INTRODUCTION

Management and nutrition of weanling pigs continues to be an area of intense interest throughout the world. As an industry, we have made gigantic strides in this arena during the past 20 years, but loss of performance, morbidity, and mortality still threaten even the best production systems.

In the following pages, I will attempt to update the reader on current thought about feeding weanling pigs. It is hoped that the information will be used to build confidence that we can, in fact, feed and care for very young pigs with the knowledge and ingredients available today. However, also know that this is not the final solution and that our approach a decade from now will surely look different than it does today.

AGE AT WEANING

Age at weaning was dramatically reduced during the 1970s to 1990s. The reason for the emphasis on reduced weaning age was to increase pigs/sow/year. If you assume a weaning age of 6 wk, 5 d for rebreeding, 114 d for gestation, and an average number of pigs weaned at 9.5/litter, then pigs/sow/year will be 21.5. Because days to rebreeding and gestation should be pretty much fixed, and assuming the same number of pigs weaned/litter, then the only way to really increase litters/sow/year (and thus pigs/sow/year) is to reduce weaning age. With a 3-wk weaning age, pigs per sow per year is increased to 24.8. So in theory, the move from 6-wk weaning in the early 1970s to 3-wk weaning in the 1990s greatly increased the productivity of those sows that consistently produced litters.

However, a shift to such a young weaning age was not without its challenges. Firstly, the nursery environment had to be greatly improved to achieve the warm, dry, draft free environment that was needed by the very young pig. Secondly, a new group of feed ingredients (high quality whey powder, select fish meal, and copper sulfate) was needed to prevent digestive upset and diarrhea. Finally, during the late 1990s, a new ingredient (plasma protein) and segregated weaning allowed us to push weaning age even to less than 10 d with excellent success rates. Indeed, it seems to be reproductive problems in sows and not issues with the weaned pigs that are yielding a preferred weaning age of 14 to 17 d at commercial units rather than an ultra-young 7 to 10 d. Still, to wean at 14 to 17 d demands careful attention to the nursery environment and diet formulations. So, let’s review what is known about preparation of diets for the early-weaned pig.
CEREAL GRAINS

The “base” cereal in the U.S. and throughout much of the world is corn. This does make sense because corn yields well and the kernels are relatively easy to harvest and store. Furthermore, corn has no significant anti-nutritional component, it is highly palatable, and its nutrients are well digested. However, this does not mean that young pigs must be fed corn and I certainly encourage producers and nutritionists to consider other cereals in the diets of weanling pigs if they become cost effective.

When sorghum is properly milled (to a mean particle size of approximately 500 microns) and used in the diets of weanling pigs, the relative feeding value of those diets will be 97 to 99% that of corn-based diets. Additionally, we have used cassava to formulate acceptable diets and rice and oat flour to achieve diets that were equal to or superior to corn-based diets. Finally, co-products of the bakery (e.g., bakery waste), dry milling (hominy feed), and ethanol (distillers grains) industries are excellent sources of calories for baby pigs.

SPECIAL CARBOHYDRATE SOURCES

With the move to 4-wk weaning in the early 1970s, it became abundantly clear that it was best to feed weanling pigs like the young mammals, i.e., with milk products. This ushered in an era of research activity to define the ideal amounts of dried whey and skim milk powder needed to ensure maximum growth performance in weaned piglets. Soon it became commonplace to see formulations with 40 to 60% milk products.

The general success with these types of diets resulted in the belief that milk proteins and lactose were essential components in such formulations. Much of the credit for good results with milk products was given to the carbohydrate fraction (lactose) especially in dried whey, which is 70 to 75% lactose. This general philosophy prevailed until the last couple years when we published a paper demonstrating that cane sugar and a high quality molasses product could be used to replace milk sugar with the same growth performance in weaned pigs. Thus, it seems that a high content of simple sugars, and not lactose per se, is the key to good carbohydrate nutrition of the early-weaned pig.

SPECIAL PROTEIN SOURCES

The other fraction of milk products that was hailed as critical to the nursery pig was milk protein. Indeed, few would argue against inclusion of milk proteins in diets for weaned pigs with their excellent profile of highly digestible amino acids. However, the high cost of supplying milk proteins in nursery pig diets continues to drive research interests in the identification of cheaper protein sources. We certainly have contributed to that body of knowledge with our work at Kansas State University.

In the past several years, our data demonstrated that dried skim milk can be replaced, on a protein basis, with much cheaper milk products such as whey protein concentrate and buttermilk. Also, we had good success with blends of lactose and soy protein isolate, soy protein concentrate, and wheat gluten to replace dried skim milk. Finally, our data suggested that the performance of pigs
fed diets with dried skim milk could be dwarfed by the performance of pigs fed diets with 10% spray-dried blood plasma. As of now, we typically use a 50:50 blend of dried animal plasma and spray-dried vital wheat gluten to replace the protein that once was supplied by dried skim milk in diets for weanling pigs.

**FAT SOURCES**

As with carbohydrate and protein sources, it seemed logical that a fat source similar to that found in milk would be ideal. However, the only natural fat source that is similar to milk fat (with lots of medium chain-length fatty acids) is coconut oil. Thus, unless you live in a tropical environment where lots of coconut oil can be had at a low cost, then coconut oil is unlikely to enter into a low cost diet formulation.

As a rule, fats with greater concentrations of medium-to-short-chain fatty acids and less saturation are more readily digested by young mammals. Our data support this concept and I propose a general ranking of fats as short-chain fatty acid sources (milk fat/coconut oil) > longer chain length but unsaturated fatty acid sources (soy oil/corn oil/sunflower oil/canola oil/etc.) > longer chain length and saturated fatty acid sources (beef tallow/choice white grease/poultry fat/etc.). The one exception to this general ranking results from data we generated with a blend of beef tallow and an emulsifier (soy lecithin) that proved to be utilized as well as coconut oil and soybean oil.

**FEED ADDITIVES**

There is no doubt that use of sub-therapeutic additions of antibiotics to the diets of weanling pigs has been a great contributor to our ability to wean pigs at younger and younger ages. It is not uncommon to see a 10 to 20% increase in feed intake and rate of gain when antibiotics are added to diets of pigs weaned into facilities with an average environment and average farm health status. However, there currently is a great deal of political pressure on the swine industry to minimize use of feed-grade antibiotics. Thus, we currently are experiencing a scramble to identify effective alternatives to antibiotics for protection of pigs from disease and for non-specific growth promotion.

As far back as the 1960s, mega-dosing with copper sulfate was proven effective for the prevention of enteric disorders and for increasing growth performance in weanling pigs. During the 1990s, mega-dosing with zinc oxide in the first couple diets after weaning and following that with copper sulfate was proven to be an even more effective strategy than using copper alone. The return on investment with copper sulfate and zinc oxide still makes these ingredients very attractive for use in weanling diets, but they also raise concern about potential impact of intensive pig rearing on the environment. Thus, the U.S. swine industry currently is in the midst of a resurgence of interest in direct-fed microbials, enzymes, and other alternative treatments to aid in the prevention of enteric disease in weanling pigs.

Our data to date suggest that preparations of lactobacillus, streptococcus, and bacillus organisms are not terribly effective substitutes for feed-grade antibiotics. Alternatively, we have found that some yeast products and mannanoligosaccharides do increase growth performance in weanling pigs but to only about half that achieved with antibiotic feeding. The bottom line seems to be that if we
do not have access to antibiotics for non-specific growth promotion in weanling pigs, there are feed additives that will help to protect the health of weanling pigs. But, in terms of maximum growth performance and return on investment, at present it seems unlikely that we can replace use of sub-therapeutic concentrations of antibiotics in piglet diets.

**FEED PROCESSING**

With the emphasis we place on proper feed processing at Kansas State University, I would be remiss to not mention those considerations in this paper. Beginning with grinding, we have demonstrated that piglets respond to fine grinding of corn, sorghum, and wheat. There certainly is no reason to think that this is not true for the other cereals that might be used as the basis for nursery diets. Currently, we recommend that corn and wheat be ground to mean particle sizes under 600 microns and that sorghum should be ground to particle sizes at least 100 microns finer than corn and wheat.

After grinding of the cereals, the dietary ingredients will need to be mixed together. This raises the issue of mix uniformity. To define mix uniformity you must first define the marker and in our experiments, CVs for the distribution of chromium and Microtracers need to be at or less than 15% to 20% in nursery diets.

After the diets are mixed they can be fed as either a meal or as pellets. In addition to the great improvements in handling characteristics that result from pelleting, we have demonstrated even greater increases in rate and efficiency of gain with pelleting of nursery diets than we normally see with diets for growing and finishing pigs.

Finally, our data indicate that advanced forms of thermal processing (extruding and expanding) may have benefit for cereals in weanling pigs. Also, extrusion of full-fat soy is an excellent method for the production of a high quality protein source for weanling pigs.