EXTENSION BULLETIN E-1156
OCTOBER 1989 (MAJOR REVISION)

pork industry handbook

COOPERATIVE EXTENSION SERVICE • MICHIGAN STATE UNIVERSITY

Feed Additives for Swine

Authors
Gary Parker, University of Kentucky
Gary Cromwell, University of Kentucky
Virgil Hays, University of Kentucky
James McKean, Iowa State University

Reviewers
E. T. Kornegay, Virginia Polytechnic Inst. & State Univ.
George Meyerholz, USDA, Washington, D.C.
Dean Zimmerman, Iowa State University

Feed additives are nonnutritive compounds added to swine diets for the purpose of enhancing animal performance. The major ones used in swine diets are antibiotics, chemotherapeutics, anthelmintics, probiotics, organic acids and copper sulfate. Of these, antibiotics, chemotherapeutics, and anthelmintics are the major feed additives used in swine feeds and have been extensively used in the United States over the last 35 years.

Antibiotics and Chemotherapeutics

Antibiotics and chemotherapeutics are medications added to swine feeds to improve health and performance. A list of compounds and use levels that can be used for specific purposes such as growth promotion, prevention of disease, and treatment of a specific disease can be found by consulting the Feed Additive Compendium (Miller Publishing Co, 12400 Whitewater Drive, Minnetonka, MN 55343, published annually). These medications, usages and levels are determined by the Food and Drug Administration (FDA). It is their responsibility to determine that products intended for animal use are safe, effective, properly labeled, and that food derived from treated animals is safe to eat.

Antibiotics are compounds produced by bacteria or molds that inhibit the growth of other microorganisms. Chemotherapeutics are chemically synthesized compounds that inhibit the growth of certain microorganisms. They may be used alone or in conjunction with antibiotics for the purposes of enhancing growth and feed efficiency, or for disease control in swine. It is generally accepted that the beneficial effects of these compounds result from alteration of the bacterial population within the animal's digestive tract. The actual mechanism by which antibiotics and chemotherapeutics exert the growth promoting effect has remained an elusive unknown throughout the 35-year history of feeding these compounds. A number of possible mechanisms have been suggested:

(1) Metabolic Effect. The metabolic effect implies that antibiotics directly influence the metabolic processes in the animal. This is not a reasonable explanation, however, for those antibiotics that are not absorbed from the intestinal tract.

(2) Nutritional Effect. Certain bacteria that inhabit the intestinal tract synthesize vitamins and amino acids that are essential to the host, while others compete with the animal for essential nutrients. Shifts in bacterial populations due to the feeding of antibiotics may result in a greater availability of nutrients to the host animal. Antibiotics have been shown to reduce the thickness of the intestinal wall, resulting in a potential for greater absorption of nutrients. In addition, antibiotics reduce the total mass of the gut, so less nutrients are wasted on these rapidly metabolized body tissues.

(3) Disease Control Effect. Antibiotics tend to suppress those bacteria in the intestinal tract that cause subclinical or nonspecific disease. These subclinical diseases prevent the animal from performing to its maximum potential.

The response to antibiotics and chemotherapeutics seems to be as large today as it was in earlier time periods[1]. Hays (University of Kentucky, 1977) summarized many of the studies on the value of antibiotics in swine diets from the period 1950-1977, and Zimmerman (Iowa State University, 1986) surveyed the literature on the effect of antibiotics on pig performance from the time period 1978-1985. The data in Table 1 compare the average percentage improvements resulting from antibiotic usage in the two time periods. The percentage improvements in rate of gain and efficiency of feed utilization are similar for the two periods. Antibiotics and chemotherapeutics remain the most consistently effective feed additives for improving animal performance.

There are many antibiotics, chemotherapeutics, and approved combinations available for use in swine diets. The more common additives and their withdrawal times are listed in Table 2. Selection of a specific feed additive and the level necessary for optimal response will vary depending on several factors: 1) the stage of growth, with response being less as the pig increases in age; 2) disease

prevalence within the herd; 3) kind of additive; and 4) the cleanliness and comfort of the environment.

Usage level of an additive or combination of additives must comply with FDA approvals and the manufacturer's directions. The FDA classifies additives into those that have a high degree of human safety with no withdrawal time and those with a higher potential risk for edible tissue residue. The latter have specific withdrawal times before slaughter[2] (Table 2). Producers must responsibly use medications in their feeding program. They must know the approved use levels and withdrawal periods of the compounds they use. There is no extra-label usage (higher than approved FDA levels or unapproved combinations) with feed additives.

Antibiotics and chemotherapeutics are not as commonly used with breeding animals as in diets for growing pigs. Research has shown antibiotics to be effective during certain critical stages of the reproductive cycle, such as at the time of breeding. A summary of nine research trials shows that a high level (0.5 to 1.0 gram/sow/day) of an absorbable antibiotic (such as one of the tetracyclines) at the time of breeding improves conception rate by 11% and improves litter size by .5 pigs/litter at the subsequent farrowing[3] (Table 3). Generally, benefit from antibiotics or chemotherapeutics in gestation diets is minimal unless the disease level within the herd is quite high. Antimicrobial agents are thought to be beneficial at farrowing and during early lactation because the sow and her pigs are more vulnerable to stress at this time. The data in Table 4 suggest that weaning weights are increased by about 5% and pig survival increased slightly when these agents are included in the prefarrowing and lactation diet[3].

Table 1. Improvements in performance of pigs fed antimicrobials during the years 1950-1985.

Years	Periods[a]	Improvement, % Daily Gain	Feed/Gain
1950-1977[b]	Starter	16.1	6.9
	Grower-Finisher	4.0	2.1
1978-1985[c]	Starter	15.0	6.5
	Grower-Finisher	3.6	2.4

[a]Starter period from about 15 to 55 lb. and grower-finisher from 55 to 200 lb. body weight.
[b]Hays (1977); 15,689 pigs.
[c]Zimmerman (1986); 10,083 pigs.

Table 2. Withdrawal time for antibiotics & chemotherapeutics in swine feeds.[a]

Chemical name	Withdrawal time before slaughter
Bacitracin methylene disalicylate	none
Bacitracin zinc	none
Bambermycins	none
Chlortetracycline	none
Oxytetracycline	none[b]
Penicillin	none
Tylosin	none
Virginiamycin	none
Apramycin	28 days
Arsanilic acid	5 days
Carbadox	70 days
Chlortetracycline/sulfamethazine/penicillin	15 days
Chlortetracycline/sulfathiazole/penicillin	7 days
Furazolidone	5 days
Furazolidone/oxytetracycline	5 days
Furazolidone/oxytetracycline/arsanilic acid	5 days
Lincomycin	6 days
Neomycin sulfate	20 days
Neomycin/oxytetracycline	c
Nitrofurazone	5 days
Tiamulin	2 days
Tylosin/sulfamethazine	15 days
3-Nitro-4-hydroxyphenylarsonic acid	5 days

[a]Feed Additive Compendium, 1989.
[b]At 500 g/ton use level, withdraw 5 days before slaughter.
[c]Withdraw from feed 20 days befor slaughter when neomycin base level is 140 g/ton and 5 days before slaughter when neomycin base level is below 140 g/ton.

Anthelmintics

Swine are susceptible to infection with numerous species of internal parasites (See PIH-44, *Internal Parasites*). These parasites vary widely in structure, size, shape, habits, life cycle, and extent of injury to swine. The pork producer has available a wide array of anthelmintics (dewormers) that are very effective in controlling several parasite species.

Some anthelmintics are more effective than others for certain species of worms. Producers should become aware of the parasite spectrum and efficacy data of each anthelmintic. Anthelmintics may be added to swine feed for limited periods to kill (purge) worm accumulation including worm eggs in growing/finishing swine and the breeding herd. This type of deworming program usually removes the immediate worm burden but needs to be repeated (time period depends on specie of worm) for improved control. Continuous feeding of some anthelmintic products will block development of parasites during the specified feeding period. Currently, two dewormers on the market (pyrantel tartrate and hygromycin) can be fed continuously in the diet. These anthelmintics remove specific worm parasites, reduce the immediate worm burden and help prevent the problem from recurring. Withdrawal periods for the feed additive anthelmintics are listed in Table 5.

Copper Sulfate

Elemental copper is a required nutrient for normal pig

Table 3. Effects of antibiotics at breeding on reproductive performance of sows.[a]

	Control	Antibiotic[b]
Farrowing rate, %[c]	68.2	79.1
Live pigs/litter	9.8	10.3

[a]Cromwell (1983); Data on 2,148 sows, 9 experiments, 1961-1985.
[b]In most cases, .5-1.0 gram/sow/day prior to and after breeding.
[c]Percent of sows bred that farrowed.

Table 4. Antimicrobial agents in the prefarrowing and lactation diet for sows.[a]

	Control	Antimicrobial[b]
Pigs born alive/litter	8.96	9.13
Pigs weaned/litter	8.01	8.25
Survival, %	89.4	90.4
Weaning weight, lb.	8.78	9.20

[a]Cromwell (1983); Summary of 7 experiments, 787 litters.
[b]Tetracyclines, chlortetracycline-sulfamethazine-penicillin, tylosin or copper sulfate fed from 3-5 days prepartum through 7-21 days of lactation.

growth and is routinely added to swine diets at the rate of 6 to 11 ppm to meet this requirement.

Copper sulfate possesses antibacterial properties and is an effective growth promotant when fed at levels of 125 to 250 ppm of copper (1 to 2 pounds of copper sulfate/ton of feed) in the diet[4,5]. The addition of 250 ppm copper to swine diets improved performance of weanling pigs and growing-finishing swine in trials conducted at the University of Kentucky (Table 6). In young pigs, the combination of copper and antibiotics gave a greater growth response than the feeding of copper or antibiotics alone[6] (Table 7).

Copper sulfate, when fed in excess of 250 to 500 ppm for an extended period of time, may be toxic. The severity of the toxicity is directly related to the level fed, and is increased if the diets are low in zinc and iron, and if the copper is fed for a long period of time. Therefore, producers should check with their feed manufacturer about the level of copper sulfate, iron, and zinc present in commercial feed before indiscriminately adding additional copper sulfate to feed. Drawbacks to copper sulfate supplementation include increased corrosion of galvanized metal and decreased bacterial degradation of manure in lagoons.

Probiotics

Probiotics are mixtures of bacteria, yeasts or other microorganisms that may be fed to pigs with the intention of establishing a population of desirable microflora within the intestine. The most common microorganisms included in probiotic products are Lactobacillus species, *Bacillus subtilis* and *Streptococcus faecium* and yeast (*Saccharomyces cerevisiae*). These organisms, through competitive inhibition, favor the development of desirable health promoting microorganisms that theoretically improve weight gain and feed efficiency. To be effective, the bacteria should be established as normal inhabitants of the intestinal tract of healthy animals. They must also be able to survive passage through the stomach and establish themselves in the small intestine where digestion and absorption occur. They should be acid and bile tolerant if they are to survive in the digestive system.

It has also been suggested that the beneficial actions of probiotics include[7]: (1) change the enteric flora and reduction of E. coli; (2) synthesis of lactate with subsequent reduction in intestinal pH; (3) adhesion to or colonization in the digestive tract; (4) production of antibiotic substances; (5) reduction of toxic amines and ammonia levels in the gastrointestinal tract and blood.

There is speculation that probiotics may have some negative effects on pig performance, which may be caused by: nutrient competition; a decrease in carbohydrate utilization; and an increase in the transit rate of the digesta.

Although probiotics have been commercialized and used extensively for at least 30 years, the documented evidence of their therapeutic and nutritional value is still quite variable. Some of the possible reasons for the variability of results are: viability of microbial cultures related to storage method; strain differences; dose level and frequency of feeding the culture; drug interactions; and lack of systematic investigation by researchers.

Previously, research information on probiotics was not required to substantiate therapeutic or growth promotional claims. However, on June 2, 1988 FDA published a compliance statement on direct fed microbial products. Under the new guidelines, a direct-fed microbial product that is labeled/promoted with any therapeutic or growth promotional claims is a new animal drug and requires a completed new animal drug application (NADA) before the product can be sold with therapeutic or growth claims. The intent of this regulation was to minimize misleading or deceptive advertising for therapeutic and growth promoting claims by microbial products in the market place.

Organic Acids

There are several organic acid compounds available for use in feeds. Fumaric and citric acid are the most common. Both have been shown to improve gain and feed efficiency in weanling pigs. The exact mode of action is not known, but has been rationalized from several positions:

(1) Acidification of the diet may decrease stomach pH and increase pepsin activity (required for protein digestion).

(2) A reduced stomach pH may decrease the rate of stomach emptying, thus increasing protein digestion time in the stomach.

(3) A reduction in stomach pH may reduce the proliferation of coliforms and other pathogens in the upper gastrointestinal tract.

Research data have shown the effects of organic acid additions to diets on performance to be quite variable. This variability may be attributed to: 1) age of pigs; 2) the

Table 5. Withdrawal time for anthelmintics in swine feeds.[a]

Chemical name	Withdrawal time before slaughter
Dichlorvos	none
Fenbendazole	none
Piperazine	none
Hygromycin B	15 days
Levamisole Hydrochloride	3 days
Pyrantel Tartrate	1 day
Thiabendazole	30 days

[a]Feed Additive Compendium (1989).

Reference to products in this publication is not intended to be an endorsement to the exclusion of others which may be similar. Persons using such products assume responsibility for their use in accordance with current directions of the manufacturer.

Table 6. Effect of copper sulfate on performance of weanling and growing-finishing pigs.

Growth Stage	Copper, ppm[a] 0	Copper, ppm[a] 250	Improvement %
Starting period (15 to 30 lb.)[b]			
Daily gain, lb.	.51	.62	21.6
Feed/gain	2.04	1.86	9.7
Growing period (40 to 123 lb.)[c]			
Daily gain, lb.	1.47	1.56	6.1
Feed/gain	2.80	2.70	3.7
Growing-finishing period (40 to 205 lb.)[c]			
Daily gain, lb.	1.56	1.63	4.2
Feed/gain	3.18	3.10	2.5

[a]Does not include copper in trace mineral mix.

[b]Cromwell et al., 1988. Summary of 12, 28-day experiments with 482 pigs weaned at 28 days of age, 44 replications of 4-8 pigs/pen, conducted at the University of Kentucky from 1978 to 1983.

[c]Cromwell et al., 1988. Summary of 18 experiments, 84 replications of four pigs per treatment, conducted at the University of Kentucky from 1970-80.

Table 7. Effects of single and combined additions of copper and antibiotics on performance of weanling pigs.[a]

	Additive			
	None	Copper[b]	Antibiotic[c]	Both
Daily gain, lb.	.46	.57	.55	.62
Feed/gain	1.98	1.87	1.81	1.75
Survival, %	95	100	93	98

[a]Two trials involving 256 pigs from 4-8 weeks of age (15 to 30 lb.)

[b]250 ppm copper as copper sulfate.

[c]55 ppm chlortetracycline in one experiment, 27 ppm of virginiamycin in a second experiment.

amount of milk by-products in the diet; and, 3) the presence or absence of antibiotics. At the present time, the optimal inclusion rate and economic benefits of organic acids in weanling pig diets have not been established.

Other Additives

Flavors are sometimes added to diets to enhance the aroma or taste of the feed. Most of the research suggests that they are of limited benefit unless one is attempting to mask feed that has off-odors or off-flavors.

Enzymes are sometimes included in feeds for the purpose of assisting in the digestive process. Most research indicates very little benefit from enzyme supplementation. An exception is the enzyme, beta-glucanase, which has been shown in certain instances to benefit the utilization of barleys that are high in beta-glucans, a complex carbohydrate that interferes with the pig's ability to efficiently utilize barley.

Antioxidants are often included in feeds that are high in fat. They help to prevent the feed from becoming rancid, especially in hot weather.

Pellet binders are occasionally added by feed manufacturers to feeds prior to pelleting. Their purpose is to increase the cohesiveness of the pellets.

Proper Use of Feed Additives by Producers

Producers should follow directions for feed additive usage as provided by the manufacturer (See PIH-86, *Management to Prevent Drug Residue Problems in Pork*). Thoughtful use of these compounds to maximize profits, while preventing residues and reducing consumer concern, is important.

Antimicrobial levels in additive claims and approved usage levels in feed are regulated by the FDA. USDA-FSIS (Food Safety Inspection Service) is actively initiating more rigid swine identification and residue-monitoring controls of pork carcasses at packing plants. Every pork producer must take precautions to abide by FDA required preslaughter withdrawal times for feed additives and other medications. To disregard these regulations could result in a sizable monetary loss to individual producers from condemnations due to tissue residue and to the pork industry from withdrawal of approval for certain effective feed additives.

In using medicated feeds (antibiotics, chemotherapeutics, and anthelmintics) the producer should:

1. Read the tag to assure that this is an appropriate additive for the stage of production and is being used for approved reasons.

2. Comply with the proper withdrawal times to avoid residues thereby ensuring safe, wholesome pork. All approved drugs have been tested for tissue clearance and length of withdrawal time is based on research data and approved by regulatory agencies.

3. Prevent drugs and medicated feed from contaminating other medicated or nonmedicated feeds through mixers and feed handling equipment.

4. Avoid giving additional medications to animals on medicated feed without professional advice. One compound may interfere with the effectiveness or clearance rate of another drug.

5. Use only those medicated feeds approved for swine and only for the appropriate purpose and stage of production.

Summary

The majority of feed additives available to producers are antibiotics, chemotherapeutics, anthelmintics, organic acids, and probiotics and to a lesser extent, flavors, enzymes, antioxidants and pellet binders. Current research has shown that antibiotics, chemotherapeutics and copper sulfate provide the most consistent improvements in growth rate and feed efficiency.

Producers should obtain professional help to develop a specific feed additive program to maximize returns. Short-term switching from one additive to another should be avoided unless made in response to a new disease problem. A well planned program can help prevent management errors associated with withdrawal times and make it easier to execute specific disease prevention and treatment programs. One should always practice good feeding, sanitation, and disease control management techniques. Don't expect to buy management in a bag of medicated feed. Seek and utilize the services of a practicing veterinarian and animal nutritionist.

Federally approved feed additives are thoroughly tested and proven to increase animal performance. Approved antibiotics and chemotherapeutics or combinations are recommended for growth promotion in each stage of the growth period and, for the improvement of breeding and lactation performance in sows.

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