REPORTS OF THE 20TH ANNUAL

SWINE DAY

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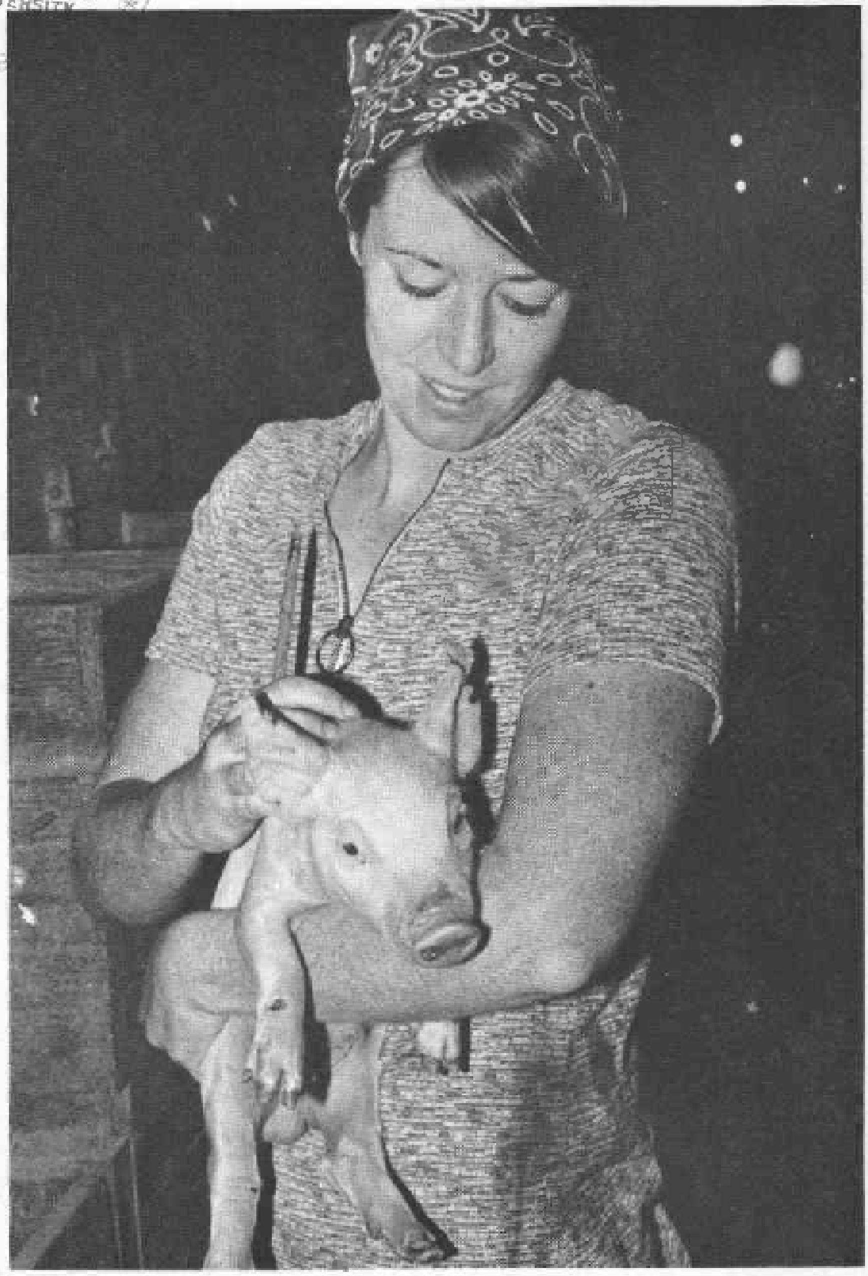

20th ANNUAL OREGON STATE UNIVERSITY SWINE DAY
WITHYCOMBE AUDITORIUM
OSU CAMPUS

Saturday December 2, 1978

MORNING SESSION

PRESIDING: J. E. Oldfield

8:30	REGISTRATION	
9:15	Welcome	J. R. Davis
9:30	Use and Regulations of Use of Nitrites in Meat Curing	W. H. Kennick
9:55	Palatability and Feed Preference Studies with Swine	P. R. Cheeke
10:20	REFRESHMENT BREAK	
10:35	An Autogenous *E. coli* Vaccine for Preventing Baby Pig Scours	B. M. Coles
11:00	Oregon Porkettes Activities	Ruth Kaser
11:10	Efficacy and Safety of Feed Additive Usage of Antibiotics	V. W. Hays
12:10	LUNCH - ROASTED MARKET HOG	Served by the Withycombe Club

AFTERNOON SESSION

PRESIDING: R. L. Pittman

1:00	Oregon Pork Producers Association Activities	Floren Zielinski
1:20	Marketing Alternatives for Pacific Northwest Hog Producers Panel Presentation with Audience Participation	Panel: C. O'Connor H.S. Flagg M. Harper B. Hawkins R. Heyerly
2:20	REFRESHMENT BREAK	
2:30	Components of Increased Litter Productivity	D. C. England
2:55	Postweaning Performance of Pigs Fed Different Antibiotics in Rations Differing in Fiber	J. S. Powley
3:20	Summary of Information from Symposium at Northwest Pork Exposition	D. C. England
3:45	ADJOURN	

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Use and Regulations of Use of Nitrites in Meat Curing

W. H. Kennick

THE ORIGIN of the preservation of edible flesh for human consumption is lost in antiquity. As early as 3000 B.C., salted fish was eaten as it was safe to eat for a number of days longer than fresh fish. By 900 B.C., in the days of Homer, the benefits of curing meat were well known. Instructions for curing meat can be found in early Roman writings.

THE DEVELOPMENT of curing methods aided in the progress of civilization by making it possible to transport food over long distances and extended times to centers of a cultural, political and industrial society.

EARLY MEAT curing was an art form; and the procedures, as is true today with many fine cured meats and specialty sausages, were passed down from generation to generation.

IT WAS not until the turn of this century that it was shown that pure salt (sodium chloride) does not produce the "cure color" associated with common practices of curing. Rather it is the presence of sodium and/or potassium nitrate present as an impurity in unrefined salt used in curing that is essential for this development. Nitrate is converted to nitrite by naturally occurring bacteria, and chemical breakdown produces nitric oxide which reacts with the color pigment of meat (myoglobin). With the addition of heat during smoking or cooking, the pink pigment (nitrosohemochrome) develops. The color of cured meat is incidental to the preservative effect of curing meat.

STUDIES CONDUCTED during the early part of this century of the residual nitrate and nitrite in commercially cured meats in the United States led to the realization that bacterial conversion of nitrate to nitrite was not dependable enough for precise quality control. Since nitrite is the essential chemical in curing, the addition of nitrite to the curing mixture would eliminate the necessity for bacterial conversion and give better quality control.

IN 1926 the Bureau of Animal Industry of the U.S. Department of Ag-

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W. H. Kennick, Associate Professor of Meats, Department of Animal Science, Oregon State University.

riculture authorized the use of sodium nitrite in quantities not to exceed 1/4 oz. per 100 lbs. of meat (156 parts per million, ppm).

HIGH LEVELS of salt were used in curing meat well into this century. I well remember my mother parboiling the Sunday ham to get the salt out of it, before baking. With the general availability of refrigeration these levels of salt became unnecessary.

FROM THE 1920's through the 1950's great strides were made in the methods of producing cured meats that substantially reduced the time and cost associated with this process. One of the discoveries that greatly aided those developments was that Vitamin C (ascorbic acid) greatly speeded the breakdown of nitrite to nitric oxide. After extensive studies the USDA authorized the use of ascorbic acid, sodium ascorbate, and sodium erythrobate (three substances having the same effect on curing) as an accelerator in the curing process. The new regulation specified that not more than 7/8 oz. per 100 lbs. of meat, or 87.5 oz. can be added per 100 gal. of pickle solution for curing solid meat cuts.

THE ROLE OF NITRITE IN CURED MEAT. Serendipity, the faculty of making desirable discoveries by accident, certainly played an important part in the development of the vast cured meat industry in this world and it's contribution to our food supply. Scientific research has now documented the functions of nitrite in the cured meat process and it's contribution to the safety and stability of these products. They are:

1. Proper levels of nitrite in the presence of sodium chloride in cured meats prevent the development of Clostridium botulinum bacteria and the potent botulinum poison they produce.
2. Nitrite (or the nitric oxide it generates) is the only known substance that selectively prevents botulinum toxin formation and acts as a general antimicrobial agent for preventing growth of yeasts and molds but does not mask evidence of spoilage (slime, mold, off odors, etc.).
3. Nitrite imparts antioxidant properties to cured meats that delay rancidity.
4. Nitrite is essential to the development of the characteristic color and flavor of cured meat.

5. Nitrite imparts a characteristic flavor to most cured meat products that is different from salted meats and helps prevent a warmed over flavor.

IN A search for a substitute for nitrite in meat curing more than 700 compounds have been tested, and no single compound has been found to produce all of the effects of nitrite.

CLOSTRIDIUM BOTULINUM is a bacterium which produces a potent toxin which causes human nervous disorders and death. It occurs in soil throughout the world. The organism is commonly found in the spore or resting state, which is harmless, but it becomes dangerous when it germinates and grows in the absence of oxygen. All foods come in contact with soil either directly or by air-born dust and must be considered contaminated by spores of *C. botulinum*. Extensive investigations have demonstrated that fresh meat is not an exception to this. Our currently used procedures in food handling have proven quite successful in avoiding this widespread danger as evidenced by the latest data (1976). The Center for Disease Control, 1977, reported 23 outbreaks of botulism involving 40 cases and 5 deaths. Only two of these outbreaks were due to animal products and both were traced to fish. This is in striking contrast to the frequent outbreaks from home cured meats in France and Spain where nitrite and/or nitrate are either not used or are poorly controlled.

RECENT RESEARCH has indicated that the initial ingoing level of nitrite is most critical. Nitrite does not prevent the true spore germination process but inhibits the outgrowth and cell division of the vegetative state which is necessary for the production of toxins.

THE ANTIOXIDANT properties of nitrite are probably due to the same reaction that produces the cured meat color. The iron compounds in the color pigment of uncured muscle act as a catalyst on lipid oxidation when in the natural (oxidized, Fe^{+++}) form. The reaction between these iron compounds and nitric oxide, which with the addition of heat forms the cured meat color, also reduces the iron pigment (Fe^{++}). The reduced iron does not catalyze lipid oxidation.

IT IS not clear at this time why nitrite prevents the warmed over flavor common to most fresh meat. The best evidence at this stage indicates that the same reaction that reduces oxidation also prevents the warmed over flavor.

THE HEALTH HAZARD? How did we arrive where we are? Why is a class of food which has been eaten for thousands of years with no known harmful effect being questioned? Its very existence is in danger and with it all of the allied industries. This is a "tangled web" that defies one clear pathway, but several occurrences are pertinent.

THE PUBLIC was made startlingly aware of proposed changes in the Food Additive Amendment to the 1938 Pure Food, Drug, and Cosmetic Act by stories such as: "Poison in the Pantry"; "Our Daily Poison"; "The Hidden Assassin"; etc. These types of publications were widely circulated and given sensationalized publicity by the media.

THE SO called Delaney Clause, which was attached to the Food Additive Amendment states "that no additive shall be deemed to be safe if it is found, after tests which are appropriate for the evaluation of the safety of food additives, to induce cancer in man or animals-------". This clause, which on the surface sounds very appropriate and proper, has had a profound effect on food law. As currently applied, this clause could be better stated, "that any substance which when fed to any animal in any quantity can be shown to cause cancer, cannot be added to the food supply or sold in the United States".

THE DISCOVERY, in 1970, that cancers were caused in laboratory animals by nitrosamines, which can be formed by interaction of sodium nitrite with normal protein breakdown products (secondary amines), set off a chain reaction that is still in progress. These facts were widely publicized and numerous meat items were implicated.

THE CURED meat industry reacted promptly to the information that nitrosamines were present in some cured meat products. Although analytical procedures to analyze for nitrosamines in parts per billion (ppb) were in many cases inadequate, results of these studies began to be published in 1973.

IN 1973 the Secretary of Agriculture appointed an Expert Panel on nitrites, nitrates, and nitrosamines to study and advise the Department of Agriculture on the safety of continued use of these products. The Panel conducted 14 official hearings over a four year period and attended foreign conferences on the subject. Canada and most European nations are also very concerned about this subject, both for their people's safety and as it affects international commerce.

CURED MEATS and curing processes were reviewed on a product-by-product basis, because the characteristics of individual cured products differ. The safety of cured meats and the possibility of botulinum toxin poisoning were reviewed and documented. The recommendations can be summarized as follows:

1. Nitrate should be restricted to use in dry-cured and/or fermented sausages pending further studies on the need for nitrate in these products.
2. Nitrite should be restricted to 156 ppm rather than 200 ppm in cooked, cured sausages, in which no nitrosamines have been detected.
3. Nitrate and nitrite should not be used in infant and junior foods containing meat and poultry products.
4. In canned, sterile products (corned beef hash, potted meat, deviled ham), residual nitrite should be limited to 50 ppm.
5. In curing solid muscle cuts (hams, picnics, canned hams, beef plates, briskets, and rounds) and in canned, shelf-stable chopped meats, nitrite additions should be limited to 156 ppm.
6. Special attention should be given to bacon. The addition of nitrite should be restricted to 125 ppm in the presence of 550 ppm of sodium ascorbate or erythorbate.

STUDIES USING today's ultra-sensitive equipment have verified the presence of nitrosamines in a large variety of cured products; the levels reported run from 0 to 48 parts per <u>billion</u>. Bacon has caused the most concern. Although zero levels have been found in raw bacon, the high heats used in cooking bacon in America stimulate the formation of nitrosamines during cooking. Levels of nitrosamines in cooked bacon vary from 30 to 106 ppb and in drippings from 60 to 204 ppb. It is also evident that nitrosamines are volatilized into the air during cooking.

THE TOXICITY and carcinogenicity of a number of nitrosamines have been determined on experimental animals. They run from 18 to 7500 parts per million - not parts per billion. This means that there is a 1000 or more fold difference between the occurrence of nitrosamines in cured products and the experimentally determined detrimental levels. There have been a number of tests feeding experimental animals cured products over more than one generation without any signs of a deleterious effect.

THE LATEST report to come before the FDA and USDA reported that nitrite itself was a carcinogen. This study was conducted by Massachusetts Institute of Technology and sponsored by the FDA. High levels of nitrite produced 12.5% cancer in the test animals while the controls developed 8.4% cancer. This study has come under serious scientific and judicial question.

THE LATEST firm proposal is to amend the Federal meat inspection regulation by requiring that 40 ppm of sodium nitrite or an equivalent amount of potassium nitrite (49 ppm) be added to bacon and by requiring that 0.26% potassium sorbate by weight be added to bacon.

RUMORS CONTINUE to fly here and abroad that the ultimate intent is to rule out the use of nitrite as an ingredient in cured meat.

IF YOU are interested in a more indepth study of this problem, I would refer you to Council for Agricultural Science and Technology (CAST), report No. 74.

PALATABILITY AND FEED PREFERENCE STUDIES WITH SWINE

P. R. Cheeke[1]

Palatability can be defined as the sum total of all influences which determine the response of an animal to a feed. The significance of palatability differences is very difficult to assess. Basically, they become important only when a feed is so unpalatable that significant feed rejection occurs, and the animal does not eat enough feed to meet its nutrient requirements for maximum performance. If, for example, feeder pigs have a choice between a corn-based ration and a nutritionally equivalent ration based on barley, they will prefer the corn-based diet, because corn is more palatable to pigs than barley. However, this is not of much practical significance, because if they are not given a choice, they will readily accept a barley-based diet. Thus it is difficult to interpret the results of preference tests, when pigs are given a choice between two feeds, with the usual practical situation where they do not have a choice. Nevertheless, it is useful to have knowledge of the relative palatability of feeds. Eventually, it would be desirable to include such information in ration formulation.

Several factors influence palatability. These include taste, smell and touch. For example, the fibrous hulls of barley are responsible for its low palatability, due to the physical irritant effect of the fiber. Taste sensations are responses to sweet, salty, bitter and sour tastes. Different animal species vary in their responses to these taste sensations.

One potential method of over-coming unpalatability of feeds is through the use of feed flavors or taste modifying substances. These may have application in specific circumstances. Certainly the only obvious use of feed flavors would be with feeds of low palatability, since feeds of acceptable palatability would be consumed in adequate amounts. An interesting application of feed flavors is called "through-the-sow flavoring." The lactating sow is fed a specific flavor, which is transferred to the pigs through the milk. The same flavor is used in the creep and starter feed. The objective is to impart a specific imprinting of the flavor-response to the baby pigs. The practical value of such a procedure has yet to be adequately determined.

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[1]Associate Professor, Department of Animal Science, Oregon State University.

Nutrient deficiencies can affect feed intake. Protein, amino acid and vitamin deficiencies all result in depressed feed intake. However this is not legitimately viewed as a palatability effect.

Orr (1978) has reported on the relative consumption of several feed ingredients by young pigs. Some of the data are shown in table 1. These results show that corn and wheat are of similar palatability, while barley and oats are unpalatable as compared to corn. However, as shown in Table 2, when pigs don't have a choice, performance on the unpalatable feed may be equal to that on a corn-soy diet.

TABLE 1. RELATIVE FEED INTAKES OF PIGS FED DIFFERENT DIETS IN A TWO-CHOICE COMPARISON TEST (ORR, 1978)

Diets compared	% Consumption of each diet	
	Corn-Soy	Other diet
Corn vs wheat	43.9	56.1
Corn vs sorghum	64.6	35.4
Corn vs corn + 30% oats	79.0	21.0
Corn vs barley	92.4	7.6
Corn vs feeding oatmeal	95.7	4.3
Corn vs dehulled rolled oats	65.1	34.9
Corn-Soy vs corn-soy + 7% meat meal	87.2	12.8
Corn-Soy vs corn-soy + 3% alfalfa meal	80.8	19.2

TABLE 2. PERFORMANCE OF WEANER PIGS FED DIFFERENT DIETS (ORR, 1978)

Trial	Diet	Average daily gain (lbs.)	Average daily feed (lbs.)	Feed/Gain
1	Corn-Soy	.79	1.50	1.87
	Sorghum-Soy	.88	1.56	1.77
	Wheat-Soy	.79	1.43	1.80
2	Corn-Soy	1.06	2.29	2.16
	Barley-Soy	.90	2.05	2.27
	Feeding oatmeal-soy	.79	1.65	2.11
	Dehulled rolled oats-soy	1.17	2.11	1.83
3	Corn-Soy	.90	1.69	1.87
	Corn-Soy + 7% meat meal	.79	1.52	1.90
4	Corn-Soy	1.36	2.44	1.78
	Corn-Soy + 3% alfalfa meal	1.12	2.24	2.00

In some studies from Yugoslavia, Zivkovic et al. (1978) reported that the use of feed flavors in creep feeds increased the gains and feed intakes of suckling pigs, but had no effect on weaned pigs. They suggested that feed flavors might be useful for baby pigs in facilitating their change from the sow to solid feed.

In studies of the potential value of alfalfa meal as a diet ingredient for swine, we have shown that its low palatability is one of the factors that limits its use. When given a choice, swine reject alfalfa containing diets at very low levels. Results shown in table 3 reveal that pigs can detect dietary alfalfa levels as low as 1%, and will reject these diets in favor of an alfalfa-free diet.

TABLE 3. COMPARATIVE INTAKE BY GROWING PIGS OF DIETS WITH AND WITHOUT ALFALFA MEAL (CHEEKE, 1978)

	% Intake of each diet	
% Dietary alfalfa	Alfalfa-Free diet	Alfalfa-Containing diet
0.5	49	51
1.0	63	37
2.5	66	34
5.0	65	35
10.0	74	26
20.0	81	19
30.0	97	3

We are attempting to identify the factors in alfalfa that account for its low palatability. One possibility is a type of compound called saponin. Saponins are bitter compounds that may be responsible for the unpleasant taste of alfalfa. Plant breeders have selected alfalfa for low and high saponin content. When diets containing high and low saponin alfalfa meal were fed to pigs, the low saponin type was preferred (table 4). However, when each of the low saponin and high saponin alfalfa were compared to an alfalfa-free diet, in a two-choice feed preference test, the alfalfa-free diet was preferred at all alfalfa levels tested (table 5). Thus, even though low saponin alfalfa is more palatable than the high saponin type, pigs would rather eat an alfalfa-free diet than one with low-saponin alfalfa. Further studies are in progress to attempt to identify other compounds that contribute to the low palatability of alfalfa for swine.

TABLE 4. RELATIVE INTAKES BY GROWING PIGS OF DIETS CONTAINING HIGH AND LOW SAPONIN ALFALFA MEAL

	% Dietary alfalfa		
	1.0	5.0	15.0
% Intake of high saponin diet	39	18	32
% Intake of low saponin diet	61	82	68

TABLE 5. PREFERENCE RESPONSES OF GROWING PIGS FOR DIETS WITH AND WITHOUT ALFALFA MEAL

	% Dietary alfalfa			
	1.0	2.5	5.0	10.0
Low saponin _vs_ control				
% intake of low saponin diet	26	34	29	11
% intake of alfalfa-free control	74	66	71	89
High saponin _vs_ control				
% intake of high saponin diet	26	27	18	9
% intake of control	74	73	82	91

We have also looked at the effect of a feed flavor on the acceptability of rations containing alfalfa. No consistent beneficial effect of the flavor was found (table 6).

TABLE 6. EFFECT OF FEED FLAVORS ON INTAKE OF DIETS VARYING IN ALFALFA LEVEL

	% Dietary alfalfa		
Treatment	2.5	10.0	30.0
Alfalfa without added flavor	53*	42	59
Alfalfa + Flavor 1**	47	58	51
Alfalfa without added flavor	56	45	53
Alfalfa + Flavor 2	44	55	47

*Intake of each diet as a % of total intake.
**Flavor 1 and Flavor 2 are two commercial feed flavors.

Conclusions

Feedstuffs differ in their palatability to swine. This is relatively easy to measure, using a two-choice comparison test. It is less easy to interpret the results. Unpalatability becomes important only when it is of sufficient magnitude to depress feed intake.

One of the factors limiting the value of alfalfa as a feed for swine is its low palatability. This is partly due to its saponin content. Alfalfa selected for low saponin content is of increased palatability. Other as yet unidentified compounds also contribute to the low acceptability of alfalfa.

References

The following papers from the Proceedings of the First International Symposium on Palatability and Flavor Use in Animal Feeds, October 10-11, 1978, Zurich, Switzerland:

Cheeke, P. R. Factors influencing the palatability of alfalfa for swine and rabbits.

Orr, D. E. Determination of individual feed ingredient and total ration palatability.

Zivkovic, S., and co-workers. Experiments with flavored feeds in the rations for piglets and growers.

AN AUTOGENOUS *E. coli* VACCINE FOR PREVENTING BABY PIG SCOURS

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Colibacillosis in neonatal pigs is caused by enteropathogenic strains of the common gut bacterium *Escherichia coli.* There are many enteropathogenic strains of *E. coli,* and each strain stimulates a specific antibody response in an animal. There is almost no cross reaction between strains, so antibodies against "Strain A" will not protect against "Strain B". A newborn piglet has no bacteria in its gastrointestinal tract, but as it comes in contact with its surroundings, the gut becomes colonized by a variety of microorganisms. If colibacillosis has been a problem in the herd, the newborn pig may be exposed to enormous numbers of an enteropathogenic strain of *E. coli.* These organisms rapidly become established in the midgut lining, outgrowing all other bacteria, and produce a toxin which results in the severe diarrhea characteristic of the disease.

Neonatal pigs receive antibodies from the sow in the colostrum and milk. If the piglet suckles immediately after birth and suckles frequently, protective antibodies in the milk will be present in the piglet gut. High levels of an antibody specific for an enteropathogenic strain of *E. coli* in the colostrum and milk will prevent the unlimited colonization of that particular strain of *E. coli* in the gut.

High antibody levels in the sow can be initiated by vaccinating the sow with the enteropathogenic *E. coli* strain responsible for the baby pig diarrhea. In vaccinated animals, the highest antibody levels are found 3-4 weeks after vaccination. If the sow is vaccinated 3 weeks before farrowing it follows that her milk will contain the highest possible antibody levels during the first week of the neonates's life.

Theoretically, a sow could be vaccinated with live or dead *E. coli* organisms using various inoculation sites and she would show elevated *E. coli* antibody levels. However, extensive studies by Dr. E. M. Kohler at Ohio Agricultural Research and Development Center have shown that the highest colostrum and milk levels are elicited by oral vaccination using live *E. coli.* By feeding enormous numbers of an enteropathogenic *E. coli* strain to sows, Dr. Kohler has demonstrated in numerous field trials that the enhanced antibody levels in the milk will prevent neonatal pig scours. The sow appears completely unaffected by this massive *E. coli* burden; the only effect may be a slight transient diarrhea in the occasional animal. The most critical factor in this method is to select the right *E. coli* strain for the vaccine; namely, the specific enteropathogenic strain which is causing colibacillosis in the neonatal piglets in that particular herd. The only sure way to collect this organism is to isolate it from an infected piglet in the early stages of the disease.

Using Dr. Kohler's method and a modification of that developed at the School of Veterinary Medicine, Iowa State University, we have tried to work out a vaccination schedule that would be workable and yet effective under actual field conditions. This procedure is directed toward the prevention of colibacillosis during the first week of life only and is effective only against the specific strain of *E. coli* included in the vaccine. We strongly recommend that a producer work closely with his veterinarian in setting up this program.

If *E. coli* scours have been diagnosed on the premises, the first step is to select a piglet less than 5 days old (less than 3 is preferable) and showing diarrhea for less than 12 hours. The pig should be untreated and nursing regularly - not starved or ill in some other way - and from litters in which no antibiotics have been given. Pigs that have been treated or have had diarrhea for a couple of days can have in their guts secondary strains of *E. coli* which can outgrow the enteropathogenic strains. If these strains were used for the vaccine, they would be useless, so every effort must be made to isolate the enteropathogenic strain of *E. coli*. The piglet should be submitted to the VDL for necropsy and culture. If a significant *E. coli* isolation is made, a culture is sent to the veterinarian, and he will work with the producer in setting up the vaccine program as shown in the following schedule. If the vaccine is made on the farm, it is essential that an incubator capable of maintaining a constant temperature of 95° - 100°F (37°C) is obtained. A small egg incubator is excellent, and some ingenious people have used a non-working refrigerator heated with a thermostatically controlled light bulb.

E. coli Vaccine Preparation

Preparation of Inoculum

Day 1 1. Inoculate a plate with the stock *E. coli* culture which has been held in semi-solid media. Incubate at 37°C (98°F) for 24 hours.

Day 2 2. Check plate to be sure it is a pure culture of *E. coli*. If O.K., make a sweep across the plate with a loop or swab and inoculate 2 tubes of Brain Heart Infusion (BHI) broth which will be supplied by the VDL. Incubate 18-24 hours at 37°C.

Preparation of Culture Milk

Day 3 1. Bring 1 quart of skim or 2% pasteurized milk to 37°C. Add the 2 tubes of *E. coli* broth cultures and incubate at 37°C for 24 hours. The milk may bubble over during incubation so put carton on a pan.

Preparation of Vaccine Milk

Require 1 pint milk for each sow on 4 consecutive days.

Day 4 I. Vaccine for 6 sows

1 gallon of milk will be required per day for 4 days.

1. Bring a gallon carton of skim or 2% milk to 37°C before inoculation. This can be accomplished by placing carton in a 200°F oven for 1½ hours.
2. Remove 1 pint of milk from carton and replace it with 1 pint of the culture milk (Day 3 above). Incubate at 37°C for 24 hours. Milk may bubble over so place carton on a pan.

Day 5 3. The next day remove 1 pint of milk from the gallon of vaccine milk and add this to a new warm gallon of milk (less 1 pint).

4. Incubate this new gallon for 24 hours at 37°C.
5. Feed the remaining gallon to the sows - 1 pint per sow - as soon as possible.

Day 6, 7, 8 6. Repeat routine (3, 4 and 5) on days 6, 7 and 8 to give a total of 4 feedings to each sow.

II. Vaccine for 15-20 sows;

Require skim milk powder

Day 4 1. Prepare the milk in a 3 gallon plastic pail. Reconstitute enough milk powder for 3 gallons using warm water (100°F). If extra strength plastic bags are available (i.e. turkey freezer bags), first line the pail with these. After incubation the bags can be tied off and transported to farm.

2. Remove a quart of milk from the pail and add the quart of culture milk.

	3.	Incubate at 37°C for 24 hours. Milk may bubble over so place a pan under pail.
Day 5	4.	After incubation, remove 1 quart of the milk and use this to inoculate a second 3 gallon pail of warm reconstituted milk which will be incubated at 37°C for 24 hours.
	5.	Feed the remaining vaccine milk to sows at 1 pint per sow.
Day 6, 7,8	6.	Repeat these procedures to allow 4 days feeding in all.

Oral Vaccination of Sows

1. Sows should be fed *E. coli* vaccine from 3-4 weeks prior to farrowing - latest should be 14 days.
2. Sows are fed cultures for 4 consecutive days using 1 pint/sow/day.
3. Sows should be fed limited feed - as in feeding crates - so they are hungry. If they are not fed 24 hours prior to feeding the culture, they will be sure to devour the whole thing.
4. The sow ration must be free of antibiotics at the time of feeding.

We have conducted several tests in this laboratory to determine the numbers of *E. coli* organisms present in the vaccine under variable conditions. If the protocol is followed, the sows should receive between 10 billion and 100 billion viable *E. coli* organisms per pint of vaccine.

EFFICACY AND SAFETY OF FEED ADDITIVE USAGE OF ANTIBIOTICS

by Virgil W. Hays
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Introduction:

Antibiotic feed supplements have been extensively used in the United States since their introduction in the early 1950's. At present, it is estimated that more than 1.0 million kg. are used annually as diet supplements. The amounts sold for medical and non-medical uses vary from year to year; but, according to U. S. Tariff reports (1949-1974) the amounts sold since 1965 have averaged 1.05 million kg. annually (figure 1). Note that the amounts used for non-medical purposes increased to about 1963 and have remained relatively constant since that time. In addition to the antibiotics, substantial quantities of arsenicals, nitrofurans and other anti-bacterial drugs are used in livestock and poultry production. Such wide acceptance of antimicrobial drugs is attributed to their established benefits of increasing growth rate, improving feed conversion and reducing mortality and morbidity from clinical or sub-clinical infections. The efficacy of antibiotics has been recently reviewed (Hays, 1978, 1979) in considerable detail and those drugs extensively used do result in marked improvements in performance.

Antibacterial agents commonly used in swine and poultry production as dietary additives include bacitracin, bambermycins, chlortetracycline, erythromycin, neomycin, oxytetracycline, oleandomycin, penicillin, streptomycin, tylosin, virginiamycin, arsenicals and nitrofurans. Among those presently used, some are more effective as growth promotants than others. A number of other antibiotics are being or have been used experimentally and have shown promise as effective additives. It is very costly, however, to develop new feed additives. New drugs that are equally effective in improving performance are usually more costly to producers, hence the economic benefits from their use may be substantially less than that for old drugs.

Our Food and Drug Administration has proposed to withdraw tetracyclines and penicillin as feed additives and to limit them to prophylactic or therapeutic use on a prescription basis only. The justification for such proposed action is based on the theory that antibiotic resistance will or has developed in the enteric bacteria and that resistance may cause untreatable or difficult to treat disease problems in man or animals. These concerns and their relationship to feed additive usage have been reviewed by Smith, 1977 and Linton, 1977.

Safety of Antibiotics:

Justification for restricting the use of penicillin and tetracycline is predicated on the thesis that such action would reduce the health risks of man and animals and would not appreciably affect the economics of producing food. FDA proposes that limiting use of antibiotics to a "prescription only" basis would reduce the reservoir of resistant organisms and in turn reduce the health risks of man. A similar proposal was implemented in the United Kingdom as a result of the Swann Committee Report (1969). Evidence to date suggests that the action in the United Kingdom has had little, if any, effect on total antibiotic usage (Braude, 1978) or on the antibiotic resistance in enteric organisms in animals being marketed (Smith, 1978).

Research data from the University of Kentucky (Langlois *et al.* 1978) suggest that antibiotic resistance once established is slow to disappear. It also appears that occasional therapeutic use would maintain the resistance, as measured by *in vitro* tests, at a similar level to that observed from more frequent low-level feed additive usage. Table 1 presents the level of resistance to various antibiotics in three herds of swine. One herd (Princeton herd) had not received any antibiotics for treatment or feed additive purposes since 1972. The second herd (Coldstream herd) had been maintained continuously on diets fortified with tetracycline (50 g/ton). The third herd (Iowa herd) had never received antibiotics as a feed additive and only occasionally was treated with antibiotics. Of the 100 Iowa pigs sampled, only one had ever been treated with antibiotics, and that was a sow that had been treated a year previous to sampling with the antibiotic tylosin.

A comparison of the data indicates that complete removal of exposure to antibiotics will reduce resistance, as expected. However, a comparison of the Coldstream and Iowa data indicates that occasional treatment will result in levels of resistance approaching that of those continuously fed the drug.

The decline in resistance in the Princeton herd has been very slow. Data to illustrate this are presented in table 2. At the beginning of the study (1972), the level of resistance was very high as antibiotics had been used rather extensively in that herd. In 1978, after 6 years of no exposure, 44 percent of the coliforms were resistant to tetracycline.

It is questionable that the proposed regulation to limit use of tetracycline to a prescription only basis would have an appreciable effect on the exposure of humans to resistant bacteria from animals. The major portion of antibiotics are presently used for medical purposes. With the exception of livestock producers, humans are more likely to be exposed to organisms from other humans than they are to organisms from animals. Furthermore, therapeutic use in animals could result in similar levels of resistance remaining in the animal environments. There is the possibility that the proposed regulation would have little, if any, effect on total amounts used in livestock and poultry production.

Efficacy of Antibiotics:

If antibiotic resistance increases the health risks, the population most seriously affected should be the animals themselves. One might expect the drugs to have no beneficial effect on performance, if a high level of resistance existed. As noted from tables 1 and 2, the Princeton and Coldstream herds had a high level of resistance in the enteric organisms. Performance records indicate that the antibiotics were still effective in improving performance. Table 3 presents a summary of the reproductive performance of the Princeton herd before and after the withdrawal of the antibiotics. Note that conception rate, litter size and weaning weight all declined after discontinuing the use of antibiotics in that herd. Also, the incidence of Mastitis, Metritis and Agalactia (MMA) increased. This herd is a small (30 sows), specific pathogen free (SPF) and closed herd (new genetic material is introduced only by artificial insemination) with extreme care to prevent exposure to disease organisms. Disease problems should be minimized, thus we would expect the effects of antibiotics to be more dramatic in larger, commercially managed herds.

The performance, rate of gain and efficiency of feed conversion, of the growing-finishing pigs also declined in that herd (table 4). The difference in rate of gain is very similar to the average response observed from including antibiotics in the diet.

The reproductive performance of the Coldstream herd, continuously exposed to tetracycline, has been superior to the Princeton herd during the same period of time (table 5). The Coldstream herd is a larger herd (150 sows) and new breeding stock are introduced into it principally from the Princeton herd and occasionally from outside sources. The within and between herd comparisons suggest that the use of tetracycline as a feed additive is highly beneficial even though a high percentage of the enteric coliforms are resistant.

Relative Efficacy:

After long and extended use, reports of *in vitro* microbial resistance to certain drugs and some reports of no response, it is only natural that questions would be raised about continued efficacy of the older antibiotics. FDA has raised such questions about continued efficacy and have proposed that alternative drugs are available.

A comprehensive review of the data for swine and poultry has been presented to the Office of Technology Assessment for their two volume report on drugs and chemicals in livestock feed (Hays, 1979). These data indicate that penicillin and tetracycline continue to be effective drugs after 28 years of extensive use. A summary for the starter stage of pig production is presented in table 6. Note the marked improvements in performance during this stage of production. The combination of chlortetracycline, penicillin and sulfamethazine has been extensively used since its introduction. The change in response with time to that combination is plotted in figure 2. During that time there has been little, if any, change in performance of the treated animals. A relative improvement in the rate of gain of control animals indicates less response in recent years if expressed as a percentage of control. However, there remains a substantial improvement, and it has tended to increase since 1972. A similar evaluation of feed/gain data shows a constant improvement 0.17 kg. of feed per kg. of gain resulting from the use of the tetracycline, penicillin, sulfa drug combination, which represents an average improvement in feed/gain of 8.4%. For the tetracycline alone data, the predicted improvement from use of the drug remained constant for the period of 1952 to 1977, 45 g. improvement in average daily gain and 0.12 g. less feed per gram of gain (table 5). This represents an average improvement of 10.9% for daily gain and 3.9% for feed/gain.

A summary of the responses during the grower stage of production is presented in table 7. A statistical evaluation of the tetracycline data reveals that the rate of gain of the tetracycline fed groups has not appreciably changed during the period of 1951 to 1977. During the same time period, the feed/gain ratio improved by 0.011 kg/kg. gain per year and the difference between antibiotic treated and controls remained constant at 0.103 kg/kg. gain. The rate of gain of the control group relative to the treated group improved with time until about 1962 and the difference between antibiotic treated and controls remained constant thereafter. These summaries confirm that the antibiotics continue to be effective in improving rate of gain and feed conversion. In fact, there is little evidence that would suggest that their effectiveness has declined during the period of use.

Likewise, the antibiotics are effective in improving reproductive performance as illustrated by the data in table 8, which represents a compilation of data from several sources and is taken from the report by Hays (1979). These data illustrate that having antibiotics in the breeding ration will improve conception on first service by 8 to 10% and increase litter size by about 0.5 pigs per litter.

Economic Significance:

It is well recognized that the returns per dollar invested in antibiotic usage as feed additives is substantial as a result of improving rate of gain and feed conversion and by reducing morbidity and mortality. The exact magnitude of this response to the total industry is more difficult to assess. A U.S.D.A. report to Congress (1978) estimates that the U. S. food bill would increase by 1.8 to 5.4 billion dollars during the first year of implementing the FDA proposed action. The effects on producers would be variable. Some might experience substantial losses because of high mortality and morbidity. On the other hand, some may experience increased profits because of higher returns from lower production.

Concrete information is not available on the effects that loss of antibiotics would have on adjustments in technology or on total costs and rates of production of livestock and poultry. Our present day systems of confinement rearing of swine and poultry and intensive systems of beef cattle finishing have developed since the introduction of antibiotics as feed additives as preventive measures for controlling disease. Using the data that are available, economic assessments tend to underestimate the effect. Most of the data available are collected in research units rather than on farms. A comparison of the responses in field trials and experiment station tests indicate that the responses are much greater in field trials (table 9). In field trials, the observed improvement in average daily gain and feed conversion resulting from the use of antibiotics is near double that observed in experiment station trials. This difference in responses is expected as most researchers are very selective in the pigs they use, house fewer pigs per pen, per unit of floor space or per house, and go to much greater effort to clean, sanitize and rest the production units than is or will be practical for commercial producers. Thus, economic assessments limited to data from research stations grossly underestimate the real impact on the industry.

Conclusion:

There is a theoretical possibility of resistant organisms developing in animals and those organisms or their resistance subsequently being transferred to man. Such problems do not appear to have developed to any appreciable extent during the 28 years of usage. Data are not available to accurately estimate the relative magnitude of such potential risks. It is scientifically impossible to prove absolute safety. If we limit technology by ruling out the use of products that may have some potential risks, we would rule out all antibiotics, including the newer ones. The evidence available suggests that the proposed restrictions would have little impact on total use of antibiotics. Without substantial restrictions in both medical and non-medical use, we would likely experience little change in the total reservoir of antibiotic resistant organisms; hence, the proposed restrictions would result in little or no change in health risks of the human population.

Production of food from animals is enhanced from using antibiotics as feed additives. To accurately assess the economic impact would require experiencing a ban or restriction in use to determine the impact on the final structure of the swine, poultry and cattle industry. There are performance data available to establish benefits with the present systems; however, data are lacking on the response of producers to the added economic risks that they would experience, the effects of additional drug restrictions in the future, the approval of new drugs and many other facets that affect production and decision making.

After implementation of the proposed restrictions, drugs for preventive medicine or growth promotion purposes would be available to a large segment of the industry through prescriptions, but would be more costly and more cumbersome to obtain. The end result would be an increased cost of production without offsetting health benefits.

The principal beneficiary of the present reduced costs of production is the consumer, not the producer. Once the majority of the livestock and poultry producers accept the technology of feed additive usage, the savings in cost of production are passed on to the consumer. The end result of unnecessary regulations of feed additive usage of antibiotics or other technology is higher prices of meat, milk and eggs to the consumer.

TABLE 2. TIME CHANGES IN TETRACYCLINE RESISTANCE OF ENTERIC COLIFORMS OF A HERD RECEIVING NO ANTIBIOTICS AND A HERD CONTINUOUSLY EXPOSED TO ANTIBIOTICS

	Isolates, no.		Resistance, %	
Year	P	C	P	C
1972	34	139	82	98
1973	46	23	64	74
1974	411	531	60	96
1975	135	150	58	95
1977	95	-	48	-
1978	255	89	44	62

P = Princeton herd, no antibiotics since May 1972.

C = Coldstream herd, antibiotics continuously.

TABLE 3. EFFECT OF WITHDRAWING FEED ADDITIVE AND THERAPEUTIC USAGE OF ANTIBIOTICS ON REPRODUCTIVE PERFORMANCE (SPF CLOSED HERD)

Item	Antibiotics 1963-1972	No Antibiotics 1972-1977
No. litters	398	288
Conception rate[a], %	89.9	78.3
Total pigs/litter	11.0	9.8
Live pigs/litter	10.0	8.6
Pigs weaned/litter	8.9	7.3
Pig wt. 3 wks, lb.	12.8	11.4
Mastitis, Metritis, Agalactia, %	10	66

[a]Conceived 1st service.

TABLE 4. PIG PERFORMANCE[a] PRIOR TO AND AFTER ANTIBIOTIC WITHDRAWAL

Item	Antibiotic Withdrawal	
	Before	After
Avg. daily gain, lb.		
Spring	1.70	1.55
Fall	1.82	1.72
Avg.	1.76	1.64

[a]350 pens for a total of 1,489 pigs. All diets were not fortified with antibiotics prior in the "before" withdrawal group.

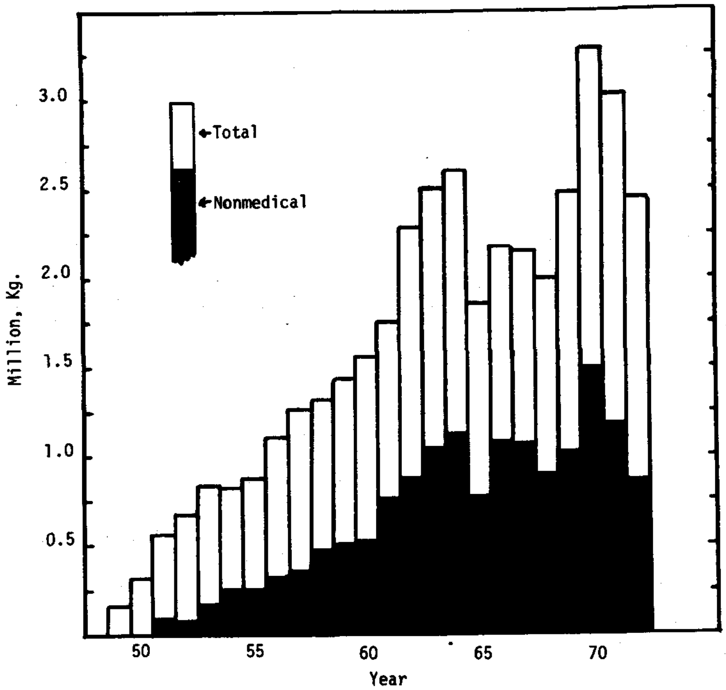
TABLE 5. REPRODUCTIVE PERFORMANCE OF PRINCETON AND COLDSTREAM HERDS

Item	Princeton[a]	Coldstream[b]
No. litters	214	193
Litter size		
Pigs/litter	10.01	10.86
Live pigs/litter	8.92	9.64
Pigs weaned/litter	7.49	8.23

[a]No antibiotics used.

[b]Chlortetracycline (50 g/ton) in all diets.

FIGURE 1. TOTAL USAGE AND NON-MEDICAL USAGE OF ANTIBIOTICS



U.S. Tariff Comm., 1949-73

TABLE 1. RESISTANT TO SELECTIVE ANTIMICROBIAL AGENTS OF FECAL ISOLATES OBTAINED FROM THREE SWINE HERDS

Antimicrobial agents	Herd and no. isolates examined: Princeton[a] (411)	Coldstream[b] (531)	Iowa[c] (651)
	(%)		
Tetracycline	60	96	72
Penicillin	81	51	83
Streptomycin	28	58	48
Sulfamethizole	21	23	43
Ampicillin	7	20	18
Neomycin	1	23	5
Kanamycin	1	39	9

[a]Herd had not been fed or treated with antibiotics for 2 years at time sampled.

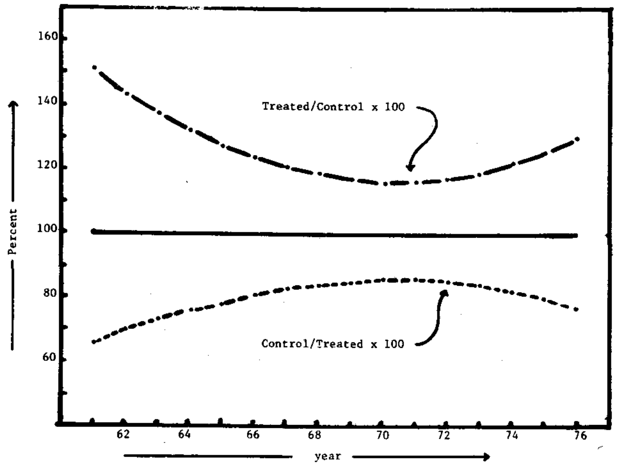
[b]Herd had been fed chlortetracycline (55 mg/kg) continuously for 2 years at time sampled.

[c]Herd had never knowingly been fed antibiotics.

TABLE 6. RESPONSE OF PIGS TO ANTIBACTERIALS (STARTER STAGE - INITIAL WEIGHT LESS THAN 35 LB)

Antibacterial	Reps.	Improvement A.D.G.	Improvement F/G
ASP-250	333	22.5	8.5
Mecadox	292	18.6	8.6
Tylan-Sulfa	76	17.6	6.8
Pen-Strep.	95	14.8	7.4
Tylosin	124	14.8	6.0
Lincomycin	8	11.1	7.6
Virginiamycin	90	11.0	5.0
Tetracyclines	234	10.8	6.2
Bacitracin	54	9.7	3.3
Penicillin	14	9.4	8.7
Nitrofurans	66	8.0	2.3

FIGURE 2. RELATIVE RESPONSE TO THE COMBINATION OF TETRACYCLINE, SULFAMETHAZINE AND PENICILLIN

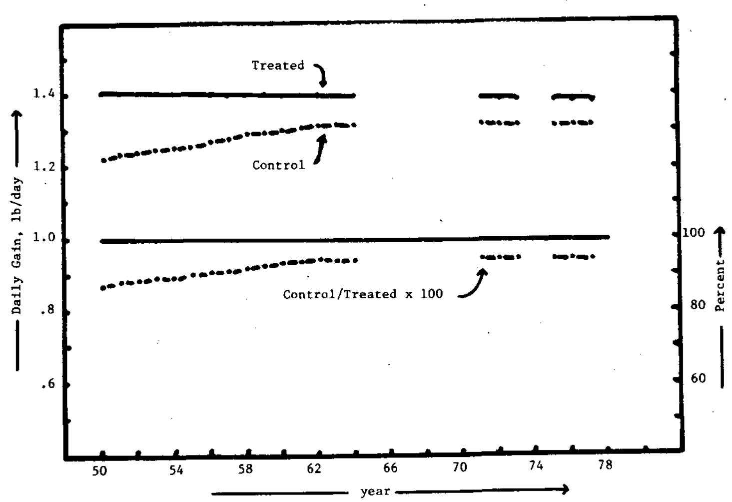


81 starter experiments; 5000 pigs; 304 replications
Avg. daily gain = 0.89 lb/day

TABLE 7. RESPONSE OF PIGS TO ANTIBACTERIALS (GROWER STAGE-37 TO 109 LB)

Antibacterial	Reps.	Improvement A.D.G.	F/G
ASP-250	62	17.5	6.4
Mecadox	63	15.1	6.9
Tetracyclines	325	10.9	3.9
Tylosin	71	10.9	4.2
Virginiamycin	142	10.7	6.6
Tylan-Sulfa	13	5.1	2.2
Bacitracin	51	5.1	2.5
Bambermycin	8	2.4	1.2
Lincomycin	4	2.4	2.5

FIGURE 3. RELATIVE RESPONSE TO TETRACYCLINE (GROWER STAGE-37 TO 109 LB)



103 grower experiments; 3318 pigs; 294 replications
Avg. daily gain = 1.29 lb/day

TABLE 8. EFFECT OF ANTIBIOTICS IN FLUSHING-BREEDING RATION ON REPRODUCTIVE PERFORMANCE

Item	Control	Treated
Farrowing rate, %	72.6	80.0
Live pigs/litter	9.9	10.3

7 reports, 1,394 sows.

TABLE 9. RESPONSE OF STARTER PIGS IN FIELD TESTS OR EXPERIMENT STATION TESTS TO ANTIBACTERIALS

	% Improvement	
Location	A.D.G.	F/G
32 Field test	28.4	14.5
128 Experiment Sta. test	16.9	7.0

12,000 pigs.
Drugs - ASP-250, Tylan-Sulfa, Tetracycline, Mecadox

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MARKETING ALTERNATIVES FOR PACIFIC NORTHWEST HOG PRODUCERS

by

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Livestock Marketing - A Systems Approach

Livestock markets today are not only fast-paced, but are operating at much higher levels of uncertainty than have historically been true. For example, there is currently controversy in the pork industry over whether pork production will rise in the feed crop marketing year that has just begun. The outcome will be important. Typically, when pork production expands, it does so by a large amount. Year-over-year increases of 10 percent or more in spring and fall pig crops have been recorded six times in the past twenty years. Expanding production requires large investments in facilities and equipment, and producers think twice about making a big bet on the infamously volatile hog market.

Another important issue in the hog industry today is the decision of evaluating marketing alternatives and deciding upon "the best decision for me." The packer paying the highest price last week may not be offering the best price this week. Several pricing systems are used in the Pacific Northwest, including the "yellow sheet"; Midwest basing points, i.e., "the river markets"; and government pricing reports. A rather quick survey of market prices may show prices ranging from $1.50 to $2.00 per cwt. for the same quality of animal. Depending on the size of lot being sold, this can amount to a sizable amount of revenue to the producer.

There are two necessary ingredients for increasing the probability of profit in livestock; efficient production and astute marketing. Marketing is usually the orphan child of the two. While there is no perfect marketing program, too often producers exert tremendous resources to assure the best possible ration or production system and are looked upon by their peers as having a well-deserved reputation, but fail to have an organized marketing program - other than searching in their local area for the highest price being paid when the animals are ready to sell.

There are no cookbook methods of marketing. Each producer needs to develop a marketing or profit plan. Marketing is more than selling - it is one piece of a complex enterprise management system that has a specific profit goal well outlined in advance of the time of selling the livestock.

There are four major components to a good marketing plan: (1) enterprise objectives, (2) a production and sales plan, (3) a budget or set of budgets, and (4) a set of alternatives to accommodate the unexpected which might put your well-designed plan in jeopardy.

The enterprise objectives must be tailored to each individual producer's needs, but basically should attempt to answer the following questions:

1. How does this enterprise fit into my total production unit?
2. What marketing alternatives are available and feasible (the main topic of this paper)?
3. Is the production a long-run or short-term venture?
4. What are the capital requirements and risks involved?
5. What is a reasonable or acceptable level of income?

Once a producer sits down and jots the answers to these questions on a scratch pad, he can then begin in earnest to continue preparing a marketing plan.

What Marketing Alternatives Are Available and Feasible?

The feasible marketing alternatives for hogs in the Pacific Northwest are relatively limited. The primary reason for this limitation is the lack of packers and the relatively small number of hogs produced in the region. A recent Packers and Stockyards Administration report shows that four packers in Washington and Oregon slaughter 98.2 percent of the hogs slaughtered in the two states. This slaughter accounts for 1.1 percent of the hogs slaughtered in the United States.

Marketing alternatives for hog producers include the following outlets:

Auctions. While not a major avenue for slaughter hog sales, packers nevertheless obtain substantial numbers through auctions.

Auction operators usually sort an owner's livestock for size, grade, or other characteristics to obtain uniformity as the animals are presented in the sale ring. This is intended to enhance sale of the entire lot. Commissions and/or handling fees (yardage) usually are charged.

Order Buyers - Dealers. Order buyers and dealers purchase livestock at auctions or direct from producers. They usually have regular customers to supply. Order buyers buy in the name of their customers, who pay a commission or handling fee in addition to the animal cost. Dealers, on the other hand, assume ownership of the animals and resell to their customers.

Bargaining Associations. Bargaining associations are organizations set up with the express purpose of bargaining for producers in the sale of their hogs. Bargaining often covers terms of trade in addition to price. Examples of bargaining associations in the Pacific Northwest are the National Farmers Organization (NFO), and the Northeastern Oregon Swine Growers Association.

Direct Marketing. Direct marketing is the marketing of livestock without the services of an intermediary (order buyers, auctioneers, or personnel of a bargaining association). Two major arrangements are practiced in direct marketing of slaughter livestock: (1) sales on live grade and weight, and (2) sale on carcass grade and weight.

Factors to Consider When Choosing An Alternative

Each type of market listed above is, or can be, "competitive". The absence of a large number of buyers does not necessarily preclude a competitive situation. Determining the value of animals is, however, more difficult for some selling methods. In general, animals receive the highest price where cost of moving the animals to the the next step in the marketing channel are lowest. The producer often can capture part of these cost savings by being aware of his marketing alternatives.

Selling hogs live weight usually allows the most competition among buyers, which is a major advantage for producers and enables prices to hold relatively close to the actual value of the animal. Still, live weight selling places pressure on sellers to stay abreast of daily markets and have a good knowledge of the quality of their hogs. Prices paid for live animals are based on the average of the group, whereas carcass prices are determined on each individual carcass. Therefore, sellers of live animals need to take care in sorting into attractive sizes groups of uniform quality. This will usually permit more efficient bidding by buyers.

Analyzing marketing from a buyer's point of view helps in understanding market conditions and making selling decisions. A buyer makes bids based on what he can expect, once the animal is reduced to carcass. This establishes a range of bids within which he can work. But, his real skill as a buyer, and the producer as a seller, hangs on the ability to see through the animal and into the carcass.

A breakdown of a buyer's mental calculations may go something like this: First, he forms an opinion of the average carcass grade of the group. He estimates dressing percentage and the amount of salable meat the carcass will produce. This gives a pretty close estimate of what he can afford to pay, but he will also have to allow for bruises and other unforeseen items that can affect the value of the animal. Now, with an idea of the highest price he can afford, the buyer will discount as much from that price as he can, and still keep competitive with other buyers in the bidding.

For the producer to represent his own interests as a seller, he also needs to actually evaluate the livestock and go through similar calculations. Then, he should figure costs involved with the live weight selling in order to evaluate the marketing options.

Marketing Costs

An estimate of the marketing costs will allow a producer to compare net returns among several marketing choices in order to make the best decision on how to sell a particular load of animals. Marketing costs include transportation, yardage and commission fees, and costs associated with live animal shrinkage. These will vary, depending on the method of selling the producer chooses, and the provisions of the selling agreement.

When sold direct from the farm, commission costs are generally eliminated. However, direct selling reduces the number of buyers in competition with bids, and means that the producer will have to be more knowledgeable about market conditions. One of the parties will pay transportation costs, and it should be reflected in the final price. Terms of agreement on shrinkage and weighing conditions are often a point of contention in direct marketing.

If a producer sells at an auction, he will pay a selling cost or commission charge. These charges can vary by sizable amounts at different markets. Most markets charge variable commission rates, depending on the size of the lot sold. However, for odd lots, or non-uniform animals, auctions may bring the best price.

Live Versus Carcass

A producer who elects to sell animals on a carcass weight and grade basis is betting that his hogs are actually better than reflected in the live weight price one would receive. If the live bid accurately estimates the animal's true quality, and current market conditions, then the price under either method of selling should be the same. On the other hand, if the live bid overestimates the quality of the stock, a producer would stand to lose by marketing carcass grade and yield. The individual seller must decide whether or not this difference in pricing will work to his advantage. A study by Iowa State University showed that producers of high quality hogs were better paid on the average when they sold grade and yield. Poor quality hogs netted more when they were sold on a live basis.

In summary, the advantages of selling live are:

1. Exact price is known the moment sale is made.

2. Payment can be made immediately.

3. Seller can retain control of the animal until exact price is established.

4. Seller may influence sales price with salesmanship and the reputation of his animals.

5. Understanding pricing is not so complicated as in carcass selling.

6. Marketing may be more convenient in some cases.

On the other hand, the advantages of selling carcass weight and grade are:

1. True value of the animal can be more closely determined before payment is made.

2. Influence of fill, shrinkage, and sorting of animals is practically eliminated.

3. Marketing costs may be reduced.

4. Carcass data provide useful information for the producer.

5. Prices are tied more closely to the wholesale market.

6. Reputation is not necessary in order to be paid for quality.

Bargaining

Bargaining is a process by which producers of a commodity join to negotiate prices in terms of trade with one or more processors, or other handlers. Producers form a bargaining association and hire staff to assemble appropriate information about costs of production, costs of handling and processing, expected costs and revenue of processors, supply and demand, and other factors. Processors gather similar information, and the two parties meet to negotiate prices, quantities, and other terms of trade.

Producers bind their production to the bargaining association by marketing contracts. The association can then negotiate a contract with processors with assurance that members will deliver the agreed upon quantity and quality of produce on schedule. A contract with a processor specifies the terms of trade and the price, or pricing formula, and covers delivery of product over a specific period of time.

Bargaining could be used to achieve a number of benefits. Foremost, is the opportunity to obtain higher prices and better terms of trade for producers. If a large number of producers unite, they have an opportunity to influence the decision of processors by limiting processor's alternative sources of supply, and to increase the number of outlets open to producers. The group also has more resources to accumulate market information and develop and implement alternative marketing strategies. Pricing accuracy, and the flow of market information to producers, could then be improved.

Bargaining also could give producers the opportunity to coordinate their production with packers' needs and make the pork meat industry more efficient. Finally, bargaining is a means of maintaining the viability of smaller production units by giving them the market advantage of larger scale operations in maintaining access to markets and in negotiating favorable prices. However, this can be achieved only if the association controls a sizable volume of livestock needed by processors.

Bargaining is more likely to be successful in markets with many sellers but very few buyers, such as the hog market in the Pacific Northwest. Markets with very few buyers tend to provide a disproportionately large share of benefits to buyers because of their market power. In these circumstances, a bargaining association could improve the marketing power of producers and provide the incentive for producers to remain committed to the association.

If bargaining is going to succeed for livestock producers, some additional legislation is likely to be needed. Bargaining is already permitted under the Capper Volstead Act. In addition, the Agricultural Fair Practices Act of 1967 makes it unlawful for processors to coerce producers into joining, or refrain from joining, a bargaining association, or to discriminate among producers on the basis of their membership in such an association. However, additional legislation is needed to facilitate the development of bargaining associations and strengthen producers' bargaining position for sale of their livestock.

Summary

A marketing plan must be a part of a total systems approach. Hog producers have scored like a Super Bowl team in the area of production management. But, as marketers, hog producers rank closer to a fledgling expansion team. Over the years, research shows that the odds, say seven out of ten times, a producer will sell at a price less than the average yearly price.

The reason can best be described as "tradition" in agriculture. Most producers are excellent animal scientists in technically producing excellent quantities of and quality in animals. But the end result--marketing the product--is usually considered a separate function of the business, and many times is simply thought of as "selling." Being a price taker, or just "selling" is not the same as marketing. Marketing should be as much a part of a producer's enterprise management as deciding whether to expand a confinement unit, given today's prospects for feed grains and expected hog prices. A production plan and marketing plan should be diligently pursued and figured on the same scratch pad.

COMPONENTS OF INCREASED LITTER PRODUCTIVITY

David C. England[1]

A large number of pigs weaned per litter is a necessity if a herd is to achieve high litter productivity per female per unit of time. The first requirement of a high average number at weaning is a high average number born; it is an irrefutable concept that average number of pigs weaned per litter cannot exceed the average number born per litter. Current average productivity and attainable levels of productivity have been listed by Cunha (1978) as follows:

	Current Average	Attainable Average
Litters per sow per year	1.8	2.1-2.2
Pigs marketed per sow per year	13	20-24
Pig losses birth to weaning (%)	13-30	5-10
Pigs raised per litter	7.5	9-10

I agree with these attainable goals but suggest that the numbers of pigs weaned per litter and per sow yearly can be higher.

There are several practices which contribute to increased average number born per litter:

1. The choice of breed or breed crosses used as dams. Although data collected on all breeds producing at the same location at the same time are impossible to obtain at present, data available indicate that the Landrace and Yorkshire breeds rank at the top in number of pigs farrowed and weaned and in overall mothering ability. Duroc and Chester White rank next highest in these traits (table 1). If the most important consideration in choice of breeds, or breeds to be used in a crossbreeding system, is the number of pigs born and weaned, breed productivity provides a guideline to follow in making a choice of dam.

   It is generally true that breeds which excel in a trait as a purebreed also excel in contribution to excellence in that trait in a crossbreeding program (England and Winters, 1953). Mating purebred dams to produce crossbred pigs adds only a little to the number born but increases number weaned; this increase is the result of the improved survival ability of the crossbred pigs. Use of crossbred dams increases both

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number born and survival percentage to weaning; thus litter size is increased even more at weaning than at birth when crossbred dams are used.

TABLE 1. HOW THE SWINE BREEDS MEASURE UP

Breed	Litter size		Mothering ability		Milking ability	
	Rank	Pigs	Rank	Score	Rank	Score
Berkshire	7th*	8.07	7th*	Low	7th*	Low
Chester White	4th	9.53	4th*	Medium	4th*	Medium
Duroc	3rd	9.66	4th*	Medium	1st*	High
Hampshire	5th*	8.78	7th*	Low	7th*	Low
Landrace	2nd	10.52	1st*	High	1st*	High
Spotted	5th*	8.78	4th*	Medium	4th*	Medium
Poland China	7th*	8.07	7th*	Low	7th*	Low
Yorkshire	1st	11.13	1st*	High	1st*	High

*Denotes tie.
(Excerpt from: Which hog breed is best?, Frank Lessiter, Ed., Nat. Livestock Producer, September 1975.)

2. Sows generally farrow and wean more pigs per litter than do gilts in spite of a higher number of deaths in sow litters. It is also generally true that gilts will farrow and wean more pigs with each increasing month of age up to about 14 months of age at breeding. The increased litter size of gilts bred at each succeeding month of age up to 14 months is due to increased number of eggs ovulated, and perhaps, also to percentage survival of embryos (George and England, 1974). This relationship has led to the general recommendation that gilts be bred at about 7½ to 8 months of age; at this age, most will be experiencing their third or possibly fourth heat period. The added number born in the first litter with increased age is achieved at the expense of added feed and other costs and should be evaluated on the basis of cost per pig weaned and pigs produced per unit of time. Potential for increased productivity per unit of time and cost by breeding at younger age will be discussed in a later section.
3. Preweaning mortality, on a total herd basis, is seldom below 15 to 25% of the pigs born and frequently is even higher. Such loss seriously decreases effective sow productivity per unit of time. Numerous studies (Kelly, 1977) have assessed extent and causes of preweaning mortality.

Numerous physical and physiological conditions of newborn pigs have been identified as conducive to such levels of mortality. In a recent study of 39 litters at Oregon State University (Bel Isle and England, 1977) 18% of the litters accounted for 44% of the total mortality. This study has now been extended to include 250 additional consecutive litters; the results are similar -- 16% of the litters accounted for 44% of the losses (table 2). These results reveal that serious death loss is not random throughout the entire population at any given farrowing session, but rather that certain litters contribute a disproportionate amount to the average death loss per litter in a population.

TABLE 2. CONTRIBUTION OF HIGH MORTALITY LITTERS TO TOTAL MORTALITY IN SWINE

Groups	No. litters	High mortality litters[a]	% of total litters	Total deaths	% of total deaths
July 1976 to September 1976	50	13	26.0	84	57.1
September 1976 to January 1977	50	5	10.0	30	30.6
January 1977 to June 1977	50	6	12.0	45	38.5
June 1977 to September 1977	50	9	18.0	60	41.4
September 1977 to December 1977	50	7	14.0	48	47.1
TOTAL:		40	16.0	267	43.8

[a]Denotes five or more losses per litter

The high mortality sows had an average per litter loss of 6.7 pigs; a comparison of other sows farrowing within the same week showed average litter loss of 1.9 pigs. Subsequent litters for these two groups resulted in losses of 3.9 and 2.6 pigs per litter respectively. Research is needed to find ways to eliminate all losses, but especially those resulting from the high mortality litters. It can be concluded that such studies should include a strong focus on the dam and other conditions particularly affecting specific litters.

An always perplexing decision which the producer must make is: Do I cull a sow or gilt because the litter she has farrowed at a particular farrowing has fewer pigs born than the average in the herd? This question was the basis of an analysis of Oregon State University records (Page and England, 1976). The findings (table 3) showed that gilts which farrowed fewer than 8 pigs in their first litter (5.6 pigs average) farrowed an average of 9.6 pigs in their second litters, whereas gilts which farrowed 8 or more pigs in their first litters (10.2 average) farrowed an average of 10.5 in their second litters. These results indicate that, on the average, culling gilts with low first litter productivity will remove those gilts most likely to produce smaller second litters.

The same study analyzed future litter productivity by sows which produced a small litter at any farrowing. Litter size of the next litter following production of a small litter was of normal size and did not differ significantly from litter size of sows in the same herd which did not produce a small litter at the previous farrowing. Thus, production of a single small litter should not result in culling of sows with otherwise productive records unless a specific and continuing cause is recognizable. It should be pointed out that all gilts and sows in this study had been selected with expectation of good prolificacy based on their dam's or their own prolificacy records.

TABLE 3. LITTER SIZE AT FIRST AND SECOND PARITIES FOR DAMS THAT PRODUCED SMALL AND NON-SMALL FIRST LITTERS

Litter type	No. obs.	First litters Mean # born	s.d.	Second litters Mean # born	s.d.	Correlation between litters	
Small	84	5.6**	1.6	8.6*	2.8	.04	N.S.
Non-Small	264	10.3**	1.7	10.5*	2.9	.19	P<.01

*Values significantly different P<.05.
**Values significantly different P<.01.
(Excerpt from: Litter traits and weaning practice in swine management, by E. B. Page and D. C. England; Proc. West. Sect. Amer. Soc. Anim. Sci. 27:74-75, 1976.)

It will only be mentioned in passing that a sound nutritional program and freedom from diseases which specifically interfere with reproductive performance are essential to a high average number born per litter; both are attainable and feasible.

It is not a uniformly accepted concept that increased number born, especially in excess of 12 per litter, results in an increased average number weaned. The correct concept is that it can result in an increased number weaned, and that it will do so if the necessary and already available management practices are followed. This is shown in table 4 (England and Day, 1970).

TABLE 4. AVERAGE BIRTHWEIGHT AND DISTRIBUTION OF BIRTHWEIGHTS IN LITTERS WITH DIFFERENT NUMBERS OF PIGS

Litter size	Av. birth wt. (lbs)	Av. no./litter and % above 2.0 lbs		Av. no./litter and % above 2.0 lbs		Av. no. weaned/ litter
		No.	%	No.	%	
1	3.35	0	0	1	100.0	1.0
2	3.39	0	0	2	100.0	1.0
3	3.25	0	0	3	100.0	2.4
4	3.31	.17	5.8	3.83	94.2	3.4
5	2.94	.65	12.9	4.35	87.1	4.6
6	2.99	.56	9.3	5.44	90.7	5.0
7	2.86	.78	11.2	6.22	88.8	6.1
8	2.87	.80	10.0	7.20	90.0	6.9
9	2.82	1.04	11.6	7.96	88.4	7.3
10	2.78	1.42	14.2	8.58	85.8	8.4
11	2.78	1.44	13.1	9.56	86.1	9.5
12	2.67	2.16	18.0	9.84	82.0	9.8
13	2.68	2.13	16.4	10.87	83.6	10.4
14	2.53	3.00	21.4	11.00	78.6	10.9
15	2.61	3.26	21.7	11.74	78.3	12.1
16	2.50	5.00	31.3	11.00	68.7	14.0
17	2.78	2.01	11.8	14.99	88.2	15.0

(Excerpt from: Relationship of litter size, birthweight and duration of farrowing to survival of pigs, by D. C. England and Paul Day; 12th Ann. Swine Day, Ore. Agric. Expt. Sta. Spec. Rep. 316, 1970, pp. 23-28.)

Management practices, in addition to the standard recommendations of clean, warm, dry farrowing quarters, and avoidance of sows farrowing "early" before moving to the farrowing facility include:

1. Attending the sow at farrowing; this permits the attendant to prevent suffocation by membranes, to revive pigs which are anoxic (semi-suffocated by slow birth passage, broken or damaged umbilical cords, etc.), to assist small or weak pigs in initial nursings, and to prevent "hysterical", clumsy, or nervous sows or gilts from intentionally or accidentally killing newborn pigs.
2. Separation of litters into two nursing groups for the first two or three days if there are more pigs than teats, or if there are very small pigs in large litters even though there are enough teats for all pigs. The small pigs are handicapped in every way in obtaining enough milk intake to meet their survival requirements. A system used at Oregon State University is to alternate nursing groups of large and of small pigs on a one hour nursing for large pigs and two hours for small pigs for the first 24 hours. Large, strong pigs can be left away from the sow overnight if kept in a warm, draft-free, dry place. Very small and weak pigs may benefit from bottle feeding of colostrum in addition to uncontested nursing opportunity.
3. Artificial rearing of young pigs is laborious, and often less-than-encouragingly successful, unless excellent facilities and equipment and devoted care of the pigs are available. One of the most successful conditions for rearing "extra" newborn pigs is the availability of foster mothers. The full potential of use of foster mothers has not generally been recognized and utilized. It has been generally recommended that pigs must be transferred within three days after the foster sow has farrowed. This recommendation is based on the rapid drying-up of udder sections not nursed regularly. An analysis of Oregon State University records (Page and England, 1976, table 5) showed that variation in time from weaning to breeding, in gestation length, and in litter size can be used to predict how many sows need to be weaned on the same day to provide farrowings close enough together to have adequate foster mothers for excess pigs to be transferred to foster dams with fewer pigs than teats within three days of age of the excess pigs; foster dams could thus farrow within three days before or after the donor litter.

A more recent concept and practice at Oregon State University is the Sow Sufficiency System ($-$-$). This system utilizes any suitable nursing sow as a foster mother when need arises, regardless of the age of the foster dam's own litter. Operationally, it consists of choosing from among the nursing sows the most suitable foster mother when need arises. It takes into account the number of pigs to be nursed -- the foster dam candidate must currently be nursing at least as many pigs as are to be transferred -- and the thriftiness, uniformity, and general good size and appearance of the foster dam's pigs which indicate that the sow is milking well. It is preferred that foster mother candidates have litters at least three weeks old; such pigs can be effectively early-weaned without excessive management requirements. Sows with pigs as young as a week to ten days of age may be used if others with older litters are not available.

TABLE 5. FARROWING AND TRANSFER DATA FOR LITTERS BORN TO DAM GROUPS OF DIFFERING NUMBER

	Group size			
	5	10	15	20
Mean days of farrowing	4.68	6.45	8.86	10.50
Mean number of farrowing/day	1.07	1.55	1.69	1.89
Pigs remaining in excess of 12/litter	11	1	0	0
Pigs remaining in excess of 11/litter	31	15	15	5

(Excerpt from: Litter traits and weaning practice in swine management, by E. B. Page and D. C. England, Proc. West. Sect. Amer. Soc. Anim. Sci. 27:74-75, 1976.)

Foster dams should be gentle, non-nervous and not overly-large. The foster litter should consist of the largest pigs in the newborn litters; the larger pigs in the litters have better expected survival capacity than the smaller ones. The pigs to be transferred should have one or two days of access to colostrum through rotational nursing of their own or other dams with newborn litters. To effect the "adoption" procedure, the foster dam is moved to the farrowing crate and allowed two to four hours without pigs to enhance readiness for nursing activity before the foster pigs are placed in the crate. An injection of oxytocin may be given to create milk letdown if nursing does not occur within a short period after pigs are placed with the sow.

The Sow Sufficiency System ($-$-$) is based on the following concepts:

1. A few hours of access to nursing colostrum provides maximum blood levels of immunoglobulins for the baby pig.
2. Immunoglobulins are present in sow milk, in decreased quantities, after the colostrum phase and these immunoglobulins are active in protecting against unfavorable bacteria in the digestive system.
3. Pigs gain physiological maturity with increased age or size. Thus, large newborn pigs are physiologically more mature than are small newborn; 10-day-old pigs are more mature than newborn; 3-week-old pigs are more mature than 10-day-old pigs. Husbandry practices are respectively less demanding with increasing maturity.
4. Rapidity of growth is of less economic importance in the preweaning pig than is increased numbers of pigs surviving for each dam that farrows.

Another concept and practice to increase the number of pigs produced per female per year is to shorten the interval from birth of one litter to birth of the next -- or, for gilts, to shorten the interval from time of selection to farrow. Considerable research has been done on use of management techniques to induce estrus in gilts (Schiemann, 1977). Much of this research has dealt only with estrus, ovulation, conception and early embryonic survival, but at least two reports (Brooks and Cole, 1973; Libal and Wahlstrom, 1974) show no significant difference in number of pigs farrowed and weaned by gilts mated at first versus second or third heat period. That time (and associated feed cost) saved by mating at first versus second or third heat period would be 21 or 42 days, respectively. For each five gilts bred 3 weeks sooner, the saved time is equal to the gestation length of one additional gilt, or approximately 20% more reproduction per unit of time and cost, if indeed litter productivity is not reduced. Schiemann, England and Kennick (1975) reported occurrence of well-synchronized estrus in 88% of gilts within 17 days after mixing, moving to the brood stock pens and exposure to boars.

A still more recent concept has been to induce mating in sows during lactation. British researchers (Rowlinson, Boughton and Bryant, 1975) reported successful mating and litter productivity of sows mated during lactation. These sows and their litters were grouped together after the litters were 21 days old; a boar was included to provide constant boar exposure. There was no adverse effect on current or subsequent litters.

Walker and England (1977) reported results of short-period daily removal of confinement-systems sows from their litters with exposure to a boar during the separation time. Results of this experiment (tables 6, 7 and 8) show no adverse effects on breeding performance, current litters or subsequent litters.

TABLE 6. BREEDING PERFORMANCE OF SOWS MATED AFTER WEANING OR DURING LACTATION

	Control	Treatment
Total number exposed for mating	28	26
Total number mated	24	26
Percentage mating during 1-5 days of exposure	54%	31%
Percentage mating during 6-10 days of exposure	0%	50%
Percentage mating during 11-15 days of exposure	7%	11%
Percentage mating during 16-20 days of exposure	18%	4%
Percentage mating after 20 days of exposure	7%	4%
Percentage that did not mate	14%	0%
Percentage mating from 1-20 days	86%	96%
Av. no. days to mating (within 1-10 days)	4.0	5.2
Av. no. days to mating (within 1-20 days)	7.7	7.0
Total sows farrowed from mating at 1st estrus	16 (67%)	18 (69%)
Sows that rebred	1 (4%)	3 (12%)
Late breeders	2 (7%)	1 (4%)
Did no breed	4 (14%)	0
Bred but did not farrow[1]	5 (21%)	4 (15%)

[1]Includes sows removed for various reasons not directly related to the experiment. (Excerpt from: Mating of sows during lactation, by C. Walker and D.C. England; 19th Ann. Swine Day, Ore. Agric. Expt. Sta. Spec. Rep. 494, 1977, pp. 28-35).

TABLE 7. POSTWEANING GAINS OF PIGS FROM WHICH DAMS HAD OR HAD NOT BEEN REMOVED FOR 6 HOURS DAILY FOR 7 OR MORE DAYS DURING LACTATION.

	Average daily gain (kg)		
Time period	Control	Treatment	Difference
Initiation to weaning	.17	.15	.02 N.S.
1-7 days postweaning	.21	.24	.03 N.S.
8-14 days postweaning	.25	.26	.01 N.S.
15-21 days postweaning	.37	.47	.10**
1-21 days postweaning	.28	.32	.05 N.S.

N.S. - No significant difference.
**Significant difference (P<.01).
(Excerpt from: Reproduction and litter performance of sows mated during lactation, by C. Walker and D.C. England, 1978. Proc. West. Sect. Am. Soc. Anim. Sci., Vol. 29.)

TABLE 8. LITTER DATA FOR DAMS FARROWING AS A RESULT OF MATING AFTER WEANING OR DURING LACTATION

	After weaning	During lactation	Difference
No. of litters	19	22	
Av. no. born alive	10.8	10.3	.5 N.S.
Av. birth wt. (kg)	1.3	1.4	.1 N.S.
Av. no. weaned	7.6	7.9	.3 N.S.
Survival percentage	70%	77%	
Av. weaning we./pig (kg)	8.2	9.6	1.4**

**Significant at P=<.01.
(Excerpt from: Mating of sows during lactation, by C. Walker and D.C. England; 19th Ann. Swine Day, Ore. Agric. Expt. Sta. Spec. Rep. 494, 1977, pp. 28-35.)

These researchers calculated an 18% increase in sow productivity per unit of time as a consequence of the shortened interval between litters without adverse effect on existing litters or without the disadvantages imposed by early weaning.

Other potentials for increasing number of pigs per sow per unit of time include hormonally induced mating during lactation; use of hormones to increase ovulation at post-weaning estrus; mating on two successive days with two different boars; and strong selection emphasis on numbers born and weaned per litter.

CONCLUSION

The potential for increased litter prodictivity of swine is seldom fully utilized. Established production practices and lack of conceptual awareness by researchers and producers contribute to failure of full utilization. Within existing awareness and knowledge, more precise and systematic utilization of available techniques could result in marked improvement in sow productivity per unit of time. Additional creatively and perceptively designed research can discover additional bases for production practices which will more nearly utilize the full potential of swine for increased litter productivity.

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The Withycombe Club, with the assistance of Meats Lab personnel, prepare and serve the roast market hog lunch.