Nursery Management Update

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Unfortunately, due to a snowstorm in Kansas I was unable to fulfill the invitation to present at the 2002 Manitoba Swine Conference. Therefore, these proceedings will highlight some recently generated information on sanitation and the impact of weaning age on subsequent finishing performance. Additionally, the oral presentation will outline some of the information presented in the report published in the 2002 Manitoba Swine Conference Proceedings (Dritz, 2002).

Multi-site and segregated production are excellent health management tools to minimize the lateral transfer of disease producing infectious agents. Implementation of these production practices has allowed implementation of all-out production and thorough sanitation of production facilities. However, we continue to observe transmission of organisms that can survive relatively easily in the environment, such as *E. coli* and *Salmonella*. We attribute this to several factors that include the training of personnel on the importance of proper cleaning procedures. Operating the power washer is usually one of the lowest status and lowest paid positions on farms. Therefore, unmotivated and untrained personnel are many times depended on for this critical health control task. In some farms we have encouraged management to set up monitoring programs to ensure facilities are free of organic matter, dry, and warm before placement. These allow for easy identification of training needs and have resulted in greater motivation of staff since management is paying more attention to their aspect of the operation. A second major factor appears to be related to seasonal factors and is especially apparent in northern climates. We seem to observe more problems with *E. coli* associated nursery disease in the late winter and early spring. We attribute this to the inability to thoroughly dry facilities between groups. Cold climates with inadequate heating when pigs are not present also make it difficult to leave facilities empty for proper drying of the environment.

Research by Dr. Sandy Amass at Purdue provides practical information on the ability of production staff to transfer infections organisms across groups of pigs (Amass et al., 2003). Using an enterotoxigenic *E. coli* challenge model to evaluate biosecurity procedures, they found that changing outerwear and hand washing did not prevent transfer of *E. coli* between groups of pigs. However, a complete change of clothing and showering did prevent transmission. This is in contrast to previous work with TGE virus and PRRS virus indicating that hand washing and changing outerwear was sufficient to prevent transmission. This information also can be interpreted to indicate that pathogens such as *E. coli* are more difficult clean from the environment compared to TGE or PRRS virus. Again this information illustrates the importance of nursery hygiene programs.

Another critical area that impacts nursery management is the average age at weaning. It is generally recognized that implementation of earlier weaning ages result in a greater output of pigs per year. The decreased subsequent reproductive performance is overcome by an increase in litters per sow per year. However, populations of weaned pigs within production operations are commonly assigned an equal value, regardless of weaning age or weight. Although there are typically individual pig quality criterion or discount programs, weaned pigs meeting the minimum standards are valued equally. Therefore, two trials were conducted to determine the effects of weaning age on pig performance in a three-site production system (Main et al., 2002a,b). Trial 2 also evaluated the effects of modifying nursery feed budgets according to weaning age. In trial 1 (2,272 pigs), treatments included weaning litters at 12, 15, 18, or 21 d of age. In trial 2 (3,456 pigs), litters were weaned at 15, 16, 18, 19, 21, or 22 d of age and categorized into three treatments (15.5, 18.5, or 21.5 d of age). In trial 2, pigs in each age group were fed a nursery feed budget classified as more or less complex. Each trial was conducted as a randomized complete block design with four blocks of linked nursery and finishing sites. All wean age treatments were weaned from a 7,300-head sow farm on the same day into the same nursery. Each block remained intact as pigs moved from nursery to finishing site. Increasing weaning age (12, 15, 18, or 21; and 15.5, 18.5, or 21.5 in trials 1 and 2, respectively) improved (linear, $P < 0.001$) ADG (299, 368, 409, 474 ± 7 g/d; 435, 482, 525 ± 13 g/d) and tended to improve (linear, $P < 0.09$) mortality (5.25, 2.82, 2.11, 0.54 ± 0.76%; 2.17, 1.56, 1.30 ± .36%) in the initial 42 d post-weaning. Finishing ADG (722, 728, 736, 768 ± 11 g/d; 783, 790, 805 ± 11 g/d) also improved (linear, $P < 0.01$) with increasing weaning age. Overall, increasing weaning age improved (linear, $P < 0.03$) wean-to-finish ADG (580, 616, 637, 687 ± 8 g/d; 676, 697, 722 ± 6 g/d), mortality rate (9.4, 7.9, 6.8, 3.6 ± 0.95 %; 3.9, 3.4, 2.5 ± 0.5 %), and weight sold per pig weaned (94.1, 100.5, 104.4, 113.1 ± 1.3 kg, 107.6, 111.6, 116.2 ± 1.1 kg). Nursery feed budget did not affect ($P > 0.27$) wean-to-finish growth performance. Income over costs ($2.00, 5.11, 7.12, 11.19 ± 0.52/pig; $7.99, 10.04, 12.46 ± 0.46/pig), and cost per hundred lb sold ($39.10, 37.76, 36.96, 35.54 ± 0.21; $36.65, 35.95, 35.15 ± 0.15) improved linearly ($P < 0.01$) with increasing weaning age. The improvements in growth and mortality largely occurred in the initial 42 d after weaning, with smaller growth improvements in finishing. These studies indicate that increasing weaning age up to 21.5 d predictably improves grow-finish throughput (i.e. 1.80 ± 0.12 kg sold/(pig weaned • d increase in weaning age) in this three-site production system.

Therefore, two critical management inputs for successful nursery programs are sanitation and weaning age. Management focus on the importance of sanitation programs and critical evaluation of weaning ages are important for successful nursery management programs.

References

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Nursery Management: Hygiene and Feeding Management Practices to Ensure Healthy Pigs
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Nursery pig enteric disease continues to be prevalent in the modern swine industry. Adapting health improvement technologies such as segregated early weaning and all-in/all-out production schemes have not eliminated enteric disease concerns. Clinical disease is the biological sum of a number of production system inputs. These inputs include presence and dose of pathogen, a genetic susceptibility population, diet composition, weight and age of weaned pig, environmental management, presence of confounding pathogens, and general farm management practices (Madec and Josse, 1983; Madec et al, 2000; Vannier et al., 1983). Thus, ensuring the health of nursery pigs depends on managing many interrelated challenges.

A large, recently published epidemiological study designed to determine the relative risk of several factors associated with nursery pig enteric disease indicated that feeding management (33.6 odds ratio) in the first week after weaning and hygiene status (7.8 odds ratio) were two of the most important risk factors associated with decreased amounts of enteric disease in the nursery (Madec et al., 1998). Therefore, this paper will focus on reviewing hygiene procedures and feeding management factors that are associated with decreased amounts of enteric disease in nursery pigs.

Hygiene Practices

The primary objective of hygiene practices is lowering the dose of infectious pathogens that can be transmitted from the environment. It has been well documented that animal performance is increased in “clean vs dirty” environments and cleanliness is probably responsible for a large percentage of the growth performance benefits from all-in/all-out production (Klassing et al, 1988; Amass et al, 2001). Also, because the young pig is more susceptible to infections from enteric organisms, sanitation is especially critical for nursery facilities. Fortunately, most swine pathogens only survive for a brief amount of time outside the host in the absence of organic materials or moisture. Up to 99% of bacteria can be removed by cleaning alone under experimental conditions. However, the relative importance of the stages of sanitation include: 1) 90% removal by removing all visible organic matter, 2) 6 to 7% killed by disinfectants, and 3) 1 to 2% killed by fumigation (Morgan-Jones, 1987). However, recent reports indicate that environmental contamination is an important contributor of Salmonella infection. From one study in North Carolina, 27% (7/26) of drag samples obtained from a fully slatted finishing floor just prior to placement of pigs were found to be positive for salmonella (Davies et al., 1999).

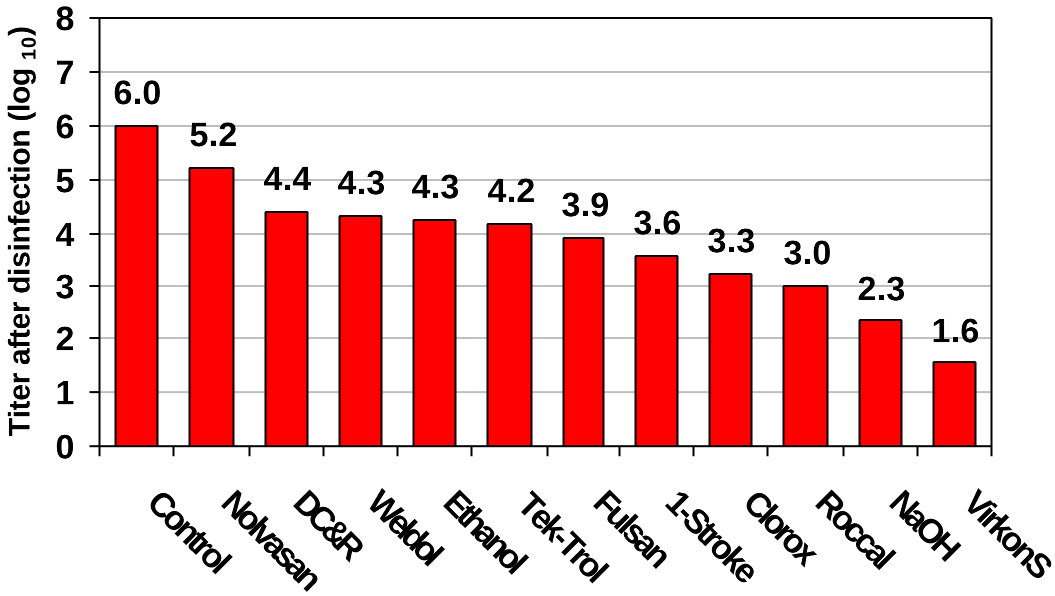
The basic principles of hygiene practices to decrease transmission from group to group from environmental contamination include: 1) Building materials that are easy to clean. Rough surfaces such as concrete are more difficult to clean than smooth surfaces such as wire. Smooth nonporous surfaces will provide easier removal of fecal matter and faster drying. 2) Thorough cleaning and removal of organic matter such as feces and feed. In general, organisms are protected against agents of disinfection by organic materials such as pus, serum, or feces. 3) Proper use of disinfectants, including dilution to proper dosage and application to the proper coverage area. 4) Proper downtime and drying of rooms. Antidotal observations from our group indicate that there is a seasonal nature to enteric problems in nurseries during the late winter and early spring period. We have observed that during this time period, due to environmental conditions, nursery spaces take longer time periods to dry and pigs are commonly placed in nurseries with moist surfaces and humid environments.

A survey of nursery hygiene practices on 129 French farms indicated several practices associated with decreased residual contamination (Madec et al., 1999). These practices included damping of the rooms immediately after the removal of the pigs. The researchers hypothesized that damping prevented dying of the fecal matter and increased the ease and thoroughness of cleaning. Use of a detergent also was suggested as associated with decreasing residual contamination. However, in another study evaluating the impact of detergent the researchers were unable to detect any impact and residual contamination after thorough washing (Kihlstrom et al., 2001). This indicates that using a detergent may be useful to improve the ease of cleaning. However, the detergents may not have much impact on the final amount of residual contamination if cleaning procedures are thorough.

As supported by several other studies, the study by Madec et al. (1999) indicated that thorough cleaning of organic matter resulted in less residual contamination (Amass et al., 2000, 2001; Kihlstrom et al, 2001). Additionally, greater distances between the surface of the slurry and the floor were associated with less residual contamination. The authors attributed this risk factor to splash back and recontamination during the cleaning process. Finally, factors associated with disinfectant usage were important. These included proper dilution and application of disinfectant. An evaluation of disinfectant ability to reduce infectivity of porcine circovirus type 2 (PCV2) indicates that commonly available disinfectants vary widely in their ability to neutralize the virus (Figure 1; Royer et al., 2001). This study evaluated 11 commonly used disinfectants in swine farms and research laboratories that included the following disinfectant classes (products tested): ethanol (alcohol), iodine (Weldol), phenol (1-Stroke, Tek-Trol), quaternary ammonium (Roccal D Plus, Fulsan), oxidizing agent (Clorox, VirkonS), alkali (NaOH), and chlorhexidine (Nolvasan). The mean titer after disinfection ranged from $10^{5.2}$ for the chlorhexidine to $10^{1.6}$ for the oxidizing agent VirkonS. This compares to the control titer without disinfection of 10^6. Thus, a reduction from 10^6 to 10^5 results in a 90% reduction, to 10^4 a 99% reduction, to 10^3 a 99.9% reduction and to 10^2 a 99.99% reduction. There are two important points to remember from this study:

1) PCV2 is a small enveloped virus similar to Parvovirus and, thus, difficult to neutralize with disinfectants.
2) This study was done under controlled laboratory conditions and optimized for maximal disinfectant activity. Disinfectant activity may be even less effective in the field setting.
3) Nonetheless, VirkonS appeared to have the best activity.

Figure 1. Reduction in infectivity of PCV2 after a 10 min exposure to disinfectant. Royer et al., 2001.



Until recently, there has been little objective scientific evidence to evaluate hygiene practices in swine operations. With an increased emphasis on evaluating biosecurity practices there have been several recent studies. In addition to the PCV2 disinfectant evaluation, these include the evaluation of farrowing house cleaning protocols (Kihlstrom et al., 2001), boot bath cleaning procedures and disinfectants (Amass et al, 2000, 2001), and methods of rapid evaluation of surface contamination in swine facilities (Kelly et al., 2001).

Briefly, the evaluation of farrowing house cleaning protocols evaluated the amount of bacterial surface contamination in a sequential manner after low pressure washing of surfaces, high pressure with or without a detergent, and after application of disinfectant. Bacterial counts were generally lowered by two logs (99%) between the low and high pressure washing irrespective if a surfactant was used or not. Counts were generally lowered by another two logs after disinfection. The major conclusion from this study is that sequential washing and disinfection steps result in reductions in bacteria and each step contributes to the decontamination process.

While boot baths are widely implemented on swine farms there appears to be little scientific literature supporting their usage. A recent study by Dr. Amass from Purdue indicates that disinfecting boots was ineffective at reducing bacterial load of boots if the fecal matter had not been removed before disinfecting (Amass et al., 2000). She indicated that removal of fecal matter alone without disinfecting was responsible for a large proportion of bacterial load on the boots. A follow up study indicated that regardless of weather boots were cleaned with water first and then placed in a VirkonS bath for 30 seconds or cleaned in a VirkonS boot bath both methods resulted in rapid disinfection of boots. As with the previous study cleaning of the boots with scrubbing was an essential step of the process. Just stepping into the boot bath was not effective.

Methods to evaluate cleaning protocols for residual contamination have been recently evaluated (Kelly et al, 2001). Bacterial culture of cleaned surfaces is considered the “gold standard” for assessing cleaning procedures. However, culture is time consuming and expensive. Therefore, two rapid low cost systems that are available for detecting surface contamination in food processing facilities have been evaluated for use on surfaces in swine facilities. These include the Lightening system that detects ATP. The Lightening system has been previously evaluated on swine transport vehicles (Faust, 1997). The second system was the BioClean system which detects the presence of protein by means of a change in color of a color strip. In general the Lightening system had a high sensitivity and low specificity or a low number of false negatives but many false positives. In other words this system did not incorrectly classify surfaces as clean when they were actually contaminated very often. However, surfaces that were sterile but contained organic matter were incorrectly classified as contaminated a large percentage of the time. This appears to be because some nonviable organic matter contains traces of ATP. In contrast the BioClean system had low specificity and high sensitivity. Thus, in most cases when the test indicated the surface was contaminated, it was positive using the gold standard culturing technique. However, several surfaces that were classified as negative by the BioClean system were actually contaminated. Implications of this research indicate that subjective visual assessment of cleaning procedures is currently the most effective and practical method of evaluating the thoroughness of hygiene practices.

Feeding Management Practices

The basic rules for a successful nutritional program for the nursery pig can be summarized as follows: 1) start with as heavy of pig as possible; 2) feed as simple of diets as possible, and 3) focus on nursery feeding management. We cannot overlook the importance of initial pig weight and age and quality of husbandry and their influence on feeding management practices.

1) Importance of pig weight and age.

The optimal feeding patterns for lactating sows continue to be debated. However, the research results in this area are clear. Restricting feed, protein, or energy intake during any period of lactation will reduce milk production, decrease litter-weaning weight, and impair subsequent reproductive performance (King and Martin, 1989; Koketsu and Dial, 1998; Tokach et al., 1992). With the implementation of early weaning strategies, the importance of litter weaning weight has increased. Pigs weaned at heavier weights and older ages are simply easier to manage in the nursery and have lower risk of developing enteric disease (Cranwell et al., 1995; Madec et al., 1998). Other data indicate that pigs with lighter weight at weaning are at a higher risk of death (Deen et al., 1998). Unfortunately, management-induced energy deficiency during lactation leading to failure to achieve potential weaning weights is a major problem on many commercial swine farms.

In a recent experiment, we characterized the importance of weaning age on growth performance in the first 28 d after weaning. We grouped pigs by age (12 to 15 d, 16 to 18 d, and 19 to 21 d old) and weight (light or heavy) within each age category (Table 1). We found a weaning age by growth performance interaction ($P < .07$). Note that the difference in average weight between the heavy and lightweight categories was approximately 1 kg (Figure 2). Thus, the heavy 12 to 15-d and the light 16 to 18-d old categories averaged similar weights at weaning. The heavy 16 to 18-d and light 19 to 21-d old categories also averaged similar weights at weaning.

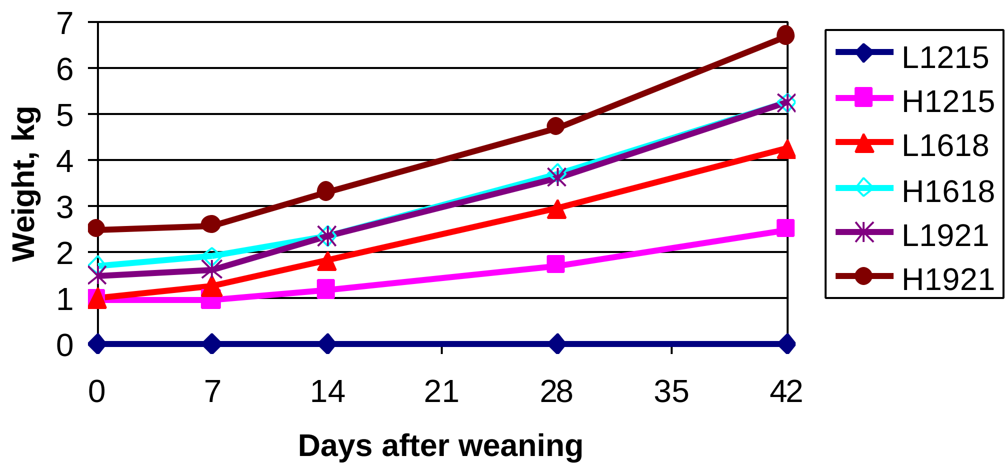
Table 1. Influence of weaning age (d) and weaning weight (lb) on nursery performance.

Age:	12 to 15		16 to 18		19 to 21			P Value		
Item Wt:	Light	Heavy	Light	Heavy	Light	Heavy	SEM	Weight	Age	Wt x Age
d 0 to 28										
ADG, g	213	241	286	286	309	295	5	0.05	0.01	0.07
ADFI, g	309	331	381	395	395	409	9	0.04	0.01	0.79
Feed/gain	1.46	1.38	1.35	1.39	1.37	1.39	0.02	0.83	0.10	0.04

Each number is the mean of 12 pens (21 pigs/pen) and pigs averaged 5.3 kg at weaning.

The youngest pigs at weaning gained the least from day 0 to 42 after weaning. The data clearly show that weaning weight is important with all ages of pigs; however, the impact of weaning weight was not as important as weaning age. When comparing pigs that were 16 days or older at weaning, the weight differences at weaning were only slightly increased by day 42 after weaning. Weaning weight was also important for pigs weaned at less than 16 days; however, age also becomes a critical factor as pigs with heavier weaning weights within the 12 to 15 d old category were not able to compensate for their young age. The heavy 12 to 15 day old pigs had the same weaning weight as the light 16 to 18 day old pigs; however, they were 2 kg lighter at day 42 after weaning. Weaning weight differences also become magnified with young pigs. Note that while the light 12 to 15 d old pigs were 1 kg lighter at weaning than the light 16 to 18 d old pigs the difference had magnified to 4 kg by 42 d after weaning.

Figure 2. Influence of weaning weight and age on weight difference between groups



Average age at weaning or lactation length calculated at weaning is based on the date of the last recorded wean event for the sow in most record keeping systems. In many farms where pigs are weaned multiple times per week, the heaviest pigs in a litter are weaned before the remainder of the litter. Thus, the actual average weaning age of the pigs will be lower than that stated on the summary report. We have observed actual weaning age as much as 1 day younger than that reported from average lactation length calculated from the sow wean event. Another common practice, even on farms that have strict policies about movement of pigs among rooms, is to hold back older lightweight pigs to wean them at an older age. This is another phenomena that will not be highlighted in records because the average age at weaning will be calculated based on the wean event of the sow.

Actual data from an experiment by Donavan and Dritz (2000) indicates that, on a farm with a 21 d maximum weaning age policy, 7.8% (83/1,062) of pigs were actually greater than the desired 21 d maximum age (Figure 3) and that 1.4% (15/1,062) were weaned at greater than 26 d of age. Also, note that 12% (128/1,062) of the pigs were weaned at 15 d of age or less. Examination of 1,800 pigs from another production system in which piglets are tattooed with date of birth indicated that 17% were greater than 21 d of age at weaning when the policy of maximum weaning age was 21 days.

Figure 3. Histogram of Ages at Weaning

Strict adherence to maximum weaning age has been advocated to minimize transfer of infectious disease. Also, a narrow spread of weaning age has been indicated as desirable for success of isowean programs with a maximum of 20 d of age suggested for the elimination or control of most swine pathogens (Harris, 2000). Our experience indicates that the actual weaning age of groups of pigs is highly variable based on farrowing house management practices. Therefore, even though most nursery pig nutritional programs are based on pig weight, we believe understanding the mean and variation in age are important for successful feeding management practices.

2) Feed as simple of diets as possible.

We adhere to three key concepts when formulating diets for the nursery pig. First, the economics of today's swine industry dictate that we must adjust pigs to the simplest and relatively lowest cost diets (i.e., grain and soybean meal) as quickly as possible after weaning. Second, we must remember that the newly weaned pig is in an extremely energy dependent stage of growth and that maximizing feed (energy) intake is essential. Third, we must remember the digestive physiology of the nursery pig and formulate the initial diets with highly digestible ingredients that complement the pattern of digestive enzymes secreted at weaning.

Strategies for feeding soybean meal to newly weaned pigs. One example emphasizing all three of these concepts is the practice of using soybean meal in diets fed immediately after weaning. An all milk or soy based diet was evaluated in a study using gnotobiotic pigs weaned at 21 d of age, challenged with an attaching and effacing *E. coli*, and fed the all milk or soy based diet for 14 d (Neff et al., 1994). Pigs fed the all milk diet grew faster than the soy fed pigs and had no evidence of attaching and effacing small intestinal lesions compared to the soy based pigs that did. Another study evaluating edema disease in pigs found an increased clinical expression and more microscopic evidence when feeding diets that contained more crude protein from soybean meal (Bosworth et al., 1996). Therefore, some nutritionists believe that weanling pigs should be fed diets with no or very little soybean meal immediately after weaning and that the level should be steadily increased over time. This slow and very gradual introduction of soybean meal into the pig's diet will minimize the potential for delayed-type hypersensitivity to the soy proteins, conglycinin and beta-conglycinin (Li et al., 1990a,b; 1991a,b) and, thus, generally results in excellent growth performance initially after weaning. However, it also leads to very high nursery feed cost. A second option is to feed a diet with a moderate level (10 to 15% of the diet for pigs weaned between 15 and 21 days of age) of soybean meal as a partial replacement for more expensive specialty protein sources (Friesen et al., 1993a). This approach is a compromise between feeding extremely expensive all milk- and animal specialty protein-based diets and too simple grain-soybean meal-based diets. As a result, the pig's feed intake is stimulated by the lactose and specialty protein sources, which are highly digestible and palatable and, thus, increase energy intake. At the same time, the pig becomes exposed to the moderate amount of soybean meal protein, minimizing the negative effects of a delayed-type hypersensitivity response. As a result the amount of soybean meal in the diet can be quickly increased in a phase feeding program to decrease the need for the more expensive specialty protein sources.

The net result of using soybean meal in this fashion is that we can still provide a highly digestible complex diet that stimulates feed intake immediately after weaning, and then quickly reduce diet complexity by increasing the amount of soybean meal protein (Dritz et al., 1996a). This strategy takes advantage of the fact that the impact of diet complexity on feed intake and pig performance decreases rapidly after weaning, especially in high health pigs. Thus, a feeding program can be developed that nutritionally allows for maximum growth performance and yet will be economically competitive.

Ingredient Selection Based on Digestive Capacity. Selection of different types and amounts of other feed ingredients also should be based on the three primary criteria of quickly reducing diet complexity to lower feed cost, maximizing feed (energy) intake, and physiology of the digestive system. Indeed, ingredient selection in addition to cost, should be based on factors including nutrient digestibility, amino acid density, lactose concentration, and stimulatory affects on feed intake and(or) growth. Another consideration is how an ingredient or combination of ingredients will react under various feed processing methods. The use of added fat is an example of this latter consideration. Although added fat is not well utilized by the pig as an energy source immediately after weaning, its inclusion is essential if diets containing high levels of milk and other specialty protein sources are to be pelleted.

The newly weaned pig's digestive system is relatively immature but, at the age of weaning, well adapted to digest the proteins, lactose, and lipids secreted in sow's milk. It has been well established that inclusion of lactose containing ingredients assists in the transition at weaning from sow's milk to a dry diet (Tokach et al., 1989; Mahan, 1992; Nessmith et al., 1997)**.** However, evidence may suggest that despite our best attempts to mimic the nutrient composition of sow's milk in a dry diet, there are dramatic changes that take place in the size, shape, and functioning of the villi in the small intestine (Cera, 1988; Li et al., 1990a, 1991a,b; and Jiang et al., 2000). The anatomical changes in the villi after weaning may be a possible cause for poor utilization of some ingredients. For example, the anatomical changes in the villi may cause the reduction in secretion of fatty acid binding protein, which correlates with poor fat utilization by pig for approximately 10 to 14 days after weaning (Reinhart et al., 1990). Ingredient selection also can change the degree to which these changes in the structure and functioning of the villi take place. An example is the shearing of villi caused by the delayed-type hypersensitivity reaction to excessive soybean meal fed immediately after weaning (Li et al. 1990a,b). Certain ingredients, such as spray-dried animal plasma also may have a positive effect on intestinal development (Jiang et al., 2000). Although our understanding of the influence of ingredient selection on structure and functioning of the villi has improved, the rapid change in function of the villi at weaning still seems to be a primary challenge in weanling pig nutrition. Despite the changes in digestive physiology at the time of weaning, protein source solubility within the intestine appears to be the primary limitation to digestion in the early-weaned pig (Asche et al., 1989a,b).

Post-weaning diarrhea and Zinc Oxide. Post weaning diarrhea associated with hemolytic *Escherichi coli* is a common, and potentially emerging problem in early wean pigs. Supplementing nursery diets with 3000 ppm ZnO post-weaning has also been observed to have beneficial effects in helping control post-weaning *E. coli* associated challenges under field conditions (Holm and Poulsen, 1996, Tokach et al., 2000).

A case study by Tokach et al. (2000), clearly illustrated the clinical and economic impact zinc oxide can have in controlling post-weaning diarrhea. Piglets were being weaned from a 1400-sow unit and sent to three different producers in loads of 600 pigs per week. Production records indicated poorer performance and a greater problem with *E. coli* associated diarrhea in one herd compared to pigs from the other two (394 g vs. 436 g of average daily gain (ADG) and 8.0% vs. 0.96% mortality for the case herd and other two herds, respectively). No environment and management differences on the sow farm of origin were found to explain the performance differences in these three groups of pigs. When diet formulations were reviewed, it was discovered that the first two diets fed to the weaned pigs in the case herd contained 612 ppm zinc from zinc oxide, instead of the specified 3,000 ppm. Comparable diets for the pigs in the other two locations did contain 3,000 ppm zinc. The diet formulation error was corrected, and performance of the next groups of pigs improved. This case study demonstrated the value of closeout records in determining the economic impact of the diet formulation error, which was calculated to be a loss of $3.13 to 5.88 per weaned pig.

In a challenge study, Jensen-Waern et al. (1998) found that adding 2500 ppm of zinc from zinc oxide to the diet prevented postweaning diarrhea without affecting the numbers of *E. coli* excreted in the feces. In another challenge study (Mores et al., 1998), high concentrations of zinc from any of four zinc oxide sources reduced the occurrence of *E. coli* diarrhea without affecting fecal shedding of the *E. coli*. In these experiments, a high prevalence of diarrhea occurred in pigs that did not receive high concentrations of zinc oxide when challenged.

Another recent study, demonstrated that pigs supplemented with ZnO at 3,000 ppm had a reduced translocation of bacteria to the ileal-mesenteric lymph node (Huang et al., 1999). The potential mechanism for this finding, as well as the other beneficial effects demonstrated above is not clearly understood. Zinc has been demonstrated to have an effect on cells undergoing rapid turnover, as it is needed for DNA and protein synthesis. Zinc also seems to play a role in stabilizing cell membranes and modify membrane functions (Bray and Bettger, 1990) Therefore, zinc's beneficial impact may be in part due to a direct supportive or protective role of intestinal epithelial cells (Huang et al., 1999).

Managing post-weaning *E. coli* challenges is increasingly becoming a more complex. These challenges need an ongoing effort for improved prevention or intervention techniques. Utilizing excess supplemental zinc early in the nursery phase is one option available to help minimize these challenges and promote growth. The environmental concerns associated with feeding zinc are significant. This concern reemphasizes the desire to restrict the 3,000 ppm ZnO inclusion in the first two weeks after weaning when feed intake is the lowest and the benefit the greatest.

3) Focus on nursery feeding management.

Many nutritionists and veterinarians recommend restricting intake by limit feeding or adding fiber in the first diets after weaning to control enteric disease. Restricting nutrient intake by adding fiber and reducing protein and energy levels has been shown to reduce clinical disease (Bertschinger et al., 1978). However, these dietary options tend to substantially increase feed cost and reduce growth potential. Subsequent to this work has been many research trials evaluating highly digestible protein and carbohydrate sources for nursery pigs based on digestive capacity (Tokach et al., 2002). This research that decreasing the damage to the small intestine and reducing the load of undigested substrate in the colon consistently results in maximal growth performance. Additionally, work from Australia indicates that pigs fed a highly digestible rice and animal protein based diet had fewer enterotoxigenic *E coli* recovered after challenge than when fed the same diet supplemented with guar gum to provide high levels of non-starch polysaccharides (McDonald et al., 1997). Fiber contains high levels of non-starch polysaccharides. A subsequent follow up study using a commercial wheat-lupin based diet compared to the rice and animal protein based resulted in significantly more pathogens isolated (Hampson et al., 2001).

Therefore, the scientific evidence appears to clearly indicate that adding fiber or restricting feed intake are not viable options for controlling enteric disease. In fact as mentioned before lower feed intake in the first week after weaning is significantly associated with greater risk of enteric disease (Madec et al, 1998). However, maximizing feed intake does not mean that feeders should be left wide open with excessive amounts of feed in the feed pan.

"If your fingers don't ache from cleaning the feed gates, you are not adjusting them properly."

We have observed decreased growth rate as a result of improper feeder adjustment. In an attempt to stimulate feeding behavior, large amounts of the first diet are placed in the feeding pan. Although intention is correct, the outcome is negative. Energy deficiency can result from pigs "sorting" the diet and a buildup of fines in the feeding pan. These fines then lodge in the feed agitator mechanism, making it difficult for new feed to flow from the feeder. This problem is remedied by management of the amount of feed flow in the pan to stimulate development of feeding behavior. Approximately 25 to 50% of the feeding pan should be visible in the first few days after weaning. As the pigs become more accustomed to the location of the feed and adjust feeding behavior, the amount of the feed in the feeding pan should be decreased rapidly to 25% or less coverage. Also, feed agitators need to be tested frequently to ensure that the buildup of fines does not prevent them from working freely.

The data in Table 2 depict growth performance before and after the institution of an aggressive feeder-management strategy. Contrary to popular belief, reducing the amount of feed present in the pan did not reduce average daily gain. Feed efficiency and daily gain both improved because of decreased wastage and continual access to fresh feed. Our recommendations are to have feed accessible for newly weaned pigs at all times in feeders that are adjusted correctly to teach the proper feeding behavior.

Table 2. Comparison of pig performance before and after institution of an aggressive feeder-management strategy in the first week after weaning.

	Strategy Change	
Item	Before	After
Weaning weight, lb	5.6	5.3
Day 0 to 7 after weaning		
ADG, lb	73	100
F/G	2.15	1.27

A total of 3,360 pigs used in analysis. Each number is the mean of 2 groups (Before) or 3 groups (After). Each group consisted of 32 pens each with 21 pigs.

In conclusion, nursery hygiene practices are focused on controlling the dosage of exposure to infectious pathogens. Feeding management practices are focused on controlling the clinical expression enteric disease. Attention to both practices is important for ensuring healthy nursery pigs.

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