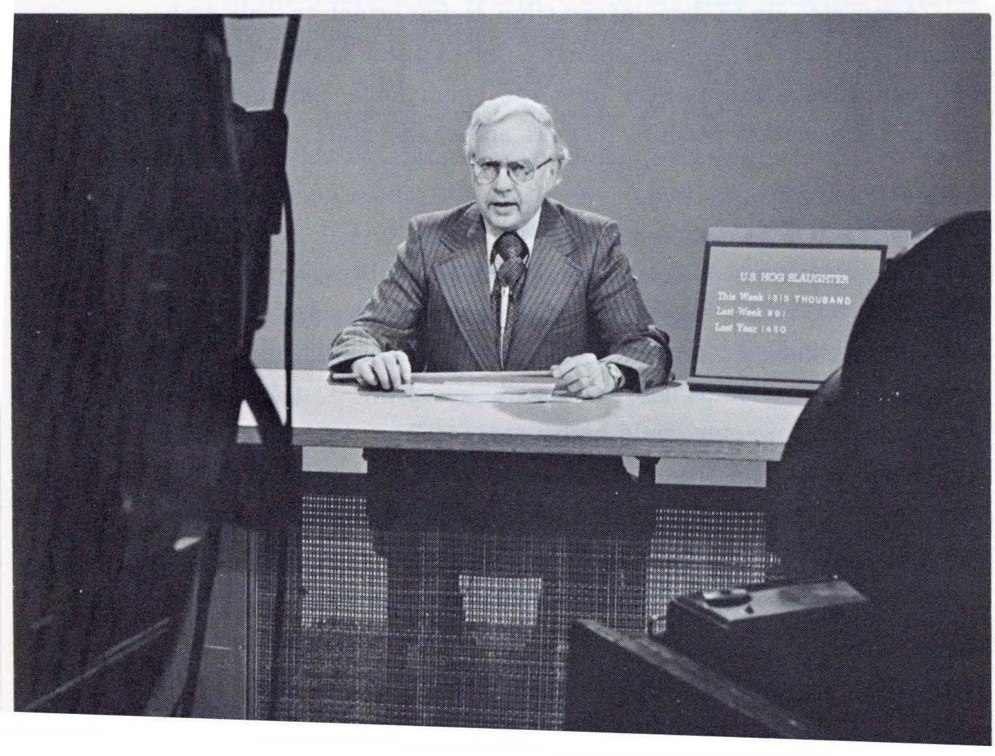
Farmers were interested in interior as well as terminal hog and cattle reports, local and terminal grain reports and local cream and egg reports. Market quotations from local markets in individual listening areas were provided, giving farmers a more accurate picture of the market situation.

How Farmers Obtain and Use Market News

The principal means by which Iowa farmers obtain and use market news was investigated in another extensive study. Information gained was for direct use by those who gathered, processed, and distributed agricultural market news. Its primary *benefactors,* though, were those who actually used that news to make marketing decisions—the farmers of Iowa.

Farmers wanted more local market information, the study revealed, and some wanted more explanations of changes in

University television and radio facilities help Iowa swine producers obtain up-to-the-minute market news and price quotations.



market prices. They asked for more information on markets for different grades of cattle. Three-fourths of the farmers surveyed wanted outlook information.

Interior Iowa-Southern Minnesota Price Report

The Interior Iowa-Southern Minnesota Price Report came about after Experiment Station studies showed that farm market news should be decentralized if it was to be used to best advantage by the greatest number of farmers.

Although marketing was being decentralized across the United States, market news still emphasized the terminal markets. Prices at local and interior markets were not generally indicated.

Agricultural economists who studied the increasing decentralization of marketing found that the trend was reducing transportation and other marketing costs. The effects of decentralization on farm prices, however, depended chiefly on the accuracy, extent, and timeliness of the market news reporting system.

Because of this discrepancy, the Iowa Department of Agriculture and the U.S. Department of Agriculture jointly developed the interior price report, to reflect prices paid at local markets across interior Iowa and southern Minnesota.

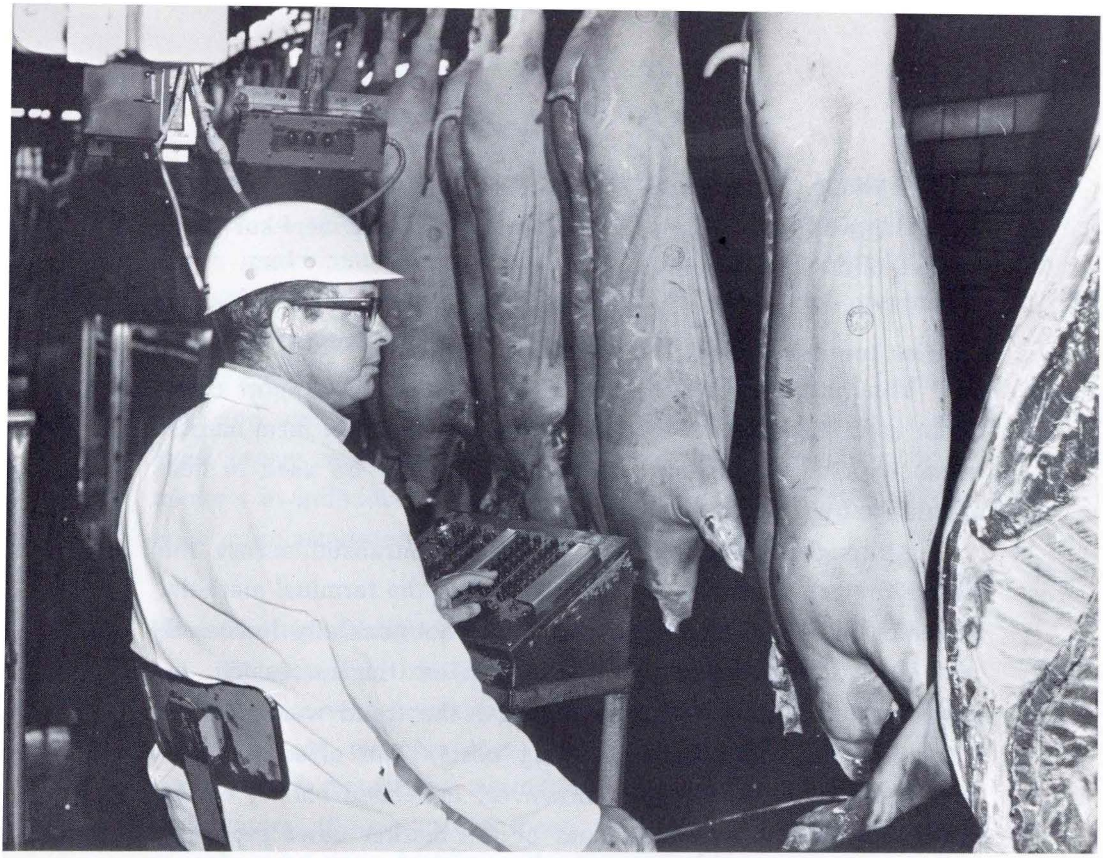
Grade-and-Yield Marketing

As producers started raising higher quality animals, particularly hogs, they began to look for marketing procedures that would adequately pay them for a better product.

Many producers felt that hogs were not so uniform in value as market prices, both terminal and interior, indicated. Prices received for high-quality animals were not in line with their actual value relative to low-quality hogs.

The field secretary for the Iowa Swine Producers' Association wrote to H.H. Kildee, then Iowa State dean of agriculture:

> "Day after day, while talking to producers concerning the desirability of. . .more loin and ham and a meat-type hog, I repeatedly get the answer 'Why should I raise this type of hog? I cannot get any more money for it.' In other



Carcass evaluation and grading requires highly trained manpower.

words, the producer feels that, although these animals can be worth considerably more per carcass, he will receive the same price, if finished, regardless of cuts and conformation."*

Scientists recognized that hogs differ considerably in actual value. They doubted, however, that these differences could be determined with great accuracy "on the hoof." Thus, Experiment Station research was directed to determining whether the basis for hog sales should be shifted from the live animal to the carcass, where much greater accuracy of appraisal is possible. Carcasses had been the basis for sale in Denmark for a number of years. The system had just recently come into use in Canada.

The ability of buyers to evaluate live hogs was measured, and compared with carcass evaluation. Carcass measurement was determined to be a superior method, and various grade-and-yield marketing systems were developed by packing plants.

Geoffrey S. Shepherd. Marketing farm products. Iowa State College Press, Ames. 1946. p. 183.

Grade-and-yield marketing hasn't increased much over the years. Most hogs are still sold live, probably because many producers feel they benefit more from an average system. But the carcass evaluation techniques that were developed led to superior evaluation of live animals. Packers are able to upgrade their buyers' ability to evaluate live animals by continually following up live evaluation with carcass evaluation.

"Break-Even" Points for Hog Sales

At what weight should hogs be sold?

That's an important short-run decision that faces every hog producer. Many simplify their decision making by always marketing at the same weight. By doing this, the producer may lose a potential profit. An Iowa State study of market data shows that the most profitable marketing weight fluctuates widely due to seasonal price changes, shifting patterns of price differentials among weight ranges, and changes in the ratio of corn to hog prices.

Break-even points for hog production were developed to guide farmers in making marketing-weight decisions under a range of feed and hog prices in an Experiment Station project.

First, economists identified the best marketing weight for hogs under the price conditions that prevailed at the first of each month for a past 10-year period. This confirmed that prices fluctuate widely and that a producer can make or lose money according to the weight at which he sells.

Break-even points, which indicate the price that must be received if increased returns are to exactly equal the increased costs of production to add 10 or 20 pounds per hog, were then figured.

A table was developed by correlating the price of hogs, the price of corn, and the weight of hogs to break-even points. A farmer can locate the current price of corn and hogs in table 1, then read from it the price he would have to receive to pay his expenses for raising the hogs to heavier weights. For example, when corn prices are low and hog prices are high, a producer may find feeding to heavier weights profitable, even if he has to sell the hogs at a lower price.

Table 1. The price needed to break even at the following weights with different current hog prices.

	If hogs now weigh 180 pounds		If hogs now weigh 200 pounds		If hogs now weigh 220 pounds		If hogs now weigh 240 pounds	
	the break-even price at:		the break-even price at:		the break-even price at:		the break-even price at:	
Current Price of Hogs (cwt.)	190 is	200 is	210 is	220 is	230 is	240 is	250 is	260 is
When the Price of Corn is $1.10 per bu.								
16.00	15.99	16.01	16.03	16.10	16.09	16.19	16.11	16.23
17.00	16.94	16.91	16.99	17.01	17.05	17.11	17.07	17.16
18.00	17.89	17.82	17.94	17.92	18.01	18.03	18.03	18.08
19.00	18.84	18.72	18.89	18.83	18.96	18.95	18.99	19.01
20.00	19.79	19.62	19.85	19.74	19.92	19.87	19.96	19.93
21.00	20.74	20.52	20.80	20.66	20.88	20.79	20.92	20.86
22.00	21.69	21.43	21.75	21.57	21.84	21.14	21.88	21.78
23.00	22.64	22.33	22.71	22.48	22.79	22.62	22.84	22.71
24.00	23.58	23.23	23.66	23.39	23.75	23.54	23.80	23.53
25.00	24.53	24.13	24.62	24.30	24.71	24.46	24.76	24.56
When the Price of Corn is $1.25 per bu.								
16.00	16.04	16.10	16.07	16.18	16.13	16.27	16.15	16.31
17.00	16.99	17.00	17.03	17.09	17.09	17.19	17.11	17.23
18.00	17.94	17.90	17.98	18.00	18.05	18.11	18.07	18.15
19.00	18.89	18.81	18.94	18.91	19.01	19.03	19.03	19.08
20.00	19.83	19.71	19.89	19.83	19.96	19.95	20.00	20.01
21.00	20.78	20.61	20.84	20.74	20.92	20.87	20.96	20.93
22.00	21.73	21.51	21.80	21.65	21.88	21.79	21.92	21.86
23.00	22.68	22.42	22.75	22.56	22.84	22.71	22.88	22.79
24.00	23.63	23.32	23.70	23.47	23.79	23.62	23.84	23.71
25.00	24.58	24.22	24.66	24.38	24.75	24.54	24.80	24.64
When the Price of Corn is $1.35 per bu.								
16.00	16.07	16.15	16.10	16.24	16.16	16.33	16.17	16.36
17.00	17.02	17.06	17.06	17.15	17.12	17.24	17.14	17.28
18.00	17.97	17.96	18.01	18.06	18.08	18.16	18.10	18.21
19.00	18.92	18.86	18.96	18.97	19.03	19.08	19.06	19.14
20.00	19.86	19.77	19.92	19.88	19.99	20.00	20.02	20.06
21.00	20.81	20.67	20.87	20.79	20.97	20.95	20.98	20.99
22.00	21.76	21.57	21.83	21.71	20.95	20.92	21.94	21.91
23.00	22.71	22.47	22.78	22.62	21.91	21.84	22.91	22.84
24.00	23.66	23.38	23.73	23.53	23.82	23.68	23.87	23.76
25.00	24.61	24.28	24.69	24.44	24.78	24.60	24.83	24.69
When the Price of Corn is $1.45 per bu.								
16.00	16.10	16.21	16.13	16.29	16.19	16.38	16.20	16.41
17.00	17.05	17.12	17.09	17.20	17.15	17.30	17.17	17.34
18.00	18.00	18.02	18.04	18.11	18.10	18.22	18.13	18.26
19.00	18.95	18.92	18.99	19.03	19.06	19.14	19.09	19.19
20.00	19.89	19.82	19.95	19.94	20.02	20.06	20.05	20.11
21.00	20.84	20.73	20.90	20.85	20.98	20.98	21.01	21.04
22.00	21.79	21.63	21.85	21.76	21.93	21.89	21.97	21.96
23.00	22.74	22.53	22.81	22.67	22.89	22.81	22.93	22.88
24.00	23.69	23.43	23.76	23.58	23.85	23.73	23.89	23.81
25.00	24.64	24.34	24.71	24.50	24.81	24.65	24.85	24.74

Thus, with $1.10 corn and $24 hogs, a producer could add 10 or 20 pounds to hogs that weigh 180, 200, 220, or 240 pounds, and break even, even though the hog prices drop. If corn is $1.35 and hogs $16, though, he can add weight profitably only if hog prices rise.

Other Hog Market Research

Other Experiment Station research has focused on developing better hog market activities over the years. Studies have determined how farmers market, where they market, and what influences their marketing decisions.

Researchers have worked cooperatively with farm organizations, auctions, terminal markets, and packing plants to develop new and improved marketing procedures to fit the needs of producers.

Packer buying stations, for example, evolved partly as the result of a study that indicated that farmers didn't want to take their animals to the packing plant to sell them. Today in Iowa, most hogs are marketed through the packer buying station.

Seasonal Price Variations

Before the 1950's, most pigs were farrowed during the summer and marketed during the winter. Consequently, winter hog prices were low and summer prices much higher.

Means to overcome the seasonal price fluctuation were investigated by Experiment Station economists. They determined relative production costs of farrowing at different times. Producers found that farrowing sows every month and marketing hogs the year round reduced seasonal price variations and increased their own operational efficiency.

Seasonal price fluctuations are much lower today as a result. Many factors made the shift to year-round marketing possible. The development of modern farrowing crates and confinement systems is one example. But the economics of shifting to year-round farrowing were developed largely through Experiment Station economic research and brought to hog producers through Extension Service activities.

SWINE REPRODUCTION

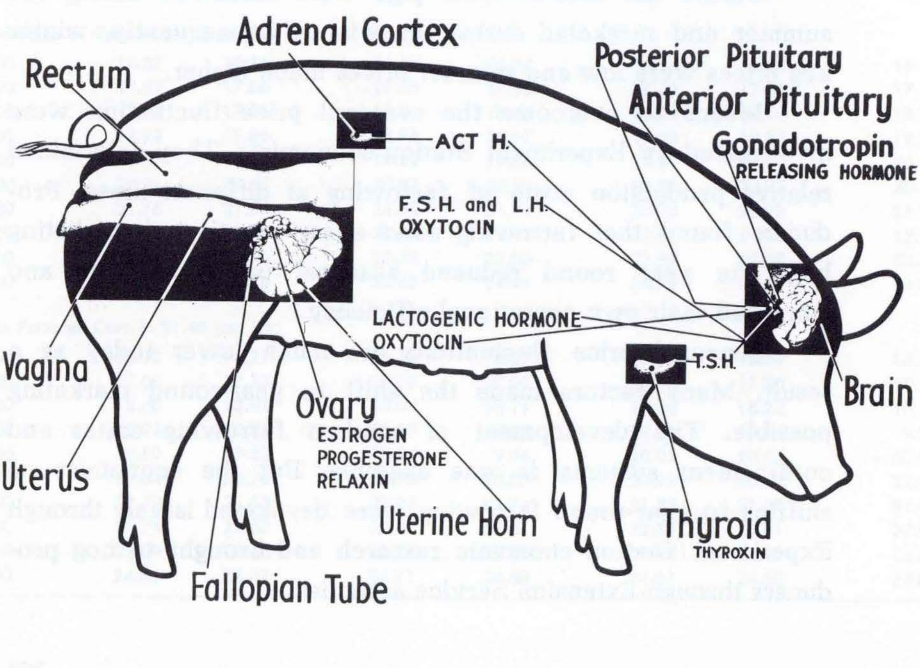
The mysteries of swine reproduction are being investigated at the Iowa Agriculture Experiment Station. Some reproduction research is sponsored cooperatively by the National Institutes of Health, the National Pork Producers Council, and the U.S. Department of Agriculture.

Understanding the Reproductive Cycle

The reproductive cycle in mammals is the period from the time the animal releases an ovum, or egg, until a fully developed fetus is born or another ovum is released.

Understanding reproductive processes may lead to practical application—improvement of the pig's reproductive potential. For example, look at the large gap between the reproductive potential of the average sow and actual pig production.

The anatomy of swine reproduction: focal point of extensive research.



17-Pig Litter Potential

Sows today have the potential to farrow 17 pigs per litter! But only about seven pigs per litter are actually marketed. Here's why:

Some breeds of pigs release about 17 ova, or eggs, during the heat period. Usually, all these ova have the potential to be fertilized and born as live pigs.

About 95 percent, or 16.2 of the 17 eggs, will be fertilized when the sow is bred. But embryonic loss accounts for 7 of the 16, and, about 4 months later, only 9 pigs will be born alive.

Of the 9 pigs born alive, only 7.2 will live to reach the market—about 40 percent of the sow's inherent potential. Experiment Station scientists are searching for ways to close this gap by increasing litter size, number of litters during a sow's lifetime, and baby pig survival.

Research in Embryonic Survival

What accounts for the sow's high rate of embryonic death loss during gestation? How can this loss be lowered? The reproductive process, especially as it affects embryonic development or survival, is being investigated at the Experiment Station.

The Estrous Cycle

Estrus, or heat, occurs in nonpregnant sows and gilts in a rhythmic cycle. The interval between the onset of one estrous period and the next estrous period is known as the estrous cycle. Physiological changes within the female's reproductive tract during estrus are important because they may affect conception, embryonic development, and litter size.

The estrous cycle of farm animals occurs in four phases: proestrus, estrus, metestrus, and diestrus. During proestrus, the reproductive system prepares for the release of the mature ovum from the ovary. During estrus, the female will mate. Metestrus immediately follows the estrous period, during which the uterus prepares for implantation of the embryo. If pregnancy does not follow, the female remains in diestrus until the onset of another estrous cycle.

Progesterone

Progesterone, the mammalian pregnancy hormone, plays an important role in the reproductive cycle. Fertilized eggs, or zygotes, for example, can be implanted in the uterus only when an adequate level of progesterone is available. Progesterone also affects embryonic development and fetal survival. A change in the progesterone level stimulates birth and, subsequently, lactation. If the animal does not conceive, a similar chain of physiological events occurs, but the high level of progesterone necessary for fetal development is not maintained. The changed environment stimulates the release of a new ovum, and the reproductive cycle begins once more.

In some mammals, the nonpregnant cycle covers the same length of time as a pregnant cycle. (After a sterile mating, "pseudopregnancy" is, in many ways, similar to a genuine pregnancy cycle, particularly in physiological changes in the uterus and ovaries.) In others, the unmated female experiences a much shorter cycle, which usually lacks full complementary uterine and ovarian development. The estrous cycle of a pig, for example, is only 21 days, while actual pregnancy lasts about 115 days.

The Role of the Corpus Luteum

Regulation of the reproductive cycle depends on an interaction of the functions of the corpus luteum, uterus, ovaries, pituitary gland, and central nervous system. Understanding how the corpus luteum works may be particularly important.

Before ovulation, a follicle forms on the surface of the functioning ovary. When the follicle ruptures, an ovum is released. The corpus luteum then forms at the site of the ruptured follicle. Its main function is to produce progesterone, which prepares the uterus for pregnancy and controls the length of the reproductive cycle.

Ovariectomy (removal of one or both ovaries) *at any time* during pregnancy causes death and absorption of the embryos or an abrupt abortion of all fetuses because this removes the corpus luteum and greatly reduces the level of progesterone production.

Daily replacement of progesterone and estrogen in ovariectomized gilts maintains the pregnancy. An inadequate level of progesterone results in increased embryonic death. Administering treatments that increase the level of progesterone, however, and adding estrogen increase embryo survival rates. For example, optimal embryo survival rates occur with daily treatment levels at a progesterone:estrogen ratio of 160:1.

The fine structure of the luteal cells in the corpus luteum of the pig reveals that the cytoplasm of these cells shows marked increases in membrane-limited granules (dense bodies) during early and midgestation and their disappearance in the last days of pregnancy. The corpus luteum of this species is a particularly rich source of a water-soluble hormone called relaxin. This hormone plays a role in the relaxation of the birth canal just before parturition. The levels of relaxin in the corpus luteum are low during the estrous cycle but increase during early pregnancy and reach maximum values just before parturition. The quantities of relaxin in the luteal cells have been correlated with the appearance and accumulation of the dense granules in the cytoplasm of the cell. Peak levels of relaxin and maximum quantities of the granules are found just a few days before parturition. In the last hours before delivery, however, relaxin levels become minimal, and the cells are depleted of granules. This suggests that the cytoplasmic granules are a likely site of relaxin storage.

Experiment Station scientists are studying the development, maintenance, and death of the corpus luteum and also the relationship of the life cycle of the corpus luteum to the uterus. Perhaps researchers may learn to manipulate reproductive cycles by controlling the corpus luteum.

Intrauterine Device (IUD)

The "intrauterine device" (IUD) somehow affects the development and maintenance of the corpus luteum and consequently influences reproductive processes such as estrus, conception, and embryonic survival. No one knows exactly how the IUD works, but researchers at Iowa State and elsewhere have found that a foreign object (in this case, inert plastic or nylon string) inserted in the uterus of an animal influences reproduction. But it affects different species in different ways.

The IUD shortens the estrous cycle of the ewe, for example, but it has no effect on the interval of the estrous cycle of the pig. But insertion of the IUD before or after mating somehow interferes with swine embryonic development. Scientists are searching for answers, both at the Iowa Experiment Station and other research centers across the United States. Perhaps learning how the IUD functions will help solve the mystery of embryonic death loss. Because the IUD affects both swine and humans similarly, the research may also be important in the understanding of human reproductive physiology.

Irritants and Toxic Agents

Irritation or inflammation of the uterus also seems to affect the life of the corpus luteum. Experiment Station researchers have introduced irritating agents and bacterial infections into the uteri of experimental swine while the corpora lutea were still producing a high level of progesterone, then studied the effects. If irritants are introduced in the latter phase of the cycle, the corpus luteum will be maintained for a prolonged period.

Influence of Hysterectomy

If the pig's uterus is completely removed (hysterectomy), the corpus luteum will remain and continue to produce progesterone for a period even longer than that of a normal pregnancy. Eventually, the corpus luteum regresses. The pig ovulates again, and a new corpus luteum functions, once more secreting progesterone for a prolonged period. If even a small part of the uterus remains after hysterectomy (partial hysterectomy), however, the normal estrous cycle will continue.

This indicates that the nongravid (nonpregnant) uterus may cause the corpus luteum to die after an unfertile mating. When the corpus luteum regresses, progesterone production is reduced, and the animal ovulates again.

In a fertile mating or conception, the corpus luteum develops and is maintained throughout gestation. But experimental evidence indicates that, if as much as a fourth of the uterus remains nongravid, the corpus luteum dies. The decreased level of progesterone then causes the embryos in the gravid portion of the uterus to die. If less than a fourth of the uterus is nongravid, however, the embryos will survive.

The significance? This phenomenon may account for the small percentage of apparently unfertile matings in swine herds. Ova may actually be fertilized, and the embryos may implant initially—but the nonpregnant parts of the uterus may dominate and cause resorption of the entire litter.

Estrogen and the Corpus Luteum

Some of the female hormone estrogen found in a gilt or sow is produced by the pregnant uterus. Research at the Experiment Station indicates that the pregnant uterus may affect the life of the corpus luteum through estrogen production. For example, when estrogen is administered to pigs, the corpus luteum is maintained and continues to produce progesterone for several months past the time it normally would have regressed.

Scientists now have methods to measure such hormonal levels in blood and perhaps learn how hormones affect other reproductive processes, such as regulation of the reproductive cycle, maintenance of pregnancy, and initiation of farrowing and lactation. Perhaps they can also learn to manipulate natural hormonal secretions, or apply synthetic hormones, that will influence or control these processes in the future. Through hormonal control, scientists might be able to cause more eggs to be released and fertilized, more fertilized eggs to be implanted, and more fetuses to live through development, be born alive, and survive.

The Pituitary Gland

The pituitary gland is the source of several protein hormones important not only for stimulation of ovarian function (development of follicles and corpora lutea) but also for body growth and metabolic functions. When the pituitary gland is removed from the immature pig, growth is markedly retarded, and sexual development is arrested. Removal of the pituitary during the estrous cycle in the sexually mature gilt results in cessation of subsequent cycles and regression of ovarian follicles and corpora lutea. The corpora lutea can be maintained in such experimental animals by daily injections of gonad-stimulating protein hormones, provided the uterus is also removed. Such experimental evidence helps to explain the interdependence of the pituitary with the regulation of ovarian and uterine function in this species.

A measure of biological activity of the gonad-stimulating, protein hormones (the gonadotropins: follicle-stimulating hormone, luteinizing hormone, and prolactin) in the pituitary gland of the pig reveals changes in their levels associated with particular stages of the estrous cycle and pregnancy. Synthesis and release of these hormones have been correlated with the growth of the ovarian follicles during the estrous cycle and the maintenance of the corpus luteum during pregnancy.

Stages of Embryonic Death Loss

Other factors also influence the high embryonic loss of swine. Experiment Station scientists are trying to determine at what stage of embryonic development the rate of death loss is highest.

The position, size, and spacing of pig embryos are being determined at 2-day intervals from day 2 to day 30 after breeding. These data are being correlated with the rate of death loss during the period to determine if a relationship exists between embryonic position in the uterus and death loss.

Experimental pigs are bred; then, small groups are hysterectomized at 2-day intervals in a current research project. Each uterine horn is opened and examined to determine development, position, and spacing of embryos within the horn.

Results for the first 16 days indicate that most embryos survive at least until the tenth day of pregnancy. Sometime after the tenth day, however, embryonic death loss rises. Why?

When scientists learn the exact stage of pregnancy at which most embryonic loss occurs, they can study the reproductive environment at that stage and perhaps determine the cause. Means to alter or optimize the embryonic environment at a certain stage of pregnancy may then be developed. A greater percentage of embryos might thus be able to live through this developmental stage and be born as live, healthy pigs.

Parameters of Embryonic Survival

Scientists are presently determining the parameters or limits of embryonic survival. Understanding the extreme limits of embryonic survival—both high and low—should help establish the optimum conditions.

The effects of nutrient intake on embryo survival, for example, are being studied. Sows are fed diets that range from an extremely low nutritional level to an extremely high one. Such research will enable scientists to determine the level of nutrient intake that will provide a uterine environment that assures maximum embryonic survival.

Increase Ovulation

Scientists are also trying to learn how to increase the number of ova, or eggs, released by the sow during her heat period. If ovulation rate can be increased and embryonic survival rate optimized, then the reproductive potential of the individual sow could be improved considerably.

Different breeds of pigs and different lines within the major breeds vary in ovulation rates. Although some breeds may consistently ovulate 15 to 20 eggs, others generally ovulate only 8 to 10 eggs. Inbreeding, age at breeding, weight at breeding, nutritional conditions, and environment also influence the rate of ovulation. Inbreeding usually reduces the ovulation rate, while crossing inbred lines markedly increases ovulation rate and the number of ovulations per sow.

Age and Ovulation

Sows normally release more ova than gilts. Research shows, however, that sows also lose a greater proportion of their embryos during the first 40 days of gestation or embryonic development.

Ovulation rates increase as the sow gets older, but litter size farrowed reaches a maximum by the fourth or fifth litter.

By the eighth gestation, the number of pigs born alive begins to decline, while those born dead increase sharply.

Ovulation Versus Litter Size

Increasing the ovulation rate does not necessarily mean that litter size also increases. Although scientists are developing means to manipulate ovulation rates, this has not thus far meant increased number of pigs born alive. Embryonic death loss is the big bottleneck holding back increases in litter size.

Success in litter size research will be measured by the number of pigs born alive, capable of withstanding the stress of survival. Increased ovulation rates and reduced embryonic losses will contribute to larger litters in the future.

Sexual Age and Litter Size

"Sexual age" refers to the number of heat periods a gilt has experienced. Animals of the same calendar age are not necessarily of the same sexual age. Sexual, or physiological, age at time of first breeding definitely affects litter size.

Three groups of gilts were raised under similar conditions in a research project at another midwestern experiment station. One group of gilts was bred the first time they came into heat. Another group skipped the first heat period and was bred when the gilts came into heat the second time. The third group passed at least two heat periods before being bred.

The results were significant. The first group farrowed an average of only 6.9 pigs per litter; the second, 8; and the third group, 9.4 pigs per litter.

Nutrition and Litter Size

Nutritional conditions can limit or enhance the productivity of the pig.

Feeding high-energy diets, usually referred to as "flushing," causes a higher ovulation rate. Pigs on a restricted diet (5,370 calories, or 4 to 4-1/2 pounds of feed per day) were compared with pigs on a high-energy diet (10,030 calories, or 8 pounds per day) in an Experiment Station research survey. Researchers found that animals receiving the higher energy intake released an average of 1.57 ova more per heat period than did those on the low-energy diet.

Such a full-feeding regimen should last from 11 to 14 days before the expected estrus or mating. Research shows that while full feeding for a longer time increases ovulation rate above normal feeding, the highest ovulation rates occur when the sows are full-fed only for the optimum 11-14 day period.

Although full feeding before mating increases ovulation rates, researchers have found that continuing the high-energy diet after mating causes a greater loss of embryos. Birthweight, however, is greater in pigs born to dams given high-energy diets.

Protein levels seem to have little effect on reproductive performance of pigs. Research indicates that increasing the crude protein in the sow's rations above 15 percent assures only a more expensive ration.

The quality of protein, however, may affect reproductive performance. Protein should provide the necessary amino acids, or body building blocks, to meet the needs of the gestating sow. Experiment Station studies indicate that corn and soybean meal will provide these essential amino acids.

Hormone Administration

Various reproductive hormones have been found to increase ovulation rates in sows. These include the gonadotropic hormones, such as pregnant mare's serum gonadotropin (PMSG), follicle-stimulating hormone (FSH), luteinizing hormone (LH), and human chorionic gonadotropin (HCG).

These hormones decrease the time between ovulations, increase the duration of estrus, increase progesterone production, and may cause an increased incidence of cystic ovarian follicles.

Shortened Farrowing Intervals

Sows in Iowa now average about 1.5-1.6 normal-sized litters per year. But reproduction research indicates that an average of 1.9 litters per sow annually is feasible for the future through early weaning and good management. Experiments show that sows can be rebred on the first heat period after weaning a litter (7 to 10 days later).

Artificial Insemination

Artificial insemination (AI) is the introduction of semen into the uterus by other than natural means. AI sometimes results in better conception rates than does natural breeding. More important, however, it extends the usefulness of a valuable, superior male breeding animal.

Artificial insemination of swine is possible, but it is not currently as practical for swine as it is for dairy and beef. The necessity of frequent semen collections and continuous maintenance of a boar stud has limited the adoption of AI in swine breeding. Boar semen can be collected and held in a liquid extender, unfrozen, for only 60 hours. Freezing techniques have recently been developed that will allow boar semen, like bull semen, to be frozen, stored, then thawed and used for AI. The semen can be stored for only 1 or 2 weeks, however, before it loses its motility and can no longer be used for insemination.

Estrus Synchronization, AI, and Fixed Mating

Estrus synchronization, a means to manipulate animal heat periods, will probably be used with artificial insemination in fixed-mating swine breeding programs in the future.

So, to use AI to its full potential, the swine breeder of the future will want to inseminate all his animals at a predetermined time. If all his sows and gilts come into heat together, they can be artificially bred on the same day. Nearly 4 months later, most of the synchronized sows will farrow during a brief period.

Experiment Station scientists are investigating estrus-inhibiting drugs that may be used for estrus synchronization. One example is an experimental drug called methallibure. The drug blocks the pituitary gland's control of the ovaries, suppressing the normal heat period and ovulation.

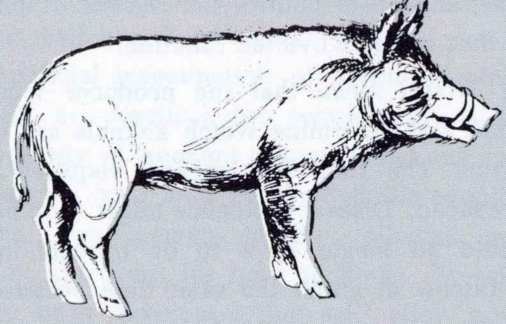
The heat-suppressing drug is then removed from all the animals' rations simultaneously, and ovulation-stimulating drugs are administered. Most of the treated sows will come into heat and ovulate 24 hours later. At that time, the entire herd can be bred artificially. Although this drug effectively synchronizes reproductive cycles in the pig, experimental evidence also indicates that it has adverse effects on embryos; therefore it is not available for practical application in pig production. Other small polypeptide hormones produced in the brain can be injected into the animal to control the release of pituitary gonadotropins, and thus regulate ovarian function.

Fixed mating would mean that the producer would no longer have to watch and determine which animals are in heat over a 21-day period. The time and expense required for AI would be greatly reduced. Disease incidence might drop because breeding stock would no longer have to be brought into the herd. Sows would farrow at about the same time because they were bred together.

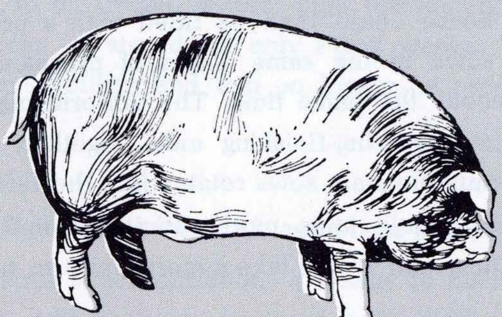
A farrowing house could then be filled with a predetermined number of sows in the same stages of pregnancy. All would farrow at about the same time. The uniform pigs then could be moved into growing-finishing units together, and a new batch of uniformly pregnant sows rotated into the farrowing house. The producer would have more efficient utilization of his labor and facilities, and would take a more uniform product to market.

Continuing Search for Reproductive Secrets

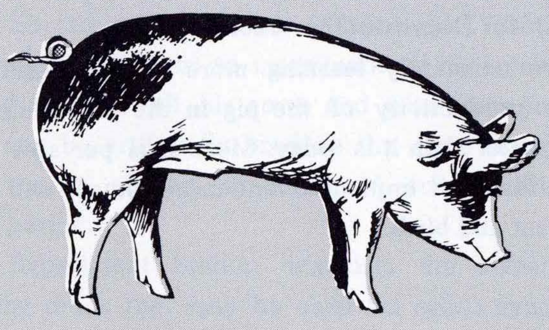
Scientists are constantly learning more of the secrets of reproduction. The productivity of the pig in the future should be considerably greater than it is today. More eggs per sow will be released, fertilized, and implanted, and more fetuses will live through development and birth.



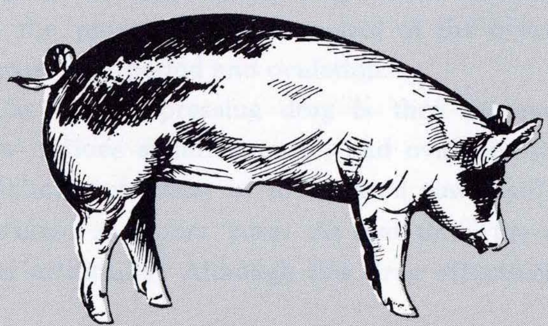
Ancestral wild pig



1940 hog



Today's hog



Hog of the future

THE HOG OF TOMORROW

What will the hog be like in 10, 20, 30 years? How about swine production itself?

No one knows for sure, of course, but researchers at the Experiment Station are looking at current trends and research to forecast future development.

No More Fat Than a Chicken?

The hog of the future may carry no more fat cover than a chicken or a steer does today. He'll be far more muscular than today's pig. This type of hog may yield just a few pounds of fat, rather than the 25 or 26 pounds that today's hog carries, or the 42 pounds on a 1956-style pig.

The image of an extremely lean and muscular pig may not seem quite normal to many people. It doesn't fit our mental picture of the way a hog should look.

But actually, the trim, lean hog of tomorrow will be closer to the pig's natural shape than either the hog produced in 1940 or the hog of today. Compare a wild pig to a domestic one. The wild animal carries practically no excess fat. He is a robust, hardy animal, well suited to his harsh environment. Tomorrow's rugged, durable hog will also be adapted, through selective breeding, to a highly specialized consumer demand as well as to a highly specialized environment.

2:1 Feed-Conversion Ratio

The hog of the future will probably convert feed to liveweight at a ratio of about 2:1. This will come primarily through controlled, selective breeding, although future improvements in nutrition and management will also contribute.

Under optimal conditions, some hogs today can produce 100 pounds gain on 250 pounds—a 2.5:1 feed-conversion ratio. Such animals, who can digest feed more completely than others and convert it to the type of product that the homemaker demands, will be used in the selective breeding programs

260 Pounds Market Weight

Market weight for hogs in the future will probably be around 260 pounds, researchers predict.

Actually, market weight has been creeping slowly but steadily upward for several years. Many hogs now go to market at 230 pounds, rather than the traditional 220 pounds.

True, feed efficiency of today's pig generally decreases after he reaches 200 pounds. Tomorrow's later maturing pig, however, will efficiently convert feed to desirable lean meat to a heavier market weight. This will be important, because labor will be far more expensive than feed in the future. And the time and labor required in the packing plant to process a 220-pound or a 260-pound carcass are about the same. It'll be more profitable to feed to heavier weights.

Hams and loins from tomorrow's hog, of course, will be larger than those at a meat counter today. This won't matter because the processor will alter cuts to the sizes and shapes that consumers desire.

Pig Psychology

Tomorrow's successful hog producer will need a better understanding not only of the *physiology*, but also of the *psychology* of the pig. Natural animal instincts and inclinations will be used as production tools to optimize health conditions and minimize labor requirements and pollution hazards.

The pig is the most intelligent and clean of all farm animals. We have seen how, in Unit K, these psychological tendencies are exploited to reduce labor requirements and make hog farming a more pleasant business.

Hogs have other psychological patterns, too. Like humans, they have preferences for where, when, what, and how much they eat. These natural inclinations will be studied and operations devised to exploit them.

We can see today that the stress-prone pig—the one that can't live with the stresses of confined rearing—won't be suited for tomorrow's more intensive confinement production. Breeding stock will be selected in the future for adaptability to confinement, just as stock today is selected for meatiness and faster growth.

THE CHALLENGE AHEAD

Modern agriculture is quite different from farming a few years ago. It will change even more in the future. Research faces an immense challenge—to provide information to help guide and direct agricultural change, and to solve problems that invariably accompany new ways of doing things.

The challenge ahead for the Iowa Agriculture and Home Economics Experiment Station is to conduct research to serve the people of Iowa and our nation, to assure the best future possible. The Experiment Station, with its facilities and expertise, has a continuing responsibility to discover and utilize new knowledge, and to seek solutions to current and future physical, social and economic problems. Planned research will lead the way to a better life for all in the future.