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Feed Management to Prevent Drug Residue Problems in Pork: Pork Industry Handbook

Michigan State University Extension Service

Gary L. Cromwell, University of Kentucky; LeRoy G. Biehl, University of Illinois; Robert A. Wilcox, Kansas State University; James McKean, Iowa State University; Kenneth B. Meyer, Purdue University

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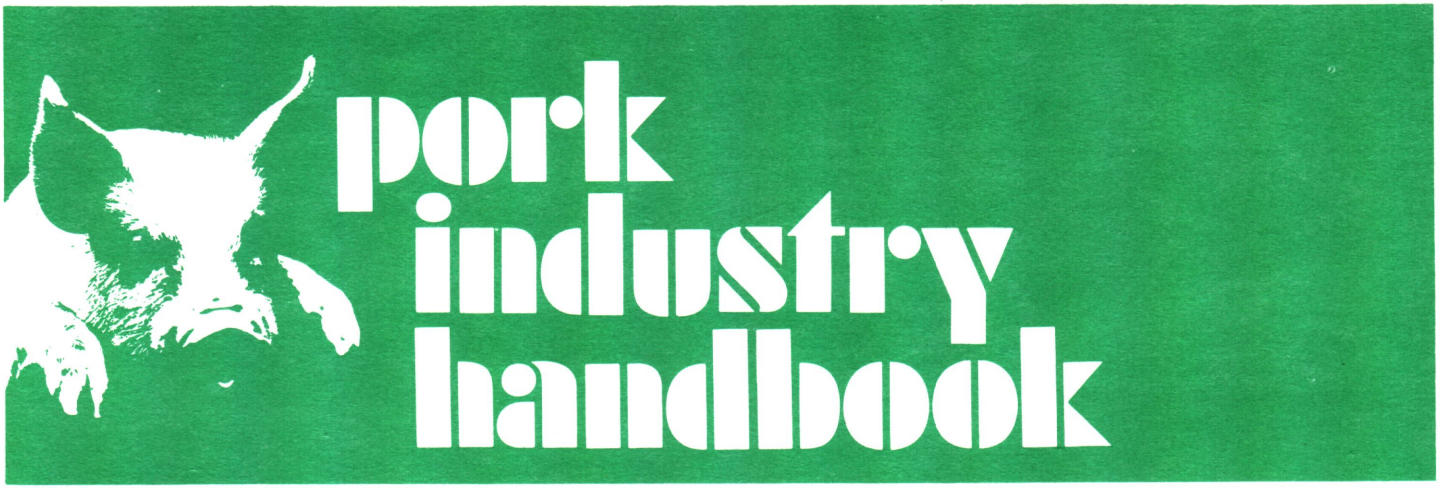

COOPERATIVE EXTENSION SERVICE • MICHIGAN STATE UNIVERSITY

Feed Management to Prevent Drug Residue Problems in Pork

Authors
Gary L. Cromwell, University of Kentucky
LeRoy G. Biehl, University of Illinois
James McKean, Iowa State University
Kenneth B. Meyer, Purdue University
Robert A. Wilcox, Kansas State University

Reviewers
Glenn Brown, Delphi, Indiana
Dean and Jane Pretzer, Diller, Nebraska
Dale Keesecker, Washington, Kansas
Gary Weber, USDA, Extension, Washington, D.C.

Antibiotics and chemotherapeutics are widely used in swine feeds. They are effective in improving the rate and efficiency of growth and in reducing mortality and morbidity associated with respiratory and intestinal diseases in pigs. Certain feed additives require a withdrawal period prior to slaughter in order to insure that residues do not occur in the carcass. The additives that require withdrawal and their withdrawal times are given in Table 1. In addition, Table 1 includes those feed additives that do not require any withdrawal.

The feed additives that have caused the greatest residue problem and received the most attention in recent years are the sulfonamides. The term, sulfonamide, includes sulfamethazine, sulfathiazole, and other sulfonamide drugs. Although this fact sheet will concentrate primarily on methods of preventing sulfonamide residues, many of the techniques that are discussed also apply to the prevention of residues that could result from other drugs.

Forms of Sulfonamides Used in Feeds

The only sulfonamides that can be legally used in feeds are sulfamethazine and sulfathiazole. They are approved only in combination with certain other antibiotics and only at one level of inclusion (100 grams per ton). The feed additive combinations that include sulfonamides are Aureo SP-250® and PfiChlor SP-250® (chlortetracycline, penicillin and sulfamethazine), Tylan-Sulfa® (tylosin and sulfamethazine) and CSP-250® (chlortetracycline, penicillin and sulfathiazole). In addition, these and other sulfonamides are sometimes used as water medications for controlling pneumonia, scours and other bacterial infections.

Efficacy of Sulfonamides

Sulfonamides are primarily used for young pigs during the early growth stages. Most pig starter feeds and about 75% of grower feeds are medicated. Approximately one-third of these medicated feeds contain sulfamethazine or sulfathiazole. One reason for the popularity of the sulfonamide-antibiotic combinations is that they are very effective growth promoters, as shown in Table 2. A summary of 453 experiments involving 13,632 pigs indicates that pigs fed sulfa-antibiotic combinations from 19 to 56 lb. gained 20.5% faster and required 7.8% less feed per pound of gain than control pigs that received no antibiotics. For 10 other antibiotics, the average improvements in daily gain and efficiency of feed utilization were less than the sulfa-antibiotic combinations, 13.8% and 6.5%, respectively. Similar trends were found in a summary of 280 experiments involving slightly heavier pigs, fed from 37 to 109 lb. (Table 2).

The sulfa-containing feed additives also have been shown to help maintain acceptable performance in herds having acute or chronic respiratory infections, such as atrophic rhinitis.

Sulfonamide Residues

The tolerance level for sulfamethazine and sulfathiazole in pork tissue (liver, kidney or muscle) is set by the Food and Drug Administration at 0.1 ppm. Regulations require that sulfamethazine be withdrawn from the feed for 15 days and sulfathiazole for 7 days prior to slaughter in order to insure that tissues do not exceed the tolerance level.

Shortly after a national monitoring program was initiated by the USDA in the 1970s, it was discovered that about 15% of hog

carcasses had violative sulfonamide residues. In almost all cases, the sulfonamide found in the carcass tissues was sulfamethazine. A major effort was initiated in 1977 by the USDA, the Cooperative Extension Service and the National Pork Producers Council to solve this problem by means of research and educational programs. Additional testing of carcasses for residues at packing plants was implemented in 1987 with stiff penalties for producers marketing hogs with violative residues. Although the problem has not been completely solved, the violation rate is now quite low, 1.12% in 1989 (43 violations of 3,855 samples) according to USDA surveillance data (Figure 1). The incidence of sulfa residues based on the Sulfa-on-Site (SOS) testing program was 0.27% in 1989 (316 of 116,726 samples), but this is based on muscle rather than liver samples. Sulfamethazine residues in liver are generally about four times higher than they are in muscle.

Causes of Sulfonamide Residues

What was the reason for the high incidence of sulfamethazine residues, and why has it been so difficult to eliminate the problem? Initially, producers were blamed for not complying with the withdrawal period. However, it was soon realized that some of the violations were from farms where producers were making a real effort to follow proper withdrawal times. In some cases, violations were even being reported on farms where sulfonamides were not being used in feed or water.

Finally, results of research conducted at Iowa State University, the University of Illinois and the University of Kentucky shed new light on the problem. Their studies showed that only a very small amount of sulfamethazine in the feed would cause a residue in the tissue. An early study at the University of Kentucky indicated that as little as 1 gram of sulfamethazine per ton of feed could result in a high incidence of violative residues. Table 3 illustrates data from a later study in which 2 grams of sulfamethazine per ton of feed was found to cause a violative residue in liver tissue. A higher level of sulfamethazine (8 grams per ton) was required before a violative level of sulfamethazine occurred in the muscle.

Sulfathiazole is excreted more rapidly than sulfamethazine and, therefore, is less likely to cause residue problems. Table 3 shows that feed can be contaminated with up to 16 grams of sulfathiazole per ton, on a continuous basis, before a violative residue occurs.

A major cause of the high incidence of sulfonamide residues was, and still is, due to the cross-mixing of clean feed with sulfonamide-containing feed. Drug carry-over can occur in commercial feed mills and on the farm. It can also result from the inadvertent purchase of sulfonamide-containing premixes and supplements. As little as 40 lb. of a sulfamethazine-medicated feed (containing 100 grams per ton), if mixed into a ton of "clean" feed, will result in a feed containing 2 grams of sulfamethazine per ton -- a carry-over level that can leave a violative residue of sulfamethazine in liver tissue.

Table 1. Feed additives that require withdrawal and those requiring no withdrawal from swine feed.[1]

Additives	Withdrawal time
Additives requiring withdrawal	
Antimicrobial agents	
Carbadox	70 days
Apramycin	28 days
Neomycin[2]	20 days
Sulfamethazine[2]	15 days
Sulfathiazole[2]	7 days
Lincomycin	6 days
Arsanilic acid, sodium arsanilate	5 days
Furazolidone	5 days
Nitrofurazone	5 days
Roxarsone (3-Nitro)	5 days
Dewormers	
Thiabendazole	30 days
Hygromycin B	15 days
Levamisole hydrochloride (Tramisol®)	72 hours
Pyrantel tartrate (Banminth®)	24 hours
Additives requiring no withdrawal	
Antimicrobial agents	
Bacitracin, zinc	
Bacitracin methylene disalicylate	
Bambermycins	
Chlortetracycline	
Oxytetracycline[3]	
Penicillin[2]	
Streptomycin[2]	
Tiamulin[4]	
Tylosin	
Virginiamycin	
Dewormers	
Dichlorvos (Atgard®)	
Fenbendazole (Safe-Guard®)	
Phenothiazine	
Piperazine	
Larvicide	
Rabon®	

[1]Feed Additive Compendium, 1990.
[2]Approved only in combination with certain other antimicrobial agents.
[3]Five-day withdrawal when high level (500 grams per ton) used.
[4]Two-day withdrawal when high level (35 grams per ton) used.

Preventing Drug Carry-Over in Feeds

Drug carry-over in feeds can occur in a number of ways. Feed manufacturing equipment such as mixers, pellet mills, augers, elevator legs, dust control devices and storage bins can harbor dust and residual feed, which can carry-over into clean feed (Figures 2, 3, 4 and 5). A vertical screw mixer may contain 40 to 50 lb. of residual feed in the boot after the feed is discharged. Failure to remove this residual feed will cause the next batch to be contaminated. In some farm mixers, such as portable grinder-mixers, even more residual feed can remain; in some cases over 100 lb. per batch. A thorough clean-out or flush of all mixing equipment, conveyors, augers, elevator legs, and similar equipment is imperative in order to reduce the chance of drug carry-over. Some producers use a second set of equipment for mixing sulfonamide-free finishing feeds in order to solve the drug residue problem.

A proper feed mixing sequence will reduce the degree of drug carry-over. For example, a finishing feed should never immediately follow a sulfonamide-medicated feed. Instead, a sulfonamide-medicated feed should be followed with a feed that is less likely to cause residue problems, such as a grower feed.

The powdered form of the sulfonamides tends to be electrostatic and will cling to metal surfaces. Grounding of equipment will reduce this characteristic, but will not completely eliminate

Table 2. Comparison of antibiotics as growth promoters for young pigs.

Item	Number of experiments	Percent improvement over control pigs: Avg. daily gain	Feed/gain
Starting pigs (19 to 56 lb.)[1]			
Antibiotic-sulfa combinations[2]	131	20.5	7.8
Other antibiotics	322	13.8	6.5
Growing pigs (37 to 109 lb.)[3]			
Antibiotic-sulfa combinations[2]	32	15.4	5.7
Other antibiotics	48	10.7	4.6

[1]Data from 453 experiments, 13,632 pigs.
[2]Aureo-SP-250®, PfiChlor SP-250®(Formerly Chlorachel-250), Tylan-Sulfa® and CSP-250®.
[3]Data from 280 experiments, 5,783 pigs.

it. Fortunately, the granulated form of sulfamethazine (the form that is present in all commercial antibiotic-sulfamethazine mixes) has helped to reduce this problem. In a study at the University of Kentucky, the sulfa level in feed dust taken from the inside surface of a mixer was 276 ppm when powdered sulfamethazine was used as compared with only 59 ppm when granulated sulfamethazine was used.

Feed should never be medicated with powdered sulfamethazine. This is an **illegal** practice, and it is likely to cause severe residue problems. Excessive dust and waste feed should not be allowed to accumulate around feed mixing and handling equipment, as they can be a source of drug carry-over. Accumulated dust should be removed at regular intervals and discarded; it should not be included in mixed finishing feed.

Bulk delivery trucks also can be responsible for drug carry-over in feeds if medicated and nonmedicated feeds are hauled at the same time or if the conveying system on these trucks is not cleaned out well between delivery of sulfonamide-medicated feed and delivery of nonmedicated feed. (Figure 6). Bulk storage bins on the farm should never be used for both sulfonamide-medicated feed and nonmedicated feed unless they are thoroughly cleaned between batches. Feed tends to cling to the sides and corners of the bins (see Figures 7 and 8) and in the discharge augers. Drug carry-over can occur in these structures if they are not completely emptied and properly cleaned between batches of feed. Hog feeders should be emptied and cleaned after sulfonamide-medicated feeds are used, if the same feeders are used to finish out hogs. If feeders are not cleaned out completely, medicated feed can build up in certain parts of feeders (see Figure 9) and can contaminate several batches of nonmedicated feed. If a thorough clean-out and flushing of the feed delivery system in a building is not possible, then separate delivery systems are recommended for sulfonamide-medicated and nonmedicated feeds. Another alternative is to completely avoid the use of any sulfonamide-medicated feed in every building that houses finishing pigs.

The same contamination principles hold true for water medicators. Care should be taken to prevent contamination of clean water with sulfonamide-medicated water. Also, one should not medicate the feed and the water with sulfonamides at the same time. This practice could cause high intakes of sulfonamides and could result in a residue, even with proper withdrawal times.

Proper Mixing of Feeds

Producers who mix their own feed on the farm must follow good feed mixing practices to insure uniform dispersal of drugs and other microingredients in feed. Adequate mixing time is a must. Both undermixing and overmixing should be avoided. Recommended mixing time for vertical mixers is 15 to 20 minutes and for horizontal mixers is 6 to 8 minutes per batch. Accurate scales must be used. Volumetric mix mills should be calibrated often (at least once a week) to insure proper inclusion rates of ingredients. Producers must be certain that only approved levels of drugs and approved combinations of drugs are used in feeds. Levels and combinations of drugs are regulated by the FDA and are published in the Feed Additive Compendium (Miller Publishing Co., Minnetonka, MN).

Producers should use a record system to keep track of their medicated feeds. An example of one is shown in Figure 10. A good record system also will help to avoid mixing errors.

Preventing Access to Sulfonamide-Containing Manure

Studies at the University of Illinois and Iowa State University indicate that sulfonamide residues in pork can be caused by pigs having access to sulfamethazine-containing manure. Pigs housed on solid floors that allow accumulation of manure and urine are more likely to pick up sulfonamide from the floors than those housed on slotted floors. Lagoons that receive wastes from buildings where sulfonamide is being used can be a source of contamination when lagoon water is used in finishing house flush systems.

Following sulfonamide withdrawal, pigs should be moved to a clean pen or the pen should be thoroughly cleaned at the time

Table 3. Effects of form (sulfamethazine vs. sulfathiazole) and level of sulfa in finisher feed on sulfa residues in pork.[1]

Form and level of sulfa	Sulfa residue: Liver	Muscle	Violations[2]: Liver	Muscle
	ppm	ppm	%	%
Sulfamethazine[3] in feed, g/ton				
0	<.01	<.01	0	0
1	.04	.01	0	0
2	.09	.02	38	0
4	.20	.05	100	0
8	.43	.09	100	40
16	.88	.19	100	100
100	4.55	1.52	100	100
Sulfathiazole[4] in feed, g/ton				
0	.01	<.01	0	0
1	<.01	<.01	0	0
2	.01	<.01	0	0
4	<.01	<.01	0	0
8	.03	.01	0	0
16	.07	.02	20	0
100	.30	.05	78	6

[1]University of Kentucky and University of Nebraska, 1981, 16 pigs/treatment
[2]Percent of samples having 0.1 ppm or more of sulfa, based on two assay methods: colorimetric (corrected for background) and GLC.
[3]Sixteen pigs per treatment were fed 100 grams of sulfamethazine per ton for 2 weeks, then these levels were fed for 15 days prior to slaughter.
[4]Sixteen pigs per treatment were fed 100 grams of sulfathiazole per ton for 2 weeks, then these levels were fed for 7 days prior to slaughter.

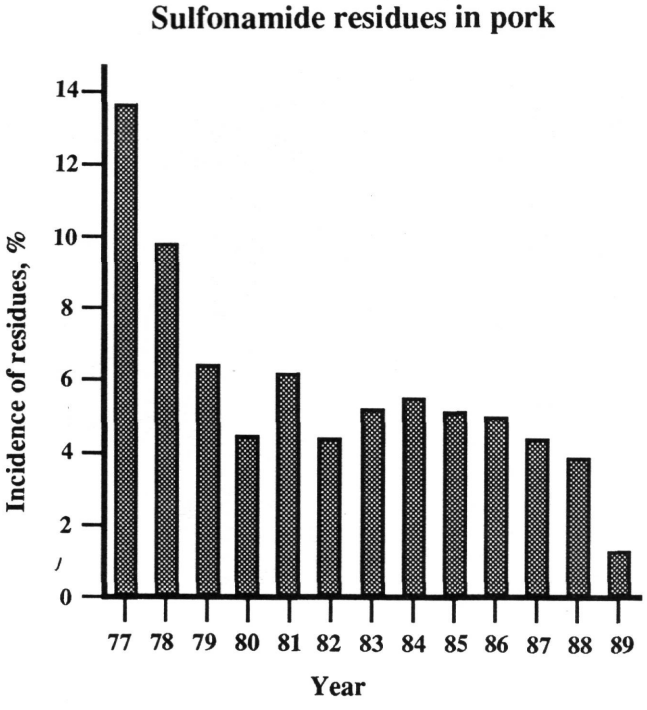

Figure 1. Incidence of sulfonamide residues in pork liver from 1977 to 1989.

of withdrawal. These pens should be cleaned 3 to 7 days following sulfonamide withdrawal. Pigs should not be allowed to have access to manure in trucks, holding pens, etc., where other hogs that may have had sulfonamide in their feed were kept. Holding pens that allow pooling of urine should be avoided before and during marketing.

Adherence to Withdrawal

Producers must be certain that they comply with the proper withdrawal periods; 15 days for sulfamethazine and 7 days for sulfathiazole in feed. Water medications may require longer withdrawal periods. To be on the safe side, it is best to include sulfonamides only in the starter feed. If sulfonamides are used in grower feed, they should not be used beyond 125 lb. body weight. Sulfonamides should be left out of the finisher feed. Some producers finish their hogs in a separate building and avoid the use of sulfonamides in the finishing building. This practice also solves the recycling problem caused by sulfonamide-contaminated manure. Sows and gilts that are sent to slaughter also can contribute to residue problems if withdrawal times are not adhered to.

Some have suggested that finishing hogs be fed only corn for several days prior to slaughter. While this practice might help insure that sulfonamide will not be present in the preslaughter feed, it may be a costly practice. Corn is extremely low in lysine and other amino acids, so growth rate and feed conversion will be markedly reduced by feeding shelled corn for any extended period of time, even to finishing hogs. However, this practice might be feasible as a last resort for producers having a serious residue problem.

Testing Live Hogs for Sulfonamide Residues

Kits are now available for on-the-farm testing of live hogs for potential residues. In these tests, urine is collected and tested. Producers who anticipate a potential problem with sulfonamide residues or who are interested in their sulfa-residue status can test a few hogs before they go to slaughter to insure that they are free of residues. When help is needed, swine practitioners can

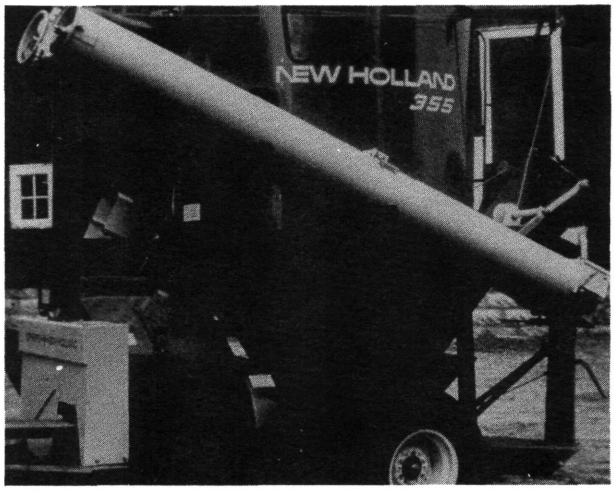

Figure 2. This type of grinder-mixer is commonly used on hog farms. Mixers can harbor excessive residual feed and dust, and should be cleaned after mixing sulfonamide-medicated feed.

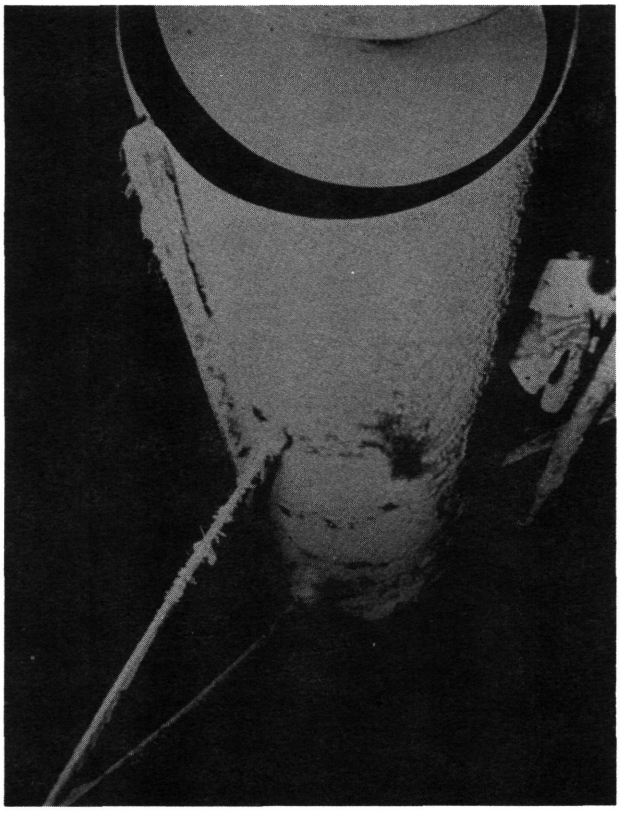

Figure 3. Vertical screw mixers are commonly found in small feed mills and in some feed mixing centers on hog farms. Because the discharge opening is above the lower end of the mixing auger, considerable amounts of feed can remain after feed no longer comes out of the discharge opening. This type of mixer also can harbor sulfonamide-laden dust.

perform these tests or have access to persons who can perform the tests. Sulfamethazine test kits are available from the following companies:

Environmental Diagnostics	IDEXX Co.	Idetek, Inc.
Box 908	100 Fore St.	1057 Sneath Ln.
Burlington, NC	Portland, ME	San Bruno, CA
27215	04101	94066

Pork Quality Assurance

The National Pork Producers Council has developed a three-stage Pork Quality Assurance program which is designed to assist pork producers in eliminating sulfonamide and other drug residues. The basis for the program is education and management changes followed by voluntary testing for residues. Information on the program is available from the National Pork Producers Council, Box 10383, Des Moines, IA 50306.

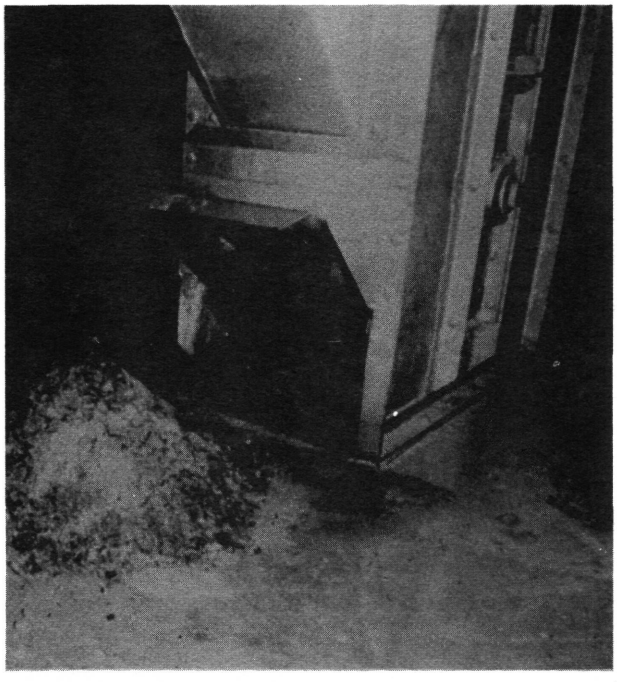

Figure 4. Elevator legs can hold sizable amounts of residual feeds or ingredients. Some of this material can be incorporated in the next batch of feed.

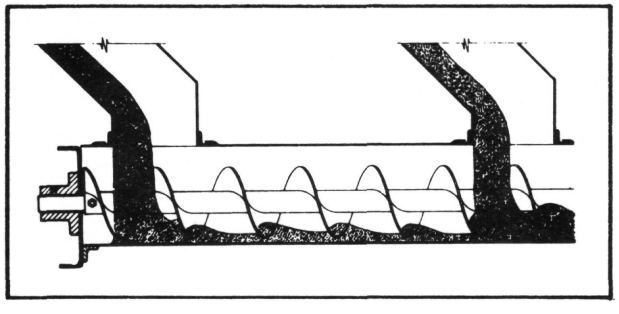

Figure 5. Augers often leave residual feed in the housing because the screws must have clearance. Drag-type conveyors are preferred because they are self- cleaning.

Figure 6. A feed delivery truck can be a source of drug carry-over. Feed can remain in the lower horizontal conveyor and in the vertical conveyor. Although the amount of residual feed depends on the design of a particular system, residual feed can range up to 100 pounds.

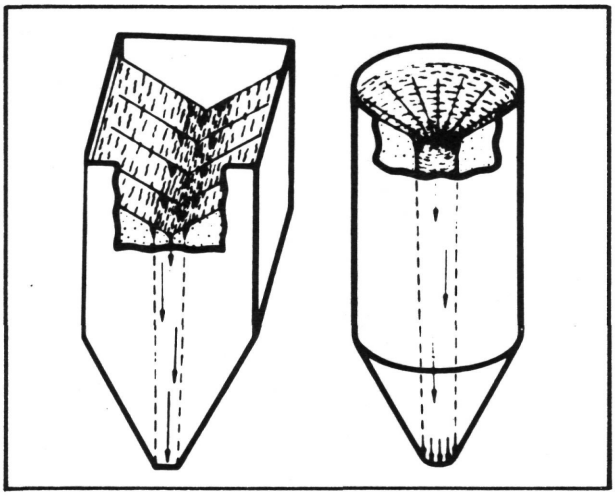

Figure 7. Movement of feed out of a bin occurs directly above the discharge opening. The remaining material then cascades down the slope of the crater that is subsequently formed. Failure to completely empty bins before refilling will result in residual feed being left in the bin.

Summary

Drug residues in pork carcasses are a deterrent to consumer acceptability of pork and to international sales of pork. Drug residues can be greatly reduced and even be eliminated by adherence to the following practices.

1. **Use only approved levels and combinations of drugs.**
2. **Follow good feed mixing practices (especially adequate mixing time) to insure that feed is mixed properly.**
3. **Maintain a record system to keep track of drug premixes and medicated feed usage.**
4. **Mix batch feeds in proper sequence to reduce the chance of carry-over of drugs into finishing feed.**

5. **Clean out or flush feed mixing, conveying and feeding equipment to reduce drug carry-over into finishing feeds.**
6. **Adhere to proper withdrawal periods for drugs.**
7. **Prevent recycling of drugs via manure and urine.**
8. **Use on-farm testing program to insure freedom from drug residues.**
9. **Read and follow the guidelines outlined in the Pork Quality Assurance Program of the National Pork Producers Council.**
10. **Inform other pork producers how to check for residues and the problems associated with residues.**

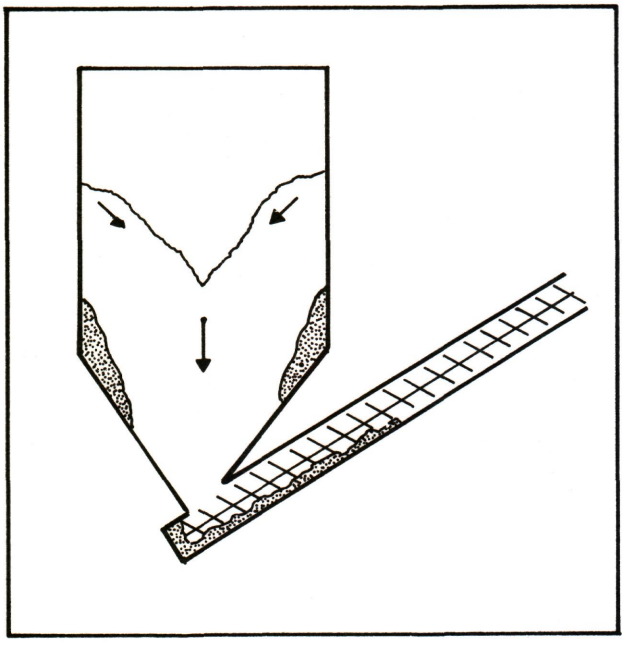

Figure 8. Typical feed flow in a bin with the dark areas illustrating where the feed is most likely to remain and contaminate the next batch.

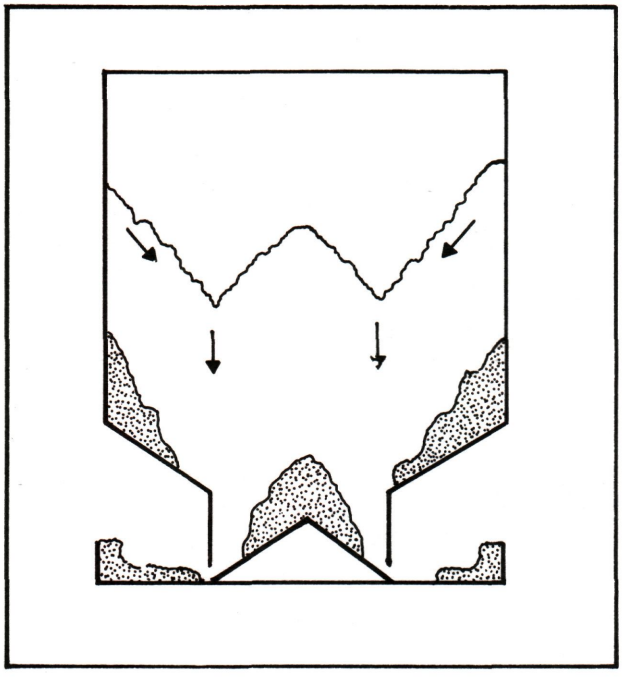

Figure 9. Typical feed flow in a hog feeder. Residual feed areas are indicated by dark areas. Failure to completely empty the feeder before refilling will result in residual feed being left in the feeder.

Date mixed	Tank number	Description of feed	Tons	Medication	g/ton
6-14-90	2	Gestation, 14%	3	—	—
6-16-90	1	Starter, 18%	1	Tylan-Sulfa	100-100
6-16-90	3	Lactation, 14%	3	Neo-terramycin	50-50
6-21-90	4	Finisher, 13%	5	Aureomycin	50

Figure 10. A feed mixing record sheet will help to eliminate mixing errors and help producers keep track of medicated feeds.

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