K·STATE
Research and Extension

Starter Pig Recommendations

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Kansas State University Agricultural Experiment Station and Cooperative Extension Service

What are the key concepts in starter diet formulation?

A successful nursery feeding program contains several components, but the most important are as follows:

1. Start with as heavy and as old a pig as feasible.
2. Adjust pigs to the lowest cost diets (usually growing–finishing diets) as quickly as possible after weaning to reduce total cost.
3. Newly weaned pigs are in an extremely energy deficient state. Thus, maximizing feed intake is important.
4. Remember biology of pig when formulating diets.
5. Provide the proper management to start pigs promptly on feed and water and continually adjust feeders to optimize feed efficiency.

Understanding these main concepts is the key to designing nutritional programs for newly weaned pigs. The concepts are relatively simple and can be applied in a variety of situations around the world.

How do these concepts influence diet formulation?

Start with as heavy and as old a pig as feasible. Recent research has shown that increasing weaning age through 21 days linearly increases growth rate and reduces mortality from weaning to market. In these studies, wean-to-finish growth performance and productivity (as measured by ADG, mortality, off-test weight per day of age, and weight sold per pig weaned) improved as weaning age increased from 12 to 21 and 15.5 to 21.5 days of age. Linear improvements in growth and mortality rate largely occurred in the initial 42 days post-weaning period, with some ongoing growth improvements in finishing performance. These studies suggest increasing weaning age up to 21.5 days can be an effective production strategy to improve wean-to-finish growth performance in a multi-site production system.

Adjust pigs to lowest cost diets as quickly as possible after weaning. The main purpose of the nutritional program in the nursery is to adjust the pig to dry feed and prepare them for the grow–finish stage. If we adjust pigs to the ingredients used in the grow–finish diets too slowly, feed cost can be prohibitive. Thus, a balance between excellent performance and low diet cost must be reached.

The strategic use of soybean meal provides an example of how this concept influences ingredient selection for starter diets. Our common grow–finish diets are grain-soybean meal-based diets. Because these are our lowest cost diets, our goal is to adjust pigs to them as quickly as possible. Strategic use of soybean meal allows us to rapidly adjust pigs to high levels of soybean meal after weaning. An alternate approach would be to delay exposure to soybean meal until pigs are older to prevent any possible hypersensitivity reaction. When exposure to soybean is reduced or delayed, typically this requires greater use of specialty ingredients like dried whey, fish meal, spray-dried blood meal, and spray-dried animal plasma. This approach can result in excellent performance in the nursery, but pigs then have to be slowly acclimated to soybean meal in later diets, and feed costs are dramatically increased.

Importance of feed intake. Newly weaned pigs cannot consume enough feed to meet their energy needs for protein deposition. They are in a highly energy dependent state. Thus, any increase in energy intake results in improvements in growth rate and lean deposition. Comprehension of this concept will lead to an understanding of the varying response to diet complexity in different situations.

Feed intake (and, thus, energy intake) is highly dependent on environmental factors. If feed intake is compromised due to disease, environment, management, or other factors, complex diets can help serve as an aid to increase consumption. Lactose, spray-dried animal plasma, and other palatable ingredients typically used in these complex diets will increase feed intake of early weaned pigs. However, if feed intake is excellent due to improved environment and removal of disease pressure, the amount of these complex diets can be reduced.

Key points in understanding the interaction of diet complexity and feed intake are: (1) feed intake drives growth performance in early weaned pigs; (2) complex diets improve feed intake for the first few weeks after weaning; and (3) diet complexity can and should be reduced rapidly as impact on feed intake declines with age.

Studies have shown that increased feed intake in the postweaning period will increase nursery growth rate, but also that this weight advantage is maintained and in some instances increased in the finishing phase compared with pigs with poor feed intake after weaning. Studies also show that increased feed will dramatically reduce the risk of enteric disease in the nursery phase.

Remember the biology of the pig. The rapidly changing biology of the young pig must

be considered in selecting sources and levels for amino acids, carbohydrates and fat. Main considerations for the young pig should be their: (1) high level of protein deposition; (2) low level of feed intake; (3) high lactase and low amylase, maltase, sucrase and lipase activities at birth; and (4) limited ability to utilize fat.

The newly weaned pig has a tremendous capacity for protein deposition in relation to the level of feed intake. Thus, diets must be formulated with high levels of amino acids. Removal of disease pressure with segregated early weaning also increases the amino acid requirements of the young pig by increasing the level of protein deposition.

Because feed intake is limited, a highly digestible carbohydrate source is advantageous, both to stimulate feed intake and due to the relatively high net energy value. The high lactase enzyme levels at birth and high digestibility of lactose make crystalline lactose or one of several lactose sources (dried whey, deproteinized whey, whey permeate, etc.) an excellent carbohydrate source for young pigs. As long as the diet contains a basal level of lactose, several other carbohydrate sources can be used for the remainder of the diet with acceptable performance. When using a cereal grain as a main carbohydrate source (corn, sorghum, wheat, barley, or oat products), finely grinding these ingredients (650 to 750 microns) is important to improve digestibility and pellet quality. An important point in formulating diets for very young pigs (< 10 days) is their limited ability to digest sucrose at birth. Thus, sugar should not be used in diets for pigs less than 10 days of age.

The low feed intake of young pigs often leads nutritionists to feed high levels of fat to increase the energy density of the diet. Unfortunately, fat utilization is limited in the pig before approximately 35 days of age. Poor utilization of dietary fat is not well understood and may be due to a combination of factors including low digestibility during the initial period after weaning and limited ability to catabolize fat from body stores. However, added dietary fat is extremely important from a feed manufacturing standpoint because it helps lubricate the pellet mill die, and, thus, improves pellet quality of starter diets that contain high levels of milk products. The bottom line is that fat utilization increases with age, and fat should be used strategically in the first diets after weaning as an aid in pelleting rather than as a main energy source. As enzyme systems mature within the body and fat metabolism improves, fat can serve as an increasingly important energy source.

What type of phase feeding program is recommended for nursery pigs?

We recommend matching the phase feeding program to the weight of pigs at weaning for your operation (Table 1). Most swine operations would use a four-phase program for nursery pigs. However as pigs become heavier or older at weaning, the amount of the most complex diets fed after weaning can be reduced. In some cases with exceptionally heavy pigs at weaning (> 15 lb) or perhaps for the very heaviest pigs within the weaning group, the Transition and/or SEW diet could be eliminated from the feeding program. Adhering to the expected feed usage guidelines in Table 1 will help minimize overfeeding of expensive starter diets. If wean-to-finish facilities are used because of the potential greater use of floor feeding and feed wastage, these feed allowances may need to be increased slightly.

By phase feeding, we can match the baby pig's nutrient requirements and digestive capabilities with the most economical diet possible, yet get maximum performance in the nursery. Although the SEW and Transition diets are extremely expensive, the low amount of feed used and excellent feed efficiency make the cost of these diets justifiable. Phase feeding of the SEW and Transition diets are often done on an individual pen basis while Phase 2 and 3 are budgeted to the average weight of the entire group.

Suggested diets for the phase feeding program are listed in Tables 4, 5, and 6. Detailed

Table 1. Recommended pounds of each diet that should be fed to each pig (weaning to 50 pounds).

	Weaning Weight, pounds						
	10	11	12	13	14	15	16
SEW	2	1	1	0.5	0.5	0.5	0.5
Transition	5	4	3	2	1	--	--
Phase 2	---------- 12 to 15 lb ----------						
Phase 3	---------- 45 to 50 lb ----------						

specifications for these diets can be found at *www.ksuswine.org*.

What lysine level should be used in each diet?

Research has demonstrated that the amino acid requirements for segregated early weaning (SEW) pigs of modern genotypes are higher than previous expectations. True ileal digestible (TID) lysine recommendations in Table 2 have been developed from several experiments.

What about other amino acids?

Other amino acids also must be maintained in the proper ratio to lysine to achieve optimal performance. For example, research at Kansas State University has shown that the correct methionine:lysine ratio is as important as the total lysine level in the diet. Appropriate levels of other amino acids relative to lysine are shown in Table 3.

What are the key ingredients in each diet?

SEW diet (weaning to 11 pounds). The high amino acid fortification of the SEW diet necessitates multiple protein sources to meet the young pig's nutritional needs. Several of the following protein sources often are used in combination in the SEW diet to meet the amino acid requirements and to stimulate feed intake: spray-dried animal plasma, fish meal, dried whey, whey protein concentrate, spray-dried blood meal, soybean meal, and further processed soy products. Other protein sources can certainly be used, but you should check with a nutritionist before making substitutions from the diets listed in Table 4.

Although spray-dried animal plasma is expensive, it is necessary to stimulate maximal feed intake in the period immediately after weaning. Most studies show a linear response in daily gain with increasing animal plasma, thus, most nutritionists include 4 to 7 percent animal plasma in the SEW diet, depending on the other protein source combinations included in the diet.

Spray-dried blood meal and spray-dried blood cells have very high lysine content (7.5 to 8.5 percent) and, thus, can be used in the SEW diet in small quantities as a concentrated amino acid source. However, spray-dried blood meal, blood cells, and animal plasma are relatively low in the amino acids methionine and isoleucine. Due to these deficiencies, it is critical that synthetic methionine is added to the SEW diet for optimal performance. Because, at this time, synthetic isoleucine is not economically available, the isoleucine:lysine ratio limits the amount of blood meal that can be added to the diet.

A high quality fish meal or whey protein concentrate often is used as an additional protein source to encourage feed intake and achieve the correct amino acid levels. Dried skim milk is still being used in this diet in some instances.

Table 2. Recommended lysine levels for weaned pigs.

Diet	Pig Weight, lb	Total Lysine, %	TID Lysine, %[a]	TID Lysine:calorie Ratio
SEW	< 11	1.70–1.80	1.55	4.45
Transition	11–15	1.65–1.70	1.50	4.35
Phase 2	15–25	1.45–1.50	1.35	3.95
Phase 3	25–50	1.40–1.45	1.30	3.80

[a] True ileal digestible, (TID).

Table 3. Minimum true ileal digestible (TID) amino acids relative to lysine[a].

Amino Acid	Ratio, % of TID lysine
Lysine	100
Isoleucine	55
Methionine	28
Met & Cys	58
Threonine	62
Tryptophan	16.5
Valine	65

[a] To use this table, first a dietary TID lysine level is set, then multiply the lysine content by the percentage for a particular amino acid. That value should be the minimum concentration for that amino acid. For example, if a diet contains 1.5% TID lysine, the minimum isoleucine level should be at least 0.825%.

However, research has indicated that the skim milk can be replaced with much lower cost protein sources without sacrificing performance. In fact, some trials have found improved feed intake when removing skim milk from the diet.

The source and level of soy protein in diets for early weaned pigs has been a controversial subject among swine nutritionists. Some nutritionists believe soybean meal should not be included in the first diet after weaning to prevent an allergic reaction to the unprocessed soy protein. These nutritionists typically will use a further refined soy protein such as soy protein concentrate, isolated soy protein or extruded soy protein concentrate to replace the soybean meal portion of the diet. If a refined soy product is used in the diet, several research trials have demonstrated an advantage to the moist extruded soy products compared to soy products that have not been moist extruded.

Other nutritionists take a different approach. They believe that exposing the young pig to increasing levels of soybean meal in each nursery diet will allow them to overcome the hypersensitivity to soy protein more quickly without causing a long-term reduction in pig performance. In the SEW diet, the levels of soybean meal should not exceed 12% of the diet. The second approach also is substantially less expensive than the first.

The appropriate level and source of soy protein for the SEW pig is not well researched. We choose to recommend approximately 12% soybean meal in the SEW diet as a means of acclimating the young pig to soy protein. We also believe that early exposure to soy protein may be more beneficial than negative. Pigs are born with an immature immune system. Over the first few weeks of life, the immune system is acclimatized to distinguish between native and foreign proteins. If exposed to foreign proteins, such as soy protein, at a very young age, the immune system will recognize them as native. The early exposure allows us to include soybean meal at higher levels in subsequent diets without reducing growth performance.

Research shows that there is a linear increase in daily gain with increasing lactose concentrations in the diet. The SEW diet should contain 23 to 25 percent lactose. High levels of lactose are beneficial; however, care must be taken during processing as high levels of milk products increase the difficulty of pelleting the diet. A high quality, edible-grade dried whey is the most common source of lactose. Dried whey contains approximately 70 percent lactose. Research has shown that high quality whey permeate (80 percent lactose) or crystalline lactose (100 percent lactose) can replace the lactose in the diet provided by dried whey. These other lactose sources become increasingly important due to their lower cost relative to edible-grade dried whey. When replacing dried whey in the diet, care must be taken to determine the replacement of amino acids provided by whey as well as the lactose. The protein in whey is a high quality protein that must be replaced with another high quality protein source.

The appropriate source of the remainder of the carbohydrate source is another area of controversy. The controversy concerning carbohydrates is whether corn or further processed grains like roasted corn or oat products should serve as the main grain source. Finely ground oat products (oat groats, oat flour) can improve stool consistency and pig appearance. The appearance of the pigs when feeding oat products is often misleading because producers assume the pigs are doing "better". However, research indicates there are no differences in pig performance when comparing oat flour to corn ground to 600 microns. Oat products are often two to three times the cost of corn. Thus, we recommend corn as the main grain source in the SEW diet. Wheat, milo, or other grains also can serve as the main grain source in the SEW diet.

The appropriate fat level in the SEW diet depends on the level of milk products in the diet and the skill of the pellet mill operator. As mentioned above, diets containing high levels of milk products are difficult to pellet. If the diet did not contain any added fat, the friction in the pellet die can become too great and denature the protein in the milk products. Typically, 5 or 6 percent added fat is sufficient to lubricate the pellet die. A high quality fat source, such as choice white grease, soybean oil or corn oil, should serve as the main fat source. Choice white grease is the most economical of these fat sources. Coconut oil is another excellent fat source for the young pig, but is simply too expensive to use in the diet. Tallow, restaurant greases, and poor quality yellow grease should not be used in the diet for early weaned pigs.

Growth-promoting levels of antibiotics are normally included in the SEW diet. Growth promoting levels of zinc (zinc oxide at 3,000 ppm) are often added to the SEW diet. When zinc oxide is used for growth promotion, high levels of copper sulfate should not be used in the diet. Sources of zinc, other than zinc oxide or zinc sulfate do not appear to offer the same increase in daily gain as these two sources.

Studies have observed improvements in growth performance when an organic acid is added to the SEW diet. Organic acids are thought to complement normal acid secretion in the pig's stomach and therefore aid in digestion. Some of the relatively low inclusion (0.20%) acid products may be more economical than those requiring higher inclusion rates (0.5 to 1.5%).

Transition Diet (11 to 15 pounds). The transition diet (Table 4) is a natural extension of the SEW diet and contains many of the same ingredients. However, the complexity of the diet is decreased because pigs are already consuming feed and do not need high levels of the complex ingredients to stimulate feed intake.

The main difference between a SEW diet and the transition diet is the level of spray-dried plasma. Plasma is added to the diet primarily to increase feed intake. Because pigs receiving the SEW diet are adjusted to feed, the transition diet contains only 2 to 3 percent spray-dried animal plasma compared to 4 to 7 percent in a SEW diet.

Table 4. Suggested SEW and Transition diets for pigs weighing less than 15 pounds[a].

Ingredient, lb/ton	SEW	Transition
Corn	694	743
Soybean meal, 46.5% CP	251	401
Spray-dried animal plasma	134	50
Select menhaden fish meal	120	100
Spray-dried blood cells	33	25
Spray dried whey	500	500
DairyLac 80 or deproteinized whey	120	---
Choice white grease	100	100
Monocalcium P, 21% P	6	14
Limestone	9	9
Salt	5	6
Zinc oxide	7.5	7.5
Vitamin premix with phytase	5	5
Trace mineral premix	3	3
L-Lysine HCl	3	5.2
DL-Methionine	3	3.6
L-Threonine	1.6	2.5
Antibiotic	20	20
Acidifier	4	4
Vitamin E, 20,000 IU	1	1
TOTAL	2,000	2,000
Calculated Analysis		
TID Lysine, %[b]	1.56	1.51
Total lysine, %	1.70	1.65
TID Lysine:ME ratio, g/Mcal	4.45	4.35
TID Isoleucine:lysine ratio, %	49	52
TID Leucine:lysine ratio, %	120	117
TID Methionine:lysine ratio, %	30	33
TID Met & Cys:lysine ratio, %	55	55
TID Threonine:lysine ratio, %	64	63
TID Tryptophan:lysine ratio, %	17	17
TID Valine:lysine ratio, %	69	66
ME, kcal/lb	1,591	1,575
Protein, %	22.6	22.2
Calcium, %	0.79	0.83
Phosphorus, %	0.73	0.77
Available phosphorus, %	0.55	0.55
Avail P:calorie ratio, g/mcal	1.87	1.89

[a] Detailed specifications for these diets can be found at *www.ksuswine.org*.

[b] True ileal digestible (TID).

Spray-dried blood meal or a high quality fish meal source also may serve as major protein sources. Because the pigs were acclimated to soybean meal while being fed the SEW diet, the transition diet can contain higher levels of soybean meal (up to 20 percent) without risk of hypersensitivity.

The lactose level in the transition diet also is decreased compared to the SEW diet. However, it is still critical that the transition diet contain at least 18 percent lactose for optimal pig performance. A high quality fat source (3 to 5 percent) is added to the transition diet for the same reason as the SEW diet (improved pellet quality). As in the SEW diet, antibiotics, an organic acid, and zinc oxide should be maintained in the transition diet for growth promotion.

Phase 2 (15 to 25 pounds). By the time the pigs weigh 15 pounds, they already will have consumed 2 to 8 pounds of feed depending on weaning weight. Feeding behavior is established and, thus, lower cost, less complex diets can be fed. The phase 2 diet is corn-soybean meal-based with dried whey (or other source of lactose) and spray-dried blood meal or fish meal serving as the only specialty ingredients. It is crucial that high levels of amino acids are maintained in this diet to allow the pig to achieve its genetic potential for lean growth. With the decrease in cost of crystalline threonine, we are now able to use up to 6 lb/ton L-lysine HCl in combination with added methionine and threonine to maintain a high amino acid concentration while maintaining soybean meal levels between 26 and 28 percent. Several options for the phase 2 diet are provided in Table 5. These different options are provided to accommodate the different specialty ingredients and lactose sources available. As individual ingredient prices change, alterations to these diets must be considered. Other diet examples can be found at: *www.ksuswine.org.* For example, removing the lactose from the phase 2 diet and replacing it with an alternative ingredient or simply with corn may reduce growth rate, but be more profitable when the price of lactose is very high. A phase 2 supplement option can also be found at: *www.ksuswine.org* for producers who would prefer to not use the individual ingredients, such as a lactose source, blood meal, fish meal, or zinc oxide in the feed mill.

Many producers make this diet on their farm and feed it in a meal form. If an economical fat source, such as choice white grease, is available, the diet should contain 3 to 5 percent added fat. Antibiotics and zinc oxide are used as growth promoters in the phase 2 diet. Research indicates 2,000 ppm zinc is the optimal inclusion level. Like in the earlier diets, when zinc oxide is used for growth promotion, high levels of copper sulfate should not be used in the diet. Generally, the use of an organic acid in the phase 2 diet will not be economically justified.

Phase 3 (25 to 50 pounds). The phase 3 diet is a simple grain-soybean meal diet formulated to high levels of amino acids (Table 6). Again like in earlier nursery diets, up to 6 lb/ton L-lysine HCl in combination with added methionine and threonine can be used to replace a portion of the soybean meal in the diet. The phase 3 diet is the lowest cost in the SEW program. However, because consumption of this diet is the greatest, it usually accounts for over 50 percent of the total feed cost from weaning to 50 pounds. Thus, phase 3 diet cost is critical. Specialty ingredients, such as blood meal, fish meal or dried whey, are cost prohibitive. Research also has indicated use of specialty ingredients is unnecessary for maximal performance during this stage.

The fat level of the diet will depend on the ability of the producer or feed company to economically purchase fat. Pigs will respond with improved average daily gain and feed efficiency with increasing levels of fat in the phase 3 diets up to approximately 3 percent. High levels of zinc oxide or organic acids should not be used in the phase 3 diet; however, antibiotics can serve to improve growth promotion. Some nutritionists may choose to use up to 250 ppm of copper from copper sulfate in this diet for growth promotion in this diet as a replacement for zinc oxide. However there is little data to confirm its effectiveness.

How important is ingredient quality for starter pigs?

Ingredient quality can dictate the success of a nutritional program for young pigs. Ingredients are selected for their palatability, as well as nutrient content. Simple lab assays for nutrients often reveal very little about the quality of specialty ingredients for starter diets. Often ingredient suppliers have to be selected from past experience and research trials with actual feeding data, rather than on quality specifications.

Ingredients that cause the greatest quality concern due to the number of products and suppliers are animal protein and lactose sources. Fish meal, blood meal and animal plasma should only be purchased from a supplier using spray-drying technology. Select menhaden fish meal is considered to be a high quality fish meal in the

United States but other excellent fish meal sources are available. Several blood meal (cell) sources are available; however, only a few suppliers are producing spray-dried blood meal. Currently, all animal plasma produced in the United States is spray dried.

Differences in quality exist between various sources of dried whey. If whey is excessively heated, it will result in a brownish color, indicating caramelization of the sugar (lactose). This lowers the feeding value of the product. Thus, only spray-dried whey should be used in starter diets. White color is desirable, although some good quality whey may have a pinkish or yellowish color from carry-over of the cheese color. A granular whey particle compared with a fine particle, absence of black specs, and an ash concentration below 9 percent are indicative of high quality dried whey. There are several forms of dried whey products, the most commonly used include whey permeate, deproteinized whey, and L-lactose. Other products such as partially delactosed whey, partially demineralized whey, and partially delactosed and partially demineralized whey can be successfully

Table 5. Suggested phase 2 diets for pigs weighing 15 to 25 pounds.

Ingredient, lb/ton	Option 1	Option 2	Option 3	Option 4	Option 5
Corn	1,036	1,036	1,031	1,043	1,041
Soybean meal, 46.5% CP	557	559	567	533	529
Select menhaden fish meal	60	45	---	90	120
Spray-dried blood cells	25	17	50	---	---
Spray dried whey	---	200	200	200	---
DairyLac 80 or deproteinized whey	180	---	---	---	180
Choice white grease	60	60	60	60	60
Monocalcium P, 21% P	15	16	21	10	7
Limestone	16	16	20	13	12
Salt	6	6	6	6	6
Zinc oxide	5	5	5	5	5
Vitamin premix with phytase[a]	5	5	5	5	5
Trace mineral premix[a]	3	3	3	3	3
Lysine HCl	6	6	5	6	6
DL-Methionine	3.5	3.5	4	3	3
L-Threonine	3	2.5	2.5	2.5	2.8
Antibiotic[b]	20	20	20	20	20
TOTAL	2,000	2,000	2,000	2,000	2,000
Calculated Analysis					
TID Lysine, %[c]	1.35	1.35	1.35	1.35	1.35
Total lysine, %	1.48	1.49	1.49	1.48	1.48
TID Lysine:ME ratio, g/Mcal	3.96	3.97	3.99	3.95	3.93
TID Isoleucine:lysine ratio, %	55	57	54	59	59
TID Leucine:lysine ratio, %	124	124	132	121	119
TID Methionine:lysine ratio, %	36	36	36	36	36
TID Met & Cys:lysine ratio, %	57	58	58	58	58
TID Threonine:lysine ratio, %	62	62	62	62	62
TID Tryptophan:lysine ratio, %	17	17	18	17	17
TID Valine:lysine ratio, %	68	67	73	65	65
ME, kcal/lb	1,548	1,543	1,533	1,551	1,559
Protein, %	21.3	21.3	21.5	21.3	21.4
Calcium, %	0.76	0.76	0.76	0.76	0.76
Phosphorus, %	0.65	0.65	0.64	0.64	0.64
Available phosphorus, %	0.37	0.37	0.36	0.37	0.36
Available phosphorus equivalent, %[d]	0.48	0.48	0.48	0.48	0.48
Avail P:calorie ratio, g/mcal	1.41	1.42	1.41	1.40	1.38

[a] Detailed specifications for these premixes can be found at *www.ksuswine.org.*

[b] An antibiotic is normally added as a growth promoter.

[c] True ileal digestible (TID).

[d] The amount of phosphorus provided by the ingredients and released by phytase in the vitamin premix.

used to replace spray-dried whey. The amount of lactose and/or minerals removed from the dried whey will affect the actual amount of protein and ash present. The key to substituting a lactose source for dried whey is to know the lactose concentrations and replace on an equal lactose basis, and then choose an appropriate protein source to replace the amino acids provided by the dried whey. Delactosed whey is not recommended for use in baby pig diets.

Are more complex diets than a SEW diet needed for pigs weighing less than 8 pounds?

When weaning pigs at a young age, a percentage of the pigs may weigh less than 8 pounds at weaning. The SEW diet can be used for these pigs, but extra attention must be given to ensure pigs start eating within 48 hours after weaning (methods are described below). Using a more complex, and more expensive, diet can reduce the amount of management input necessary for these small pigs. An Intensive Care Diet of this type is shown in Table 7. The key to using a diet of this type is to limit the usage to pigs weighing less than 8 pounds to prevent feed cost from becoming excessive.

What about compensatory gain?

Some people believe that slower growth rate in the nursery phase as a result of feeding simple grain-soybean meal diets will be made up for in the growing–finishing phase by compensatory gain. This is not true. Research has shown that every additional pound a pig weighs coming out

Table 6. Suggested Phase 3 diets for pigs weighing 25 to 50 pounds.

Ingredient, lb/ton	No Fat	Added Fat
Corn	1,272	1,166
Soybean meal, 46.5% CP	651	696
Choice white grease	0	60
Monocalcium P, 21% P	22	23
Limestone	20	20
Salt	7	7
Vitamin premix with phytase[a]	5	5
Trace mineral premix[a]	3	3
Lysine HCl	6	6
DL-Methionine	2.2	2.6
L-Threonine	2.0	2.5
Antibiotic[b]	10	10
TOTAL	2,000	2,000
Calculated analysis		
TID Lysine, %[c]	1.25	1.30
Total lysine, %	1.38	1.44
TID Lysine:ME ratio, g/Mcal	3.77	3.77
TID Isoleucine:lysine ratio, %	63	62
TID Leucine:lysine ratio, %	131	128
TID Methionine:lysine ratio, %	32	33
TID Met & Cys:lysine ratio, %	58	58
TID Threonine:lysine ratio, %	62	63
TID Tryptophan:lysine ratio, %	18	18
TID Valine:lysine ratio, %	69	69
ME, kcal/lb	1,504	1,564
Protein, %	21.0	21.6
Calcium, %	0.71	0.73
Phosphorus, %	0.63	0.65
Available phosphorus, %	0.31	0.32
Available phosphorus equivalent, %[d]	0.42	0.43
Avail P:calorie ratio, g/mcal	1.27	1.26

[a] Detailed specifications for these premixes can be found at *www.ksuswine.org*.
[b] An antibiotic is normally added as a growth promoter.
[c] True ileal digestible (TID).
[d] The amount of phosphorus provided by the ingredients and released by phytase in the vitamin premix.

of the nursery will result in fewer days to market. However, in growing–finishing pigs, if growth performance is decreased for a short period by low nutrient intake (i.e., lysine), there may be compensatory gain when pigs are switched to an adequate diet. Therefore, the ability for compensatory gain will depend upon the severity and duration of a deficiency, whether it is ingredient and(or) nutrient induced, and the age of the pig when it occurs.

Should the starter diets be pelleted?

Whether to feed the SEW and(or) the transition diet as pellet or in meal form is a controversial area. Producers and nursery managers have definite opinions on which they prefer. While a few studies would suggest no difference between meal and pelleted diets, the majority of studies favor pelleting these diets. Not only does this improve pig growth performance, it dramatically improves the flow ability characteristics of the diet. We recommend pelleting the SEW, transition and intensive care diets. A small diameter 3/32- or 1/8-inch pellet or crumble should be used for these diets. Young pigs have difficulty swallowing larger pellets while eating at the feeder. These pigs will take a mouthful of feed to the resting area and allow saliva to soften it before swallowing. This process limits feed intake and increases wastage. However, the drawback of using small diameter pellets is that friction through the pellet die is increased which may increase heat damage of the dietary proteins and carbohydrates.

Another disadvantage with small diameter pellets is reduced throughput through the mill. Therefore, it is critical to supplement fat (5 to 6 percent) to pelleted nursery diets and have skilled operators running the pellet mill.

If meal diets are to be used, producers must realize feed wastage will be approximately 20 percent greater and daily gain slightly lower for pigs fed meal diets compared to those fed pelleted or crumbled diets in our experience. Producers feeding meal diets with large amounts of specialty ingredients also must be careful not to limit feed intake through poor feeder management. Meal diets bridge and do not feed down and flow out of feeders easily leading to limited feed intake flow. Several dietary adjustments can be made to help with flow ability. These include decreasing the added fat content and using granulated sources of blood meal, animal plasma, and whey permeate.

The phase 2 and 3 diets can be fed as a meal or pellet. Feed efficiency will be 5 to 8 percent better with a pelleted diet than with a meal diet

Table 7. Intensive Care Diets for pigs weighing less than 8 pounds.

Ingredient, lb/ton	Intensive Care Diet < 8 lb
Corn	124
Soybean meal, 46.5% CP	28
Spray-dried animal plasma	134
Select menhaden fish meal	120
Spray dried whey	500
Lactose	120
Extruded soy protein concentrate	200
Pulverized oat groats	600
Choice white grease	100
Monocalcium P, 21% P	6
Limestone	12
Salt	5
Zinc oxide	7.5
Vitamin premix with phytase[a]	5
Trace mineral premix[a]	3
Lysine HCl	5
DL-Methionine	4.2
L-Threonine	1.4
Antibiotic[b]	20
Acidifier	4
Vitamin E, 20,000 IU/ lb	1
TOTAL	2,000
Calculated Analysis	
TID Lysine, %[c]	1.66
Total lysine, %	1.79
TID Lysine:ME ratio, g/Mcal	4.69
TID Isoleucine:lysine ratio, %	56
TID Leucine:lysine ratio, %	109
TID Methionine:lysine ratio, %	33
TID Met & Cys:lysine ratio, %	58
TID Threonine:lysine ratio, %	63
TID Tryptophan:lysine ratio, %	18
TID Valine:lysine ratio, %	68
ME, kcal/lb	1,605
Protein, %	24.2
Calcium, %	0.86
Phosphorus, %	0.77
Available phosphorus, %	0.55
Available phosphorus equivalent, %[d]	0.67
Avail P:calorie ratio, g/mcal	1.89

[a] Detailed specifications for these premixes can be found at *www.ksuswine.org.*

[b] An antibiotic is normally added as a growth promoter.

[c] True ileal digestible (TID).

[d] The amount of phosphorus provided by the ingredients and released by phytase in the vitamin premix.

in these stages. A larger pellet (5/32 or 3/16 inch) can be used for these older pigs. The decision to pellet the phase 2 and 3 diets should be based on the expected change in feed efficiency and the potential for a slight increase in daily gain versus feed manufacturing costs.

Should I provide creep feed before weaning?

Research has shown that little creep feed will be consumed before 3 weeks of age. Often, more creep feed is wasted than consumed before 3 weeks of age. Therefore in the past with weaning age typically less than 18 days, it was believed creep feeding was unnecessary. However, with the shift to older weaning ages, creep feeding may offer some advantages. If a producer will creep feed, it is recommended that the feed be provided on a daily basis to keep a fresh diet in front of the baby pig. If creep feed is used, floor feeding may aid in increasing the consumption of creep feed. It also is recommended that the same diet used as a creep feed should be fed during the first week after weaning. Research on the effects of creep feeding on pig growth is needed before a definitive recommendation can be made.

Should I provide a liquid feed supplement either before and (or) after weaning?

Research has shown that providing pigs a liquid feed supplement either before or a short period after weaning will increase average daily gain. However, these studies also show that the extra weight gain from providing a liquid supplement is not maintained and that by the end of the nursery phase, pigs provided a liquid supplement will weigh the same as pigs provided no supplement. We are unaware of any explanation for this response. Therefore, because there is no weight advantage, the decision whether to provide a liquid supplement must be made on the potential to reduce death loss due to starvation and fall back or cull pigs leaving the nursery. The potential to reduce death loss in the nursery will need to offset the added cost associated with the milk replacer, the equipment needed to distribute the milk replacer, and the added labor costs needed to maintain the equipment. It is extremely important that the milk replacer is kept fresh and the equipment kept clean.

Should young pigs be limit fed during the first week after weaning?

Pigs should NOT be limit fed after weaning. Feed intake is critical during this stage. Some producers believe that pigs will adapt to dry feed faster if limit fed several times per day. The theory is that pigs should be fed several small meals similar to when nursing the sow. However, you simply cannot feed the pigs often enough to prevent reductions in daily gain and pig weight out of the nursery. Pigs can be offered feed several times per day on a feeding board, but fresh feed should always be present in the feeder.

What type of feeder or feeding board should be used?

This answer will vary on the age of pigs at weaning, type of facility, and type of feeder used. Pigs weaned at less than 15 days of age still exhibit feeding behavior as if nursing the sow. All pigs try to eat at the same time, and thus, feeder space must be available to accommodate all the pigs in the pen in the immediate postweaning period. A properly designed, non-solid partition encourages proper social interaction and maximal feed intake, while preventing the small pigs from laying and defecating in the feeders or becoming trapped in the partition. With traditional dry feeders, a minimum of 6 inches per feeding space for nursery feeders and at least one feeding place for every four pigs in the pen is recommended.

Single-stage nurseries in which pigs are kept from weaning to 70 pounds may require up to 12 inches per feeding space. Data from the University of Illinois suggests that in wean-to-finish barns (feeders with 12 inch openings), approximately 0.80 inches of feeder space per pig is adequate until approximately 6 weeks after weaning, then 1.6 inches of feeder space per pig is needed.

In any situation, the feeder also should be easily adjustable and facilitate the free flow of feed with a feed agitator that can be easily manipulated by the pigs. In our experience, feeder adjustment has a larger impact on minimizing feed wastage than actual design. We have observed many cases of excellent feed efficiency and growth performance with a wide variety of different feeders. Consequently, we have also observed a wide variation in feed wastage among nurseries in a production system with similar feeder design throughout, depending on the operator. The belief that feeders need to be "opened up" so as not to restrict intake is not true as long as there is an agitator that young pigs can manipulate. Keeping feeders properly adjusted actually improves the flow of feed as well as obviously improving feed efficiency.

Feeding boards or mats can be used to help supply adequate feeding space during the first week after weaning. The feeder board must be made of an easily cleaned material like plastic or rubber to

prevent problems with diseases, such as coccidiosis. If used, feeding boards must be properly managed and promptly removed from the pen after the pigs are eating readily from the feeder (3 to 4 days after weaning). Remember to always have feed present in the feeder, even when using feeding boards.

What type of waterer is best for young pigs?

Either nipple or cup waterers can be used for nursery pigs. Water intake is critical in the newly weaned pig. Thus, water availability should be carefully monitored to ensure that all pigs have access to water. If nipple waterers are used, an unguarded center flow water nipple works well for pigs weaned less than 16 days of age to facilitate drinking and prevent dehydration. Guarded or "bite down" nipple waters are suitable for pigs weaned greater than 16 days of age. Regardless of the type of nipple waterer, the correct height adjustment is essential to ensure pigs can drink easily. Cup waterers have been demonstrated to reduce water wastage compared with nipple waterers. In commercial facilities it is recommended to have at least two nipple waterers per pen (unless using wet dry feeders) and up to 10 to 15 pigs per waterer. In systems using cup waterers, it is not uncommon to only have one cup waterer per pen.

How can we encourage feed intake to prevent "starve outs" after weaning?

Teaching feeding behavior to a small number of pigs is critical. Some pigs in an early weaning system are developmentally younger and not as quick to learn to eat. Even highly complex and very expensive diets will not encourage all young pigs to eat. As we attempt to reduce cost by decreasing diet complexity, techniques to manage the problem pigs become more important. In our experience, two strategies work well for encouraging young pigs to start eating feed. By following either of these strategies, producers have been able to save the 1 to 2 percent of SEW pigs that can be commonly lost to starvation with less attentive managers. The first strategy is the use of a gruel (diet mixed with a small amount of water) to encourage pigs to eat. However, care should be taken so that pigs do not become used to the gruel and are not encouraged to eat dry feed. As discussed earlier in this report, the use of liquid supplements may be another option. However, in addition to the liquid supplement, dry feed should be in the feeder at all times and the liquid supplement allowance reduced quickly to encourage dry feed intake. Offering liquid supplement too long after weaning will sometimes result in a second "weaning" similar to the transition from the sow to dry feed.

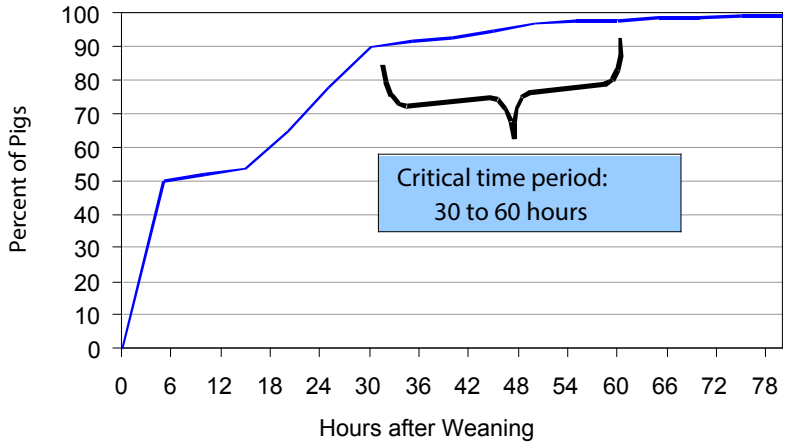
The second strategy is to individually teach pigs to eat that do not learn on their own. The procedure is described as follows. After pigs enter the nursery, they should have feed present for them to eat. However, pigs should be allowed time to adjust to the surroundings, waterers, and feeders before the manager worries about intervention. The critical time period for intervention for pigs that have not started to eat after weaning is approximately 36 to 60 hours after weaning. Pigs that are consuming feed will begin to have round abdomens; whereas pigs that have not begun to eat will be gaunt. Pigs that are not consuming food after 36 to 48 hours postweaning should be identified and marked. Each pig not consuming feed should be individually encouraged to eat by taking a small hand full of pellets, wetting them from the nipple waterer, and gently placing the pellets in the pig's mouth. The moist pellets stick to the tongue of the pig, start to dissolve and are swallowed. The next step is to carefully set the pig down near the feeder so the pig associates the food in its mouth with the feeder. For large groups of pigs, a syringe with the tip removed also can be used to dose individual pigs with a gruel instead of hand feeding pellets. It is important to perform these procedures gently. Hence, these methods rely on patience and an understanding of animal behavioral principles. As few as 20 to 30 grams of feed will provide the energy to keep the pig from starving.

Data from France (Figure 1) indicates that approximately 90 percent of the pigs will have eaten by 30 hours after weaning. Therefore the most critical time to identify and intervene to teach pigs to eat will be 30 hours after weaning.

What should the goals be for average daily gain and feed efficiency in the nursery?

Numerous factors will influence performance in the nursery including weight and age of the pigs entering and leaving the nursery, disease level, nutrition program, genetic potential, and management level. The targets in Table 8 are presented as interference levels for high performance herds and should be targets for low performance herds. Exit weight is incorporated in the targets for average daily gain (ADG) because it is one of the most important factors influencing mean growth rate in the nursery. Expected feed efficiency will vary with the weight of the pigs leaving the nursery, energy level of the diet, and whether the diets are pelleted.

Figure 1. Percentage of Pigs that have Eaten by Hours After Weaning



Adapated from Bruinix et al., 2001

The following equation uses these factors to determine target efficiency in the nursery:

(1 + (exit wt x .011)) x (grain factor + ((.05 – fat level) x 2) x (1– pellet factor).

The factors in the equation are: exit wt = weight exiting the nursery; grain factor = 1 for corn and 1.02 for milo; fat level = percent fat in the diet; and pellet factor = percentage improvement in feed efficiency due to pelleting (Table 8). As an example, a group of pigs with an exit weight of 60 pounds being fed a 3 percent added fat, corn-soybean meal based diet in a meal form would have a target feed efficiency of (1 + (60 x .011)) x (1 +((.05 – .03) x 2) x (1– 0) = (1 + .66) x (1 +0) x 1) = 1.66. If the same group was fed a milo-soybean meal based diet without any added fat, the expected feed efficiency would be (1 + (60 x .011)) x (1.02 + ((.05 - 0) x 2) x (1- 0) = (1 + .66) x (1.02 +0.06) x 1) = 1.66 x 1.12 = 1.79.

Table 8. Nursery Performance Interference Levels for High Performance Herds and Targets for Low Performance Herds.

		Feed efficiency[a]			
Exit Weight, lb		Corn-soybean meal		Milo-soybean meal	
Weeks in the nursery	ADG, lb	3% added fat	0% added fat	3% added fat	0% added fat
		Meal diets			
40 (6 to 7)	0.75	1.44	1.53	1.47	1.56
50 (7 to 8)	0.85	1.55	1.64	1.58	1.67
60 (8 to 9)	0.95	1.66	1.76	1.69	1.79
70 (9 to 10)	> 1.00	1.77	1.88	1.81	1.92
		Pelleted diets			
40 (6 to 7)	0.80	1.35	1.43	1.38	1.46
50 (7 to 8)	0.88	1.46	1.55	1.49	1.58
60 (8 to 9)	1.00	1.56	1.65	1.59	1.69
70 (9 to 10)	> 1.05	1.66	1.76	1.70	1.80

[a] The equation to determine feed efficiency goals in the nursery is: (1 + (exit wt x .011)) x (grain factor + ((.05 – fat level) x 2) x (1– pellet factor), where exit wt = weight exiting the nursery; grain factor = 1 for corn and 1.02 for milo; fat level = percent fat in the diet; and pellet factor = percentage improvement in feed efficiency due to pelleting.

Notes

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