SWINE FOCUS #003

Strategies for managing weanling pigs fed no antibiotic growth promoters

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Summary

There are a number of strategies that have been effective in reducing the negative impacts of discontinuing the use of antibiotic growth promoters in diets fed to weanling pigs. If possible, producers may reformulate diets to include barley, naked oats, or oats rather than only corn, and 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 added to the diets. 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 if problems with scouring are observed. These measures will help pigs get through the weaning period without developing gastrointestinal diseases. Profit from swine 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. If the above strategies are used, it is likely that pig performance can be maintained at the same levels as if antibiotic growth promoters are used. However, it is also likely that without antibiotic growth promoters in the diets, profits will be reduced.

Introduction

The use of antibiotic growth promoters in diets fed to livestock has been banned in the European Union since 2006. Similar policies are under discussion in the United States, and it is necessary that producers have strategies in place in the event that a ban is enacted here. It is believed that discontinuation of the use of antibiotic growth promoters will reduce pig performance and increase health problems in weanling pigs. However, a wide body of research indicates that weanling pig performance does not necessarily have to suffer, if the correct management strategies are used when use of antibiotic growth promoters is discontinued. While not all producers may be able to include all of these strategies into their specific systems, at least some of the management strategies that have been shown to be effective can be implemented by most producers.

Weaning practices

- Wean between 21 and 28 days of age
- If possible, employ off-site weaning
- Otherwise, use an all-in-all-out system and separate each age group into different rooms

Weaning age

A review of the literature indicates that the best overall performance of weanling pigs is achieved if pigs are weaned between 21 and 35 days of age. Pigs weaned before 21 days of age have a reduced disease resistance due to an immature immune system (Niekamp et al., 2007), poorly developed digestive functions resulting in low nutrient digestibility (Leibbrandt et al., 1975), low concentrations of beneficial intestinal microbes resulting in high intestinal pH that is favorable for pathogenic growth (Mathew et al., 1995), and a higher susceptibility to stress. These effects result in poor growth performance for early weaned pigs compared with pigs weaned at an older age (Leibbrandt et al., 1975). It also has been demonstrated that early weaned pigs experience growth depressions if they are vaccinated because of their immature immune systems. Mortality and the incidence of post-weaning diarrhea decline as age at weaning increases, and overall pig performance is improved (Fangman et al., 1996a; Dunshea et al., 2002; Main et al., 2004; Callesen et al., 2007). 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 21 and 28 days of age. If pigs are weaned at an earlier 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.

Table 1. Comparative effects of feed additives in diets fed to weanling pigs

Additive	Daily gain	Feed intake	Gain to feed	Profit
Acidifier	↑	↑	↑	↑
Functional proteins	↑	↑	-	Varies
Probiotics	↑	-	↑	↑
Prebiotics	↑	-	↑	-
Essential oils	-	-	-	↓
Zinc and copper	↑	↑	↑	↑

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 (Alexander et al., 1980). 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 (Fangman et al., 1996b; Harris, 2000). Segregated early weaning involves weaning into a facility that is clean, empty, and disinfected when the pigs enter it, which prevents the transfer of pathogens from older pigs to the newly weaned pigs. Subsequent research has indicated that the clean facility is the key to preventing newly weaned pigs from getting infected (Bassaganya-Riera et al., 2001; Le Floch'h et al., 2006, 2009). All-in-all-out weaning into a clean, disinfected barn works well regardless of the weaning age of the pigs, so it appears that it is the sanitary environment and strict biosecurity that are important factors in avoiding infections and disease challenges in weanling pigs. These conditions are most easily enforced in off-site weaning systems, but they may also work well in on-site weaning systems (Fangman et al., 1998; Johansen et al., 2004). It appears 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.

Table 2. Effect of management strategies on performance, health, and economy

Category	Performance	Health	Economy
Weaning age	The later weaning the better performance. However, if pigs are weaned later than 21 days 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 further improves performance.	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

For producers who do not have the ability to practice off-site weaning, an all-in-all-out system may be used with separation of each age group in different 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.

Off-site weaning usually increases costs to transport pigs, feed, and people compared with on-site weaning. There may also be increased construction costs associated with this system. However, if off-site weaning is combined with a wean-to-finish production system, most of these extra costs may be reduced. To date, there are no extensive economic analyses available to describe the true costs involved with each system, so it is not possible to determine if off-site weaning or on-site all-in-all-out weaning is more economical.

Environment

The environment in which weanling pigs are kept plays a crucial role in their wellbeing and overall health. Facilities should be designed to reduce stress and pathogen exposure as much as possible. To prevent crowding and social stress, nursery pigs need a space allowance of at least 0.34 m^2 if they are kept in the nursery until they are 30 kg (Holden and Kliebenstein, 2002), but more space may be required if no antibiotic growth promoters are used (Varley, 2004). Exposure to cold temperatures increases the risk of pigs getting diarrhea (Hessing and Tielen, 1994), and temperatures above the pigs' comfort zone may reduce feed intake and growth performance. Therefore, the ambient temperature should be 28-30 °C at weaning and then it should be gradually reduced (Le Dividich and Herpin, 1994). Drafts should be completely avoided, and air needs to be as clean as possible with no contaminants.

Control of pathogens is especially important when antibiotic growth promoters are not used. Fly and rodent control practices need to be in place and bio-security should be observed at all times. Commingling of pigs from different sow herds is strongly discouraged because this practice will increase disease pressure and reduce performance (Gray et al., 1996). Within a farm, commingling cannot be completely avoided, but the fewer litters that are mixed together the better -- both for pathogen control and to reduce social stress (Puppe et al., 1997).

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Diet

Physical form of the diet

Highly digestible nutrients provide less substrate for pathogens in the hindgut. Energy and nutrient digestibility is improved if grains are ground 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. Feed conversion is usually increased by at least 5 to 10% if diets are pelleted (Stark et al., 1994; Wondra et al., 1995; Laitat et al., 1999; Xing et al., 2004). The greatest improvement is in the period immediately after weaning (Stark et al., 1994; Xing et al., 2004). The reason for this effect may be that the heat treatment involved in pelleting increases nutrient and energy digestibility (Wondra et al., 1995; Medel et al., 2004; Xing et al., 2004). Pelleting also reduces feed wastage (Wondra et al., 1995). Palatability of corn and barley is also improved if diets are pelleted (Solà-Oriol et al., 2009).

Environment

- Allow greater than 0.34 m^2 of space per nursery pig
- Maintain temperatures between 28-30 °C at weaning and then reduce gradually
- Minimize exposure to pathogens by controlling flies and rodents, and by avoiding commingling pigs from different sow herds

Grinding feed to a small particle size results in greater digestibility of nutrients (Kim et al., 2002), and reduces the amount of undigested feed entering the hindgut. This, in turn, will lead to less pathogen growth and fewer intestinal diseases. For growing-finishing pigs, a particle size of 450 to 600 microns is recommended, but there are no data for the optimum particle size of grain in diets fed to weanling pigs.

If it is possible, diets for weanling pigs should be fed in a liquid form. Experiments in Denmark have 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 two weeks post weaning (Jensen and Mikkelsen, 1998), but research in the U.S. has indicated that greater improvements in performance may be achieved (Odle and Harrel, 1998; Kim et al., 2001). Pigs fed liquid diets during the immediate post-weaning period will also reach market weight almost four days earlier than pigs fed dry diets (Kim et al., 2001). 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 immediately after weaning (Jensen and Mikkelsen, 1998). The reasons for these improvements in pig performance for pigs fed liquid or fermented liquid feed are improved

intestinal health and reduced colonization by pathogens (Deprez et al., 1987; Scholten et al., 1999; Højberg et al., 2003).

Liquid feeding of weanling pigs during the initial 1 to 2 weeks post-weaning can be accomplished by mixing dry feed and water in a 1:1 ratio. After 10 to 15 minutes, the pellets will be dissolved and the feed can be mixed with a whisk and poured into a trough in the pen. Pigs should be fed at least 4 to 6 times per day. The amount of feed poured into the trough at each feeding should be limited to the amount pigs can consume within 15 minutes after feeding. Dry feed should also be offered from a feeder on an ad libitum basis, and water needs to be available from a drinking nipple at all times. Offering liquid feed to pigs ensures that they will ingest water along with the feed and will not be dehydrated.

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 for the entire nursery period.

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 on a restricted basis during the immediate post weaning period (Wathes et al., 1989). Days 3 to 9 post-weaning appear to be critical for the development of diarrhea, so if feed intake is restricted during this period, improved health is observed (Rantzer et al., 1996).

The reduced weight gain that is often associated with restricted feeding is usually compensated for during the period following feed restriction (Ball and Aherne, 1987). Pigs that are fed on a restricted basis 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 restricted in their feed intake (Ball and Aherne, 1987).

Restricted feeding usually increases labor costs because frequent feedings are required to prevent pigs from overeating when feed is available (Ball and Aherne, 1982). However, the reduction in diarrhea, mortality, and antibiotic treatments and the improved feed conversion more than compensate for this. As a consequence, profitability will improve if pigs are fed on a restricted basis during the immediate post-weaning period.

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 (Pluske et al., 1996; Siba et al., 1996; Vicente et al., 2004; Mateos et al., 2006). However, cooked white rice is too costly to be used as the basis of swine diets 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 compared with pigs fed diets based on corn or wheat (Medel et al., 1999; Stein and Kil, 2006). 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 cereal grains may also be used.

The reason for the improved performance of nursery pigs fed diets based on barley, naked oats, or oats is

Diet formulation

- Feed diets in a liquid form if possible – preferably as fermented liquid feed. If liquid feed cannot be used, then feed diets in a pelleted form
- Restrict feed intake to approximately 75% of ad libitum intake during the initial 2 weeks post-weaning. Feed small amounts often
- Formulate diets containing barley, naked oats, or oats
- 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%
- Consider using acidifiers, probiotics, and pharmacological levels of zinc and copper in the diets

believed to be related to specific fibers that are present in these grains (Stein and Kil, 2006). These fibers are fermented in the hindgut and the short chain fatty acids that are produced may stimulate the expression of cytokines in the intestinal tract (Pié et al., 2007), which will reduce the risk of pathogens being able to colonize the intestinal tract. Additionally, these fibers may serve as pre-biotics and increase the concentration of favorable microbes in the hind gut of the pigs (Smiricky-Tjardes et al., 2003; Konstantinov et al., 2004). Both of these effects reduce the risk of pathogens being able to colonize the intestinal tract.

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. Thus the improved performance and reduced incidence of diarrhea in pigs fed diets based on these grains will result in a better overall profitability.

Feed additives

A number of feed additives are available for inclusion in diets fed to weanling pigs. Acidifiers are added to weanling pig diets to compensate for insufficient hydrochloric acid secretion in the first three to four weeks post-weaning. A gastric pH of 2 – 3.5 provides the proper environment for pepsinogen activity, which in turn stimulates the secretion of proteolytic enzymes from the pancreas. When gastric pH is too high, these activities are suppressed and feed digestion is reduced. High gastric pH also allows proliferation of coliform bacteria (Ravindran and Kornegay, 1993). Fumaric acid and citric acid have been tested in numerous experiments and have been shown to increase pig performance (Giesting et al., 1991; Radecki et al., 1998). Research in Greece (Tsiloyiannis, 2001) has demonstrated positive effects on post-weaning diarrhea from dietary additions of propionic, lactic, formic, malic, citric, and fumaric acids, with lactic acid providing the best results. Addition of certain salts of acids to swine diets may also improve performance and reduce disease, including calcium formate (Pallauf and Huter, 1993), potassium diformate (Paulicks et al., 2000; Canibe et al., 2001), and sodium bicarbonate (Giesting et al., 1991).

Certain proteins in swine diets have value beyond the simple provision of amino acids. Spray-dried animal plasma added to the diet is believed to improve immunocompetence of pigs, possibly due to the presence of immunglobulins. Two reviews on spray-dried animal plasma concluded that it improved average daily gain by 25% or more, and some studies showed a decrease in diarrhea as well (Coffey and Cromwell, 2001; van Dijk et al., 2001). Immunized egg proteins, derived from eggs laid by hens that have been immunized against pig pathogens, may prevent development of disease in pigs (Marquardt et al., 1999). However, immunized egg products are expensive, and thus are not widely used. Currently available evidence is insufficient to determine if whey protein and conventional egg proteins provide benefits sufficient to warrant their inclusion in swine diets (Pettigrew, 2006).

Probiotics, or direct-fed microbials are live cultures of beneficial bacteria or yeast that are added to the diet. The beneficial bacteria are believed to work by colonizing the intestinal tract and suppressing the concentration of pathogens. Pigs showed a positive growth response in 30 of 31 experiments reviewed in which lactic acid-producing bacteria were added to diets (Kremer, 2006). Supplementing pig diets with yeast may also improve growth performance, but the mode of action is unclear (van Heughten et al., 2003).

Pharmaceutical levels of copper sulfate (150-250 ppm) and zinc oxide (2-4000 ppm) in starter diets improve growth performance beyond that seen when zinc and copper are present in the diet at nutritionally adequate levels (Hahn and Baker, 1993; Hill et al., 2001). High dietary levels of zinc can also protect against intestinal diseases in weanling pigs (Pettigrew, 2006) by suppressing coliform bacteria (Namkung et al., 2006).

Mannan oligosaccharides have a prebiotic effect similar to that of the fermentable carbohydrates in barley and oats. A positive effect from adding these carbohydrates to swine diets has been demonstrated (LeMieux et al., 2003; Rozeboom et al., 2005), but effects have not been sufficient to always make this practice profitable.

Certain essential oils are sometimes used in swine diets because of their microbicidal properties, but scientific evidence for the efficacy of essential oils is lacking. Experiments using different combinations of essential oils have shown either a negative effect on pig performance (Namkung et al., 2004) or no effect (Ilsley et al., 2005; Manzanilla et al., 2006).

The advantages of using acidifiers, probiotics, zinc, and copper are of a magnitude that often justifies the cost associated with including these additives in diets fed to weanling pigs. The cost of including functional proteins is greater; whether or not the cost is economically justifiable depends on the magnitude of the increase in performance compared with the cost of the specific products used. Spray-dried animal plasma is the most cost-effective functional protein.

Low protein diets

Because newly-weaned pigs secrete less hydrochloric acid than older pigs, their ability to digest proteins is impaired and undigested protein provides substrates for microbial fermentation in the hindgut. Feeding a low-protein diet reduces protein fermentation in the distal gastrointestinal tract (Heo et al., 2009). As a consequence, the incidence and severity of diarrhea during the post-weaning period can be reduced by approximately 25% (Callesen and Johansen, 2006) or more (Heo et al., 2009) if pigs are fed diets containing 18% crude protein rather than 21%.

The concentration of crude protein can be further reduced, resulting in an even greater reduction in diarrhea. However, low-protein diets need to be fortified with six crystalline amino acids to ensure that they meet amino acid requirements. Crystalline lysine, methionine, and threonine can be purchased inexpensively, but crystalline tryptophan, isoleucine, and valine are often cost prohibitive. Diets with protein levels as low as 15.0 to 15.5% reduce diarrhea greatly, but these diets contain only about 80% of the levels of amino acids required for maximum growth. Pigs fed such diets will, therefore, have a growth rate of 60 to 80 g/d less than pigs fed diets containing the full requirement of amino acids (Stein and Kil, 2006). However, 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 (Wellock et al., 2009). 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 (Stein and Kil, 2006).

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

Conclusions

There are a number of management strategies that can be implemented to ameliorate negative effects of discontinuing the use of antibiotic growth promoters in pig production. The most important of these strategies involve reformulation of diets, which is a relatively easy step and something all producers can do immediately without increasing diet costs significantly. This should, therefore, be the first step a producer takes if no antibiotic growth promoters can be used.

Pigs should be weaned at an age between 21 and 28 days, using an all-in-all-out production system. Proper biosecurity procedures must be followed to prevent the introduction of pathogens. Maintaining the proper temperature, ensuring that pigs have enough space, and minimizing commingling of pigs from different herds will all reduce stress on the animals.

Disease pressure and mortality do not necessarily have to increase if no antibiotic growth promoters are used, but profits will likely be reduced because costs to prevent illness without the prophylactic use of antibiotics are greater than the cost of antibiotic growth promoters.

A full list of references is available at http://nutrition.ansci.illinois.edu/SwineFocus003References.

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