

**Title:** Management guide for reduced usage of antibiotics in swine production – NPB #05-173

**Investigator:** Hans H Stein

**Institution:** South Dakota State University

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**Abstract:** A thorough review of the literature on management strategies for weanling pigs documented that there are a number of strategies that have been effective in reducing the negative impacts of discontinued use of antibiotic growth promoters in diets fed to weanling pigs. Producers need to reformulate diets to include barley, naked oats, or oats rather than corn, and the inclusion of soybean meal should be limited as well. Crude protein concentrations should be reduced to less than 18% and acidifiers, probiotics, zinc oxide, and copper sulfate may be used. Diets should be fed in a liquid form if possible, preferably as fermented liquid feed. If dry feed is used, diets should be pelleted. Feed intake should be restricted to 75% of ad libitum intake during the initial 2 weeks post weaning. These initiatives will all help pigs get through the weaning period without developing diseases. The profit from pig production will be maximized if pigs are weaned between 21 and 28 days of age. All-in all-out production should be practiced and pigs should always be weaned into an empty, clean, and disinfected room. If possible, this room should be at an off-site facility, possibly a wean to finish unit. Disease pressure and mortality does not necessarily have to increase if no antibiotic growth promoters are used, but profits will likely suffer because costs to prevent pigs from getting sick if no antibiotics are used, are greater than the cost of antibiotic growth promoters.

### Introduction

The discontinued use of antibiotic growth promoters in the EU and the discussion about similar policies in the US necessitates that producers have strategies in place that can be used if antibiotic growth promoters can no longer be used in the US. It is widely believed that discontinuation of the use of antibiotic growth promoters will reduce pig performance and increase health problems in weanling pigs. However, there is a wide body of research that indicates that weanling pig performance does not necessarily have to be reduced, if the correct management strategies are incorporated into swine production systems based on no use of antibiotic growth promoters. It is recognized that not all producers may be able to include all of these strategies into their specific systems, but most of the management strategies that have been shown to be effective can be implemented by most producers.

### Objective

It was the objective of this project to summarize available information about management strategies that can be implemented to improve the performance and reduce the mortality of weanling pigs fed diets to containing no antimicrobials.

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### For more information contact:

**National Pork Board, P.O. Box 9114, Des Moines, Iowa USA**

800-456-7675, **Fax:** 515-223-2646, **E-Mail:** [porkboard@porkboard.org](mailto:porkboard@porkboard.org), **Web:** <http://www.porkboard.org/>

## **Materials and methods**

Relevant literature from a wide variety of sources and in several languages was searched using available search engines and databases for information related to management strategies that can be used to improve pig performance and reduce mortality in weaning pigs fed diets without antibiotic growth promoters. Peer reviewed as well as non-peer reviewed literature was searched. The search engines “Pub Med”, “Hog Info”, and “Google Search” were used to search for information in English while local search engines were used to search literature published in German, Danish, and Swedish. Materials were summarized within eight different management categories. All the material was written together in a final report that is formatted for peer-reviewed publication. This report contains a large number of references. Results were also written into a producer-oriented short management bulletin.

## **Results**

The literature review revealed that current knowledge obtained from pigs fed diets containing no antibiotic growth promoters can be summarized into eight categories. Within each category, research has been conducted to investigate how pigs respond to feeding diets containing no antibiotics and to find the best recommendation. The eight categories include the following:

- Weaning age
- Segregated early weaning
- Physical form of diet
- Restricted feeding
- Low protein diets
- Alternative cereal grains
- Environment for post-weaning pigs
- Dietary additives

Within each category, results were summarized and the strategies that were shown to be most effective in promoting pig performance and overall health or reduce incidence of health challenges were identified. An overall summary of the eight strategies was also developed in a table form (Table 1).

### ***Weaning age***

Results of the literature review showed that the best overall performance of weaning pigs is obtained if pigs are weaned between 21 and 35 days of age (Table 1). Pigs weaned before 21 d of age have a reduced disease resistance due to an immature immune system, poorly developed digestive functions resulting in low nutrient digestibility, low concentrations of beneficial intestinal microbes resulting in high intestinal pH that is favorable for pathogenic growth, and a higher susceptibility to stress. The combined results of these effects are poor growth performance for early weaned pigs compared with pigs weaned at an older age. It also has been demonstrated that early weaned pigs experience growth depressions if they are vaccinated because of the immature immune system. The older the pigs are, the lower is the mortality and the incidence of post-weaning diarrhea and the better is the overall pig performance. However, as weaning age is increased, the number of litters produced per sow per year is reduced. Therefore, the most economical weaning age is between 25 and 28 days of age. If pigs are weaned at a lower age, more expensive feed is needed and pigs are more likely to develop post weaning-diarrhea and other diseases. If pigs are weaned later than 28 days of age, the reduction in litters produced per sow per year will reduce sow productivity and thus reduce profitability.

### ***Segregated early weaning and all-in all out production***

Segregated early weaning was originally introduced for weaning of pigs less than 14 to 16 days of age. It was believed that this early weaning would prevent the transfer of pathogens from sows to piglets because the pigs were still protected by maternal immunity. It is, however, now clear that the real advantage of this system is the weaning into an off-site facility that is clean, empty, and disinfected when pigs enter the facility, which prevents the transfer of pathogens from older pigs to the newly weaned pigs. The system works well regardless of the weaning age of the pigs and it is now believed that the potential transfer of pathogens from sows to pigs before weaning plays only a minor role in the development of diseases in newly weaned pigs. When age

segregation is also combined with site segregation, the highest degree of protection against infections is achieved. However, most producers do not have the ability to segregate weaning groups at the farm level, and most often, several weaning groups are present at the same site, but in separate buildings. This system has been shown to work quite well provided that biosecurity is strictly observed for each building to avoid transfer of pathogens from one age group to another.

In systems where off-site weaning is not possible, an all in-all out system may be used with separation of each age group in separate rooms. This system can work as well as off-site weaning if strict biosecurity is enforced and the transfer of animals from one room to another is avoided. It appears, therefore, that it is the all-in all-out concept and strict biosecurity that is the key to avoiding infections and disease challenges in weaning pigs. These concepts are most easily enforced in off-site weaning systems, in particular if they are combined with age segregation. However, the concepts may also work well in on-site weaning systems.

Off site weaning usually increases costs to transport pigs, feed, and people compared with on-site weaning. There may also be increased construction costs involved with this system. However, if off-site weaning is combined with a wean to finish production system, most of these extra costs may be prevented or reduced. There are, however, no extensive economic analyses available to describe the true costs involved with each system, and it is, therefore, not possible to decide which system is most economical.

### ***Physical form of the diet***

It is well documented that energy and nutrient digestibility is improved if grains are ground at to a smaller rather than larger particle size. Feeding pelleted diets rather than diets in a mash form also improves performance of all categories of pigs and feed conversion is usually increased by 5 to 10% if diets are pelleted. However, research has demonstrated that a greater improvement in performance is often obtained in newly weaned pigs if diets are pelleted rather than fed in a mash form. The reason for this effect may be that the heat treatment obtained during pelleting increases nutrient and energy digestibility. Palatability and therefore also feed intake is sometimes also improved if diets are pelleted. The down side to small particle size and pelleting is that the risk of pigs developing ulcers is increased and it is, therefore, recommended that the particle size is at least 600 microns in pelleted diets fed to newly weaned pigs.

If it is possible, diets to weaning pigs should be fed in a liquid form. Experiments in Denmark demonstrated that daily gain is improved by an average of 12.3% if pigs are fed liquid diets rather than dry diets during the initial 2 weeks post weaning, but research in the US has indicated that even greater improvements in performance may be obtained. It also has been shown that pigs that are fed liquid diets during the immediate post-weaning period will reach market weight almost 4 days earlier than pigs fed dry diets. Even greater improvements in performance have been reported if the liquid feed, or at least the grain portion of the feed, is fermented prior to feeding. In Danish experiments, performance was improved by an average of 22% if fermented liquid rather than dry feed was provided right after weaning. The reason for these improvements in pig performance for pigs fed liquid or fermented liquid feed is improved intestinal health and a reduced colonization with pathogens.

There are costs associated with pelleting but because of the improvement in performance, this cost is easily justified. For liquid and fermented liquid feeding, costs vary depending on the farm that is using it. For new constructions, liquid feeding systems are not more expensive than dry feeding systems, but considerable costs are involved if existing facilities built for dry feeding are converted to liquid feeding.

### ***Restricted feeding***

When newly weaned pigs are allowed ad libitum access to feed, they often consume more feed than they can digest in the small intestine. Undigested feed will be fermented in the large intestine and result in nourishment for microbes, which in turn often results in diarrhea. It is, therefore, possible to reduce the incidence of diarrhea if pigs are fed restricted during the immediate post weaning period. Results have indicated that the incidence of diarrhea is reduced by 50% and the need for antibiotic treatments is reduced by 56% if pigs are restricted to 75% of ad libitum intake during the initial 2 weeks post-weaning. In an experiment from Sweden it was shown that this effect may be obtained if feed is restricted from day 3 to 9 post-weaning, so this period appears to be critical for the development of diarrhea.

The reduced weight gain that is often associated with restricted feeding is usually compensated for

during the period following feed restriction. Pigs that are fed restricted during the initial 2 to 3 weeks post-weaning will, therefore, reach market weight at the same time as pigs that were not restricted and the restricted feeding schedule does not reduce overall pig performance. In contrast, feed efficiency is usually improved if pigs are on a restricted feed intake.

Restricted feeding usually increases labor costs before more frequent feedings are required. However, the reduction in diarrhea, mortality, and antibiotic treatments and the improved feed conversion more than compensates for this. As a consequence, profitability will improve if pigs are fed restricted during the immediate post-weaning period.

### ***Low protein diets***

It is well documented that many of the compounds that cause diarrhea in weanling pigs originate in the protein fraction of the feed. As a consequence, the incidence and severity of diarrhea during the post-weaning period can be reduced by approximately 25% if pigs are fed diets containing 18% crude protein rather than 21%. If the concentration of crude protein is reduced to levels below 18%, the reduction in diarrhea is even greater.

Low-protein diets need to be fortified with crystalline amino acids to ensure that diets are adequate in amino acids. However, if the crude protein concentration is less than 18%, this cannot be accomplished in an economical way. Therefore, diets containing less than 18% crude protein usually contain fewer indispensable amino acids than required for maximum growth. Pigs fed such diets will, therefore, have a lower growth rate than pigs fed diets that are adequate in amino acids. However, data from the UK and the US have shown that pigs that are fed a low-protein diet during the initial 2 to 4 weeks post-weaning will compensate during the following period when they are allowed to consume diets that are adequate in amino acids. As a consequence, there is no difference in final body weight at the end of the nursery period between pigs fed low-protein or conventional diets during the immediate post-weaning period. However, due to the compensatory growth, pigs fed low-protein diets have a better feed conversion for the entire post-weaning period than pigs fed conventional diets.

Low protein diets are not more expensive to formulate than conventional diets and because of the reduced incidence of diarrhea and the improved feed-conversion, there are fewer costs associated with producing pigs fed low protein diets.

### ***Alternative cereal grains***

There is ample evidence that nursery diets based on cooked white rice will improve performance and disease resistance of pigs compared with diets containing other cereal grains. However, the high costs of cooked white rice make this concept in-economical under commercial conditions. It has also been demonstrated that nursery pigs fed diets containing barley, naked oats, or oats have better performance and reduced incidence of diarrhea than pigs fed diets based on corn or wheat. It is, therefore, recommended that all or some of the cereal grains in nursery diets consist of barley, naked oats or oats. Barley and naked oats can fully replace corn in these diets, but the inclusion of oats should not exceed 30% of the diet. A combination of different sources of grain also may be used. The reason for the improved performance of nursery pigs fed diets based on barley, naked oats, or oats is believed to be related to specific fibers that are present in these grains. These fibers may serve as pre-biotics that increase the concentration of favorable microbes in the hind gut of the pigs. This in turn reduced the risk of pathogens being able to colonize in the intestinal system of the pigs.

Barley, naked oats, and oats are usually not more expensive than corn. There are, therefore, no added costs associated with using these grains in the diets. However, the improved performance, and reduced incidence of diarrhea in pigs fed diets based on these grains will result in a better overall profitability.

### ***Environment***

The environment that weanling pigs are kept in plays a crucial role in their wellbeing and overall health. It is documented that nursery pigs need a space allowance of at least 0.34 m<sup>2</sup> if they are kept in the nursery until they are 30 kg. The ambient temperature should be 28°C at weaning and then it should be gradually reduced. Drafts should be completely avoided and air needs to be as clean as possible with no contaminants. Fly and rodent control practices need to be in place and bio-security should be observed at all times.

Co-mingling of pigs from different sow herds is strongly discouraged because this practice will increase disease pressure and reduce performance. Within a farm, commingling cannot be completely avoided, but the

fewer litters that are mixed together the better. Introduction of new animals to a farm should be done only after animals have spend time in isolation and blood samples have confirmed that the new animals do not diseases.

### ***Feed additives***

A number of feed additives are available for inclusion in diets fed to weanling pigs. Acidifiers, some functional proteins, and probiotics have all been shown to improve performance and may be used in diets containing no antibiotic growth promoters to both improve performance and reduce diseases (Table 2). The dietary inclusion of pharmaceutical levels of zinc and copper also is documented to improve performance and reduce diarrhea in weanling pigs. However, other additives such as essential oils and prebiotics have not consistently been shown to improve pig performance or reduce the disease pressure in pigs.

The advantages of using acidifiers, probiotics, zinc and copper are of a magnitude that the cost associated with including these additives in diets fed to weanling pigs. The cost of including functional proteins is, however, greater and may not always be economical, but it depends on the magnitude of the increase in performance compared with the cost of these products.

### **Discussion and summary**

The results of this research clearly indicate that there are a number of management strategies that can be implemented to reduce any negative effects of discontinuing the use of AGP in weanling pig production. The most important of these strategies involve reformulation of diets to include barley, naked oats, or oats, and to reduce the protein concentration in the diets. These strategies will have an immediate impact and improve performance while reducing disease problems. Dietary inclusion of acidifiers and probiotics will also contribute to a reduction of the negative impacts of not using antibiotic growth promoters. The inclusion of zinc oxide and copper sulfate in weanling diets at pharmaceutical levels will further help control intestinal diseases and improve performance. Reformulation of diets is easily done and something all producers can do immediately without increasing diet costs significantly. This should, therefore, be the first thing a producer is doing if no antibiotic growth promoters can be used. The combined effects of these changes in diet formulations will be improved profits from the production.

If there are problems with scouring during the immediate post-weaning period, pigs should be fed at a level of only 75% of ad libitum intake during the initial 2 weeks post-weaning. This is something that most producers can accomplish and it will greatly reduce mortality and the need for antibiotic treatments of pigs.

Feeding pigs pelleted diets rather than diets in a mash form will also improve pig performance and feed utilization. However, providing feed as liquid feed or fermented liquid feed is even more beneficial because pigs will not only have improved performance but also an improved immunity and a reduced incidence of diseases. Producers should, therefore, investigate possibilities for implementing liquid feeding systems in nurseries. The economic benefits from liquid feeding and fermented liquid feeding easily justify investments in equipment and technologies that can be used to accommodate liquid feeding.

One of the most effective management tools that can be used to prevent problems caused by the discontinuation of antibiotic growth promoters is to delay weaning of the pigs until they are close to 4 weeks old. Research has shown that disease problems are reduced and performance is improved if pigs are weaned later than 21 days of age rather than earlier than 21 days. However, to delay weaning until pigs are four weeks old, most production systems would have to add more farrowing space. There are obviously costs associated with adding farrowing space, but the economic benefits from later weaning are such that the overall profits would improve if pigs are weaned at an age between 3 and 4 weeks.

Using production systems that allow weaning groups to be weaned into empty, clean, and disinfected rooms is something all producers should observe. The benefits of all-in and all-out production cannot be ignored and is something that all producers should take advantage of. If strict biosecurity systems are observed, this system can work very well even if pigs are weaned on-site and the all-in all-out system is practiced by room. If possible, pigs should be weaned to an off-site facility to further reduce the risk of disease contamination from other age groups of pigs, but the economic benefits of off-site production have not been documented. However, if pigs are weaned into wean to finish facilities then the costs of operating off-site nurseries will be reduced. There is, however, very little information on the economic consequences of using different production systems.

## **Lay interpretation**

A summary of research conducted to investigate possibilities for reducing the negative impact of discontinuing the use of antibiotic growth promoters has documented that many management tools are available for producers.

The most important of these tools are the following:

- Increase weaning age to between 21 and 28 days
- Use all-in all-out production systems. Wean to off-site facilities if possible
- Regardless of the weaning system, provide pigs with a clean, draft-free environment. Provide room temperatures around 28°C during the initial weeks post-weaning. Control of flies and rodents and strict biosecurity is required
- Feed diets in a liquid form if possible – preferably as fermented liquid feed. If liquid feed can not be used, then feed diets in a pelleted form after grains have been ground to an average particle size around 600 microns.
- Restrict feed intake to approximately 75% of ad libitum intake during the initial 2 weeks post-weaning
- Formulate diets based on barley, naked oats, or oats. Avoid corn and soybean meal in the early weaning diets. Use diets that contain less than 18% crude protein during the initial 2 weeks post weaning – sometimes crude protein levels need to be as low as 15%. Use acidifiers, probiotics, and pharmacological levels of zinc and copper in the diets.

Using these management strategies, producers will be able to wean pigs without encountering increased problems with intestinal diseases and the use of therapeutic antibiotics will not increase. In many cases, producers will also be able to obtain pig performance at the same level as is obtained in systems that use antibiotic growth promoters. However, due to increased costs of production, profits may be reduced if no antibiotic growth promoters are used.

For more information, please contact Dr. Hans H Stein at the University of Illinois (email:hstein@uiuc.edu).

**Table 1.** Effect of management strategies on performance, health, and economy

Category	Effect on		
	Performance	Health	Economy
Weaning age	The later weaning the better performance. However, if pigs are weaned later than 21 d of age, the weight out of the nursery is not influenced by weaning age.	Later weaning reduces incidence of post weaning diseases.	Weaning between 21 and 28 days gives the greatest return on investment.
Segregated early weaning and all-in all out production	Pig performance is improved by all-in all out production. Best results are obtained if off-site weaning is used, but it may also work in on-site weaning systems.	Health is improved if pigs are weaned to off site facilities, in particular if this is combined with age segregation.	No economic analyses have been reported to investigate the effects of these weaning systems.
Physical form of diet	Grinding feed to a particle size of 600 microns and pelleting the diets will improve performance by at least 10%. Liquid feeding and fermented liquid feeding improves performance by an additional 12 and 22%, respectively.	The impact of pelleting on health may be slightly negative because of ulcers. Liquid and fermented liquid feeding results in improved intestinal health and less diarrhea.	Pelleting will improve profits. Economics of feeding liquid or fermented liquid feed depends on how the farm is constructed but will be economical in most cases
Restricted feeding	Performance unchanged, but mortality reduced	Less diarrhea, reduced need for antibiotic treatments	Improved profit
Low protein diets	Improved feed conversion	Less diarrhea	Improved profit
Alternative cereal grains	Improved performance	Less diarrhea	Improved profit
Environment	Improved performance if proper environment is maintained	Improved health of pigs in superior environment	Improved profit
Feed additives	Improved performance if acidifiers, functional proteins, probiotics, zinc oxide or copper is included in the diet	Improved health status of the pigs – often associated with improved intestinal health	Improved profit

**Table 2.** Comparative effects of feed additives in diets fed to weanling pigs.

Additive	Effect on			
	Daily gain	Feed intake	Gain to feed	Profit
Acidifier	6 - 12%	2 – 6%	2 – 10%	Improved
Functional proteins	Up to 25%	Up to 25%	No effect	Varies
Probiotics	2 – 9%	No effect	2 – 5%	Improved
Prebiotics	0 – 4%	No effect	0-2%	Not improved
Essential oils	No effect	No effect	No effect	Reduced
Minerals	5-20%	2-10%	2-10%	Improved