LUNCH BUCKET APPROACH TO ON-FARM FEEDING OF GROWER-FINISHER PIGS

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INTRODUCTION

Given the strong relationship between feeding management and profitability in the growing-finishing (G/F) barn, it is critical to pay close attention to the various aspects of developing effective feeding programs for G/F pigs. In this workshop the main aspects are discussed and illustrated with some examples.

The format of the paper and workshop follows the approach that should be used when reviewing the nutritional program used in the G/F phase for a swine producer or production system. A Swine Nutrition Audit program, developed in 1998 at Kansas State University, has been quite popular with producers. In a Swine Nutrition Audit, producers submit their close-out records, carcass information from the slaughter house, diet formulations, and ingredient prices. A farm visit is conducted to review other aspects of the nutritional program and prioritise the areas with the biggest opportunities for increased profit.

The key areas that need to be reviewed to determine the effectiveness of the feeding program for G/F pigs are as follows:

- Record analysis
- Diet formulation
- Ingredient procurement
- Feed processing
- Feed delivery
- Application in the barn
- Simplification

KEY AREAS FOR REVIEW

I. Record Analysis

As most producers have moved to all-in, all-out systems, the quality of close-out records has improved immensely However, the importance of accurate records can not be overstated. Accurate data is essential for proper decision making for direction of the G/F nutrition program and to assess whether the program in place is being followed. The records that we use include close-out data, carcass information, and feed delivery records.

We use the records to make an assessment of normal production numbers, such as average daily gain (ADG), feed to gain (F/G) and feed cost per kg of gain. We try to adjust the numbers to a common base when comparing different producers. For example, feed efficiency is adjusted for in weight and out weight, the energy level in the diet, and the diet form using baseline targets, such as those presented in Table 1. These values should be used as upper limits for the feed efficiency targets. If your performance is not better than these values, diet formulation, feeder adjustment, particle size, or other issues need to be reviewed.

The ADG values must be taken in context of the available space in the system. A big question that must be answered is whether improved ADG would yield more profit for the system. In essence, are pigs able to achieve the optimal market weight with the available finishing space? The carcass grade and yield sheets from the packer also help in this assessment. However, market weights must be interpreted with caution. Some producers sell their pigs below optimal weights even though the finishing capacity is available to further increase shipping weights. The question of available space may change with season of the year and may drive your diet formulations to be different for some seasons versus others. For example, because ADG is reduced during the summer, the value of higher energy diets to drive ADG and technologies, such as Paylean (not [yet] allowed in Canada) increase during the summer months.

Table 1. Feed efficiency targets for G/F pigs consuming corn-soybean meal based diets.

		Meal diets		Pelleted diets	
Entry wt, kg	Market wt, kg	0% fat	5% fat	0% fat	5% fat
18	110	2.92	2.63	2.74	2.47
18	115	2.97	2.67	2.79	2.51
18	120	3.02	2.72	2.84	2.55
23	110	2.97	2.67	2.79	2.51
23	115	3.02	2.72	2.84	2.55
23	120	3.07	2.76	2.89	2.60
28	110	3.02	2.72	2.84	2.55
28	115	3.07	2.76	2.89	2.60
28	120	3.12	2.81	2.93	2.64

From the packer kill sheets, we also try to assess carcass leanness. This data may be needed in the review of diet formulations if other data is not available.

The other records that are used is feed delivery information. Our main goal in reviewing the total tons of each diet delivered to each group of G/F pigs is to determine whether the feed budget is being followed or if particular diets are being over or underfed.

II. Diet Formulation

In reviewing diet formulas, numerous issues must be considered. Given the cost of protein (lysine and other essential amino acids), energy and phosphorus in pig diets, careful consideration must be given to feed formulation. It is usually appropriate to consult a qualified nutritionist when developing specific feeding programs for individual pig units. The keys to diet formulation for finishing pigs are as follows:

a. Determine the appropriate lysine to energy ratios in the various diets, which will allow you to set the target dietary levels for lysine and other amino acids.
b. Determine the appropriate energy level in the diet- appropriate energy levels may vary whether the goal is to meet nutrient needs at as low of cost as possible (e.g. minimise feed cost per kg of [lean] gain) or to maximise return over feed cost (e.g. maximise profit per pig place in the barn).
c. Carefully review any "extra" feed additives that increase cost.
d. Consider environmental impact of formulations and make sure that meat quality is not reduced by the feeding program.

II.a. Set targets for dietary lysine to energy ratios

The lysine to energy ratio should vary with pig type, management conditions, economic conditions and production objectives. Once target lysine to energy ratio are established, target levels for other amino acids and phosphorus can be estimated easily as well. Various approaches, that differ in complexity, may be used to set target lysine to energy ratios:

1. Conduct full-scale nutrition experiments where pigs are fed different diets and the animal response is closely monitored. This requires a major commitment and accurate data collection. If experiments are not conducted correctly, results can be misleading and efforts are wasted. This approach is valid for very few large operations with units dedicated to experimentation. Producer groups with common genetics and production systems should consider joining together to build research barns to conduct appropriate large-scale trials under field conditions.

2. Establish lean tissue growth and feed intake curves, based on weighing and scanning with real-time ultrasound of representative groups of pigs at regular intervals. This approach is quite critical when multiple phase feeding programs are considered, i.e. to establish the optimum diet composition for the various stages of growth. It requires expertise in taking and interpreting real time ultrasound measurements, and deriving lean tissue growth curves and feed intake curves. For establishing lean tissue (and fat tissue) growth curves, a group of 40 representative pigs (per sex) should be weighed and scanned every 3 weeks, to obtain at least 5 and preferably 6 data points covering the entire body weight range in the G/F barn. Feed intake curves may be established directly, or indirectly based on estimated dietary energy requirements for lean tissue growth, fat tissue growth and maintenance. Feed intake curves may be established directly based on observations from the same number of animals as required for establishing lean tissue growth curves (using software like PorkMa$ter: a com-

puterized performance monitoring system for grower-finisher pigs) or based on total feed usage for the entire G/F pig unit.

3. Standardized or practical version of approach 2. Derive average lean tissue growth rates over the entire G/F period and use some standard lean tissue growth curve shapes to estimate farm-specific lean tissue growth curves. This approach is used by NRC (1998) and may be combined with estimates of feed intake (see approach 2) to derive estimates of optimum energy to lysine ratios.

In Canada, for the calculation of average fat-free lean gains for groups of G/F pigs the following information is required:

1. average body weight (kg) when pigs enter the growing-finishing barn,
2. average hot carcass weight (kg),
3. average lean content (%) in the carcass (unfortunately this is now given as a percentage of cold carcass sides, rather than the hot carcass; see assumption 2 below), and
4. the average number of days required to grow pigs from initial to final body weight.

Two assumptions are required:

1. The lean content in pigs at the initial body weight. This value is unlikely to vary much between pig genotypes at body weights between 15 and 30 kg. It may be predicted from body weight:

   lean content (kg) = 0.441 x live body weight (kg) - 1.751.

2. The difference in weight between the weight of the hot carcass and cold carcass sides. This represents the weight of the head, feet, kidney, leaf fat and some drip losses that may occur. Based on the results of the Ontario Pork Carcass Appraisal project (Courtesy Dr. John Gibson, U of Guelph; data from more than 1700 pigs) the weight of the cold carcass sides can be predicted using the following equation:

   weight of cold carcass sides (kg) = 2.400 + 0.867 x hot carcass weight (kg).

For example, in a G/F pig unit, pigs are entered at 26 kg body weight, pigs require, on average, 110 days to reach market weight, have an average hot carcass weight of 86 kg and a lean yield of 60.5%. In this example, the amount of lean in the pigs body at initial body weight is 9.715 kg (0.441 x 26 - 1.751). The weight of the cold carcass sides is 76.962 kg (2.400 + 0.867 x 86). The amount of lean in the carcass is 46.562 kg (76.962 x 60.5/100). The lean gain is 335 g/d ([46.562 - 9.715] / 110 = 0.335 kg/d x 1000).

To be consistent with NRC (1998), this average lean gain needs to be converted to average fat-free lean gain. Since lean gain, according to the Canadian conditions contains about 10% fat, average lean gain should be multiplied by .90.

Based on average lean tissue growth rates, optimum levels of lysine and other amino acids may be derived from NRC (1998), (e.g. Table 2).

Table 2. Effects of body weight, fat-free lean gain and feed intake on true ileal digestible lysine (Lys) and threonine (Thr) and available phosphorus (av. P) requirements when fed a diet containing 3400 kcal/kg DE and according to NRC (1998). If diet energy density differs the target nutrient levels may be changed proportional to diet energy density.

	Feed intake 90% of NRC			**Feed intake 80% of NRC**		
Fat-free lean gain (g/d)	Lys (%)	Thr (%)	Av. P (%)	Lys (%)	Thr (%)	Av. P (%)
			30 kg body weight			
400	1.09	.68	.24	1.07	.68	.24
350	.96	.61	.24	.94	.60	.24
300	.83	.53	.24	.81	.52	.24
			75 kg body weight			
400	.81	.52	.17	.87	.56	.17
350	.71	.46	.17	.76	.49	.17
300	.62	.40	.17	.66	.43	.17

Nutritionists at Kansas State University use all three approaches depending on the information available from the particular producer. If the producer is not a member of a production group with research barns (approach 1) and serial ultrasound curves are not available (approach 2), they use a short-cut approach that they have developed to determine the appropriate diet lysine to energy ratio from the NPPC fat free lean index information that U.S. producers receive on their kill sheet. The concept uses a standardized approach to determine protein accretion from the fat free lean index, as published by Schinckel and de Lange (1996). Fat accretion curves were developed from data developed at the Prairie Swine Center (Lorschy *et al.*, 1997) and from data that we developed in the field. Their data allowed for the conversion of backfat to percent body fat. Data that we developed in field allowed calculation of a linear regression of increases in backfat as body weight changes. Thus, we could determine fat accretion on a daily basis. Using the protein and fat accretion curves, energy intake can be estimated. The influence of changing growth rate and fat-free lean index was modeled. Growth rate did not have a major impact on the predicted optimum diet lysine to energy calorie ratio. Thus, we obtained estimates of the target diet lysine to energy ratio based on fat free lean index alone.

There are two main problems with approaches 2 and 3. First, you rely on estimates of the amount of dietary lysine required for each incremental unit of protein accreted. Research in this area is not always in agreement. For example, NRC relies on an estimate that for each gram of protein accretion, 0.12 g of true digestible lysine is required. The two numbers that go into this calculation are the lysine content of body protein and the efficiency of utilisation of true digestible lysine for protein accretion. Research in commercial G/F barns indicated that the value from NRC (0.12 g of lysine per gram of protein accretion) will overestimate the lysine requirement and that the value may be closer to 0.11 g. The second problem with approaches 2 and 3 is getting a good estimate of energy intake. Recent equations published by Noblet *et al.* (1999) appear to match feed intake measurements in the field more appropriately than equations published in NRC (1998).

II.b. Establish optimum energy density

Another important concept in feed formulation is the concept of optimum diet nutrient density. Two aspects should be considered: the cost of nutrients and the relationship between diet nutrient density and daily nutrient intake. Rather than evaluating diets based on cost per ton of feed, it is important to consider the diet nutrient density at which the cost per unit of nutrients (energy balanced with other nutrients against energy) is the lowest. This can be evaluated by formulating diets that differ in nutrient density, e.g. increase or decrease the target diet nutrient content all in the same proportions, and calculate the cost per unit of energy at each of the diet nutrient densities. The diet with the lowest cost per unit of nutrients will generally results in the lowest cost per kg of body weight gain.

However, when the value of throughput in the pig unit is considered, there is value to increasing the nutrient density to levels that are higher than those in diets that yields the lowest cost per unit of energy. This is because an increase in diet nutrient density will increase the daily nutrient intake, and as a result growth rate will increase. This is particular applicable to young pigs, up to about 60 kg body weight. It may also apply to finishing pigs that are managed under practical conditions, e.g. that are crowded or that are under mild heat stress.

In these considerations, the producer's production goal must be established. The question to ask is whether the goal is minimise production costs per kg of gain or the maximise profit over feed cost. Because of the importance of energy intake in driving average daily gain and market weight, high energy diets can often increase margin over feed cost and, thus, net profit, while not being the lowest in feed cost per kg of gain.

The following example illustrates the impact of adding extra energy to the diet (as dietary fat in this example) in field conditions on feed cost per kg of gain and return over feed cost.

Value of energy density example.

The data used in this example is from an experiment conducted in a commercial research facility using 480 pigs to determine the influence of fat additions to the G/F diet on pig performance and carcass composition. The four dietary treatments were based on increasing added dietary fat (0, 2, 4, or 6%). Diets were corn-soybean meal based and fed in three phases. Within each phase, identical lysine to energy ratios were maintained among the experimental diets. The lysine to energy ratio was decreased in each subsequent phase and as pigs became heavier.

A brief summary of the response to fat is shown in Table 3. The influence of added fat on pig performance is listed as the percentage improvement over the control diet. The influence of added fat on ADG was greater (1.5% for every 1% fat) and more consistent during phase 1 than during subsequent phases. Overall, addition of each 1% fat resulted in approximately a 1% increase in ADG. The negative influence of added fat on ADFI became greater as the trial progressed with approximately a 1% reduction in ADFI for every 1% added fat. The most consistent response to dietary fat was the improvement in F/G. Every 1% addition of fat resulted in approximately 2% improvement in F/G. Not only was the F/G response to added fat consistent among the three phases, within each phase, increasing added fat from none to 2, 4, or 6% resulted in a 4, 8, and 12% improvement in F/G.

Table 3. Percentage response in pig performance to each 1% increment of added dietary fat.

Item	ADG	ADFI	F/G
Phase 1 (36 to 59 kg)	1.50%	-0.80%	-2.00%
Phase 2 (59 to 95 kg)	0.80%	-1.10%	-1.60%
Phase 3 (95 to 120 kg)	0.60%	-1.30%	-1.90%
Overall (36 to 120 kg)	0.83%	-1.10%	-1.84%

To further examine the value of fat for an individual production system, we will consider a series of six G/F diets, phase fed from 27 to 110 kg (Tables 4 and 5). In Table 4, the average prices from a 5-year price series from 1994 through 1998 were used to determine the economics of adding fat to each individual phase. Because fat price can vary considerably depending on the method of purchase and handling, we also present a similar analysis in Table 5 with an extra $.02/lb added to the fat price. This $0.02 handling charge allows us to evaluate the sensitivity of the economic scenario to a small change in fat price. Using the prices without the handling charge (Table 4), feed cost per pig decreases slightly in the first three diets (27 to 74 kg) as fat is added to the diet. From 74 to 120 kg, feed cost per pig increases slightly, such that for the overall period, there was no difference in feed cost for pigs fed corn-soybean meal based diets with or without 6% added fat. However, because of the extra weight gain, adding fat to the diet increased return over feed cost for every dietary phase. The return ranged from an extra $1.23 when adding fat to the diet for pigs weighing 27 to 45 kg to $0.02 for pigs weighing 99 to 120 kg. This is because the response in ADG was greatest in the early phases compared to the later phases. The other cost that must be considered is the potential negative effect on carcass premiums. Recent research from Kansas State University suggests that if a decrease in carcass premium is discernible when fat is added to the diet under field conditions, it is only because of the fat added during the last dietary phase from approximately 99 kg to market weight.

The data in Table 5 demonstrates the impact of a small change in fat price on the economic scenario. By adding $0.02/lb to the price of fat, adding fat to the diet will no longer reduce feed cost during any phase. Feed cost per pig is increased by $0.05 to $0.22/phase or $0.63 per pig if added for every G/F phase. Thus, if space was not limited, adding fat to the diet would increase production cost. However, because of the increased weight gain with added fat; it is still economical at the higher price in systems that are limited in space. In this scenario, adding fat to the diet would increase margin over feed cost for every diet from 27 to 99 kg. The only phase that would realise a net loss by adding fat to the diet is the last phase from 99 to 120 kg. The improvement in daily gain during this last phase is not great enough to overcome the increased feed cost.

This example demonstrates that economic analysis of a dietary program should not focus on feed cost per pound of gain alone. More inclusive measurements of profitability need to be included. Margin over feed cost is a relatively easy value to calculate and provides a more complete picture of the impact of a dietary change on profitability. Similar cases can be presented where slightly higher lysine levels or feed additives, such as Paylean, will increase feed cost per pound of gain, but still be more profitable because of higher margin over feed cost.

II.c. Feed additives

The cost of additives (antibiotics, extreme fortification with vitamins and minerals, etc) in G/F pigs diets can be substantial. The value of these additives should be questioned at regular intervals, considering solid scientific evidence demonstrating their value, health problems and environmental management. Some technologies, such as synthetic lysine and phytase, can decrease nutrient excretion and lower feed cost. Conversely, other additives in the G/F area, such as antibiotics, often must pay for themselves through reduced death loss or decreased variation, which is much more difficult to quantify. Feed additive (antibiotics, etc) use on commercial farms is often much higher than specified in diets and can consume a big chunk of profit for our commercial producers compared to many integrated systems. A typical problem that can occur is that the producer experiences a problem in the G/F barn and adds a particular antibiotic, which quickly becomes a routine procedure for all subsequent groups instead of being removed from the diet after the problem is under control.

II.d. Consider Environmental issues

In regions where the negative impacts of pigs on the environment is a concern, diets may be modified to reduce the excretion of nitrogen (reduce diet protein levels by replacing protein sources with synthetic amino acids), phosphorus (include phytase, the enzyme that enhances phosphorus availability in feed ingredients of plant origin), or odourous compounds (feed additives that may influence microbial fermentation in the pig).

III. Ingredient Procurement

In choosing the proper pig feed ingredients various aspects should be considered, including available nutrient content, variability, effect on diet palatability, effect on carcass and meat quality, contamination with compounds such as mycotoxins, storage and handling, availability and cost.

In terms of nutrients, the content of available amino acids, energy and phosphorus should be considered. Tables are available that provided average contents of true ileal digestible amino acids, digestible energy and available phosphorus for the most common pig feed ingredients. Routine sampling of ingredients (at harvest time) for content of dry matter (water content should be considered before any other nutrient), protein (can be used to estimate amino acid content) and fiber (NDF, neutral detergent fiber) is recommended. Depending on the ingredient additional analyses may be conducted, such as fat (high oil corn, full-fat soybeans), ash, calcium and phosphorus (meat meals, mineral sources), mycotoxins (corn and wheat samples).

Table 4. Example of economic decision on adding fat to the G/F diet by phase of production [a]

Weight		Feed Budget, lb/pig		Feed cost, $/pig			Feed cost, $/lb of gain		Extra gain from fat		Value of fat
Initial	Final	With fat	No fat	With fat	No fat	Diff.	With fat	No fat	lb/pig	$/pig	$/pig
27	45	34.5	39.0	$6.30	$6.34	$.04	$0.161	$0.163	3.99	$1.19	$1.23
45	60	34.5	39.0	$6.05	$6.07	$.02	$0.178	$0.179	2.73	$0.77	$0.79
60	74	34.5	39.0	$5.69	$5.70	$.01	$0.184	$0.184	1.89	$0.51	$0.52
74	87	34.5	39.0	$5.45	$5.44	($.01)	$0.195	$0.194	1.21	$0.32	$0.31
87	99	34.5	39.0	$5.27	$5.25	($.02)	$0.203	$0.202	0.7	$0.18	$0.16
99	120	68.0	77.1	$10.11	$10.07	($.04)	$0.215	$0.214	0.24	$0.06	$0.02
				$38.87	$38.87	$0.00	$0.190	$0.190	10.8	$3.03	$3.03

[a]Average 5-year prices from southern Minnesota were $2.51/bu corn, $207/ton SBM, $0.158/lb fat, and $0.46/lb market hog price.

Table 5. Example of economic decision on adding fat to G/F diet by phase of production with $0.02 handling charge on fat [a].

Weight		Feed Budget, lb/pig		Feed cost, $/pig			Feed cost, $/lb of gain		Extra gain from fat		Value of fat
Initial	Final	With fat	No fat	With fat	No fat	Diff.	With fat	No fat	lb/pig	$/pig	$/pig
27	45	34.5	39.0	$6.39	$6.34	($.05)	$0.164	$0.163	3.99	$1.19	$1.14
45	60	34.5	39.0	$6.14	$6.07	($.07)	$0.181	$0.179	2.73	$0.77	$0.70
60	74	34.5	39.0	$5.79	$5.70	($.09)	$0.187	$0.184	1.89	$0.51	$0.42
74	87	34.5	39.0	$5.54	$5.44	($.10)	$0.198	$0.194	1.21	$0.32	$0.22
87	99	34.5	39.0	$5.36	$5.25	($.11)	$0.206	$0.202	0.7	$0.18	$0.07
99	120	68.0	77.1	$10.29	$10.07	($.22)	$0.219	$0.214	0.24	$0.06	($0.16)
				$39.50	$38.87	($.63)	$0.193	$0.190	10.8	$3.03	$2.40

[a]Average 5-year prices from southern Minnesota were $2.51/bu corn, $207/ton SBM, $0.178/lb fat ($0.158/lb plus $0.02 handling charge), and $0.46/lb market hog price.

Based on ingredient specific effects the inclusion level of some ingredients may be limited, such effects on diet palatability (canola meal), carcass quality (full fat soybeans).

To assess the actual value of pig feed ingredients, least cost – or best cost – feed formulation systems should be used. These systems provide information on the actual financial value versus the actual cost based on the costs of other ingredients.

Optimal purchasing of ingredients is essential to control the cost of the G/F feeding program. Reviewing ingredient costs with individual producers yields different ingredients that need work. Understanding of budgets and diet formulas help put the different ingredients in perspective relative to cost. A mental model that can be used to prioritize efforts in managing feeding programs to increase return is depicted in Figure 1. This two dimensional graph can help improve understanding of where opportunities for cost savings exist. The percentage of feed cost contributed by various ingredients is depicted along the horizontal axis. The opportunity margin is depicted along the vertical axis. The opportunity margin is defined as the average percentage of each component cost that may be available for increasing net profit. The opportunity margin is derived from either reducing ingredient cost or changing usage of that ingredient to reduce feed cost or increase revenue. Therefore, the area of each box represents the opportunity for profit by reducing the cost of a particular ingredient.

As expected, corn and soybean meal comprises the largest percentage of feed cost. However, the opportunity from lowering corn or soybean meal price is usually small such as $0.10 per bushel of corn or $10 per ton of soybean meal. However, because of the large area of opportunity with corn, soybean meal, and fat, usage of these ingredients drives a large share of a nutritionist's focus on lysine and energy requirements in swine diet formulation. Obviously, other energy and protein sources can be substituted for corn and soybean meal in this graph depending on local prices and manufacturing situations. The next area that usually results in a large opportunity is feed manufacturing. The impact of feed manufacturing and delivery will be further detailed in a subsequent section. The next three opportunity areas are pelleted diets (starter diets fed to pigs weighing less than 7 kg), vitamin premixes, and to a lesser extent the specialty nursery diet ingredients of whey, fish meal, or blood meal. There is little centrally reported pricing for these ingredients, thus, fairly large differences in pricing exist in the market place. Secondly, the composition and quality of these ingredients varies greatly, leading to difficulties in making accurate price comparisons. Thirdly, usage has an impact on the opportunity cost. For example since the pelleted diets are usually much more expensive than the average diet cost, small unneeded increases in usage lead to large increases in cost without improvements in net return. Feed medications are also in this category, however, pricing is usually fairly consistent and the opportunity lies in medication selection and amount used. An ingredient that we have found a fairly large opportunity is salt. Two factors are responsible. The first is the grade of salt fed. Sometimes the design of the feed mill cannot handle a feed-grade salt and a free-flowing food grade must be utilized. The second is that since salt is such a low cost ingredient per kg, transportation costs has a large impact on opportunity. The final significant area of opportunity is the phosphorus source. Most of the opportunity for this component results from efficient transportation or purchasing and quantity discounts.

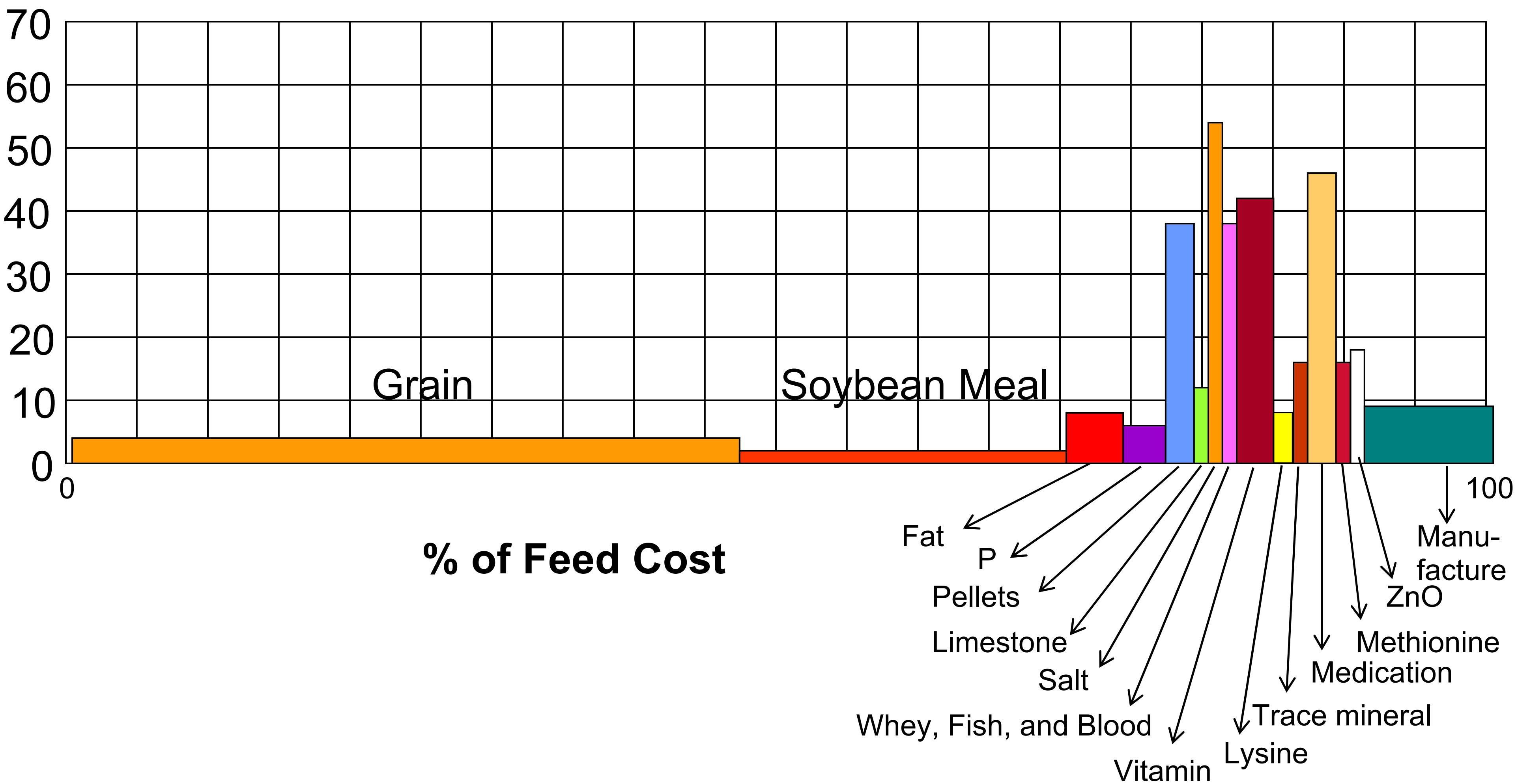


Figure 1. Opportunity margin for various parts of the feeding program.

IV. Feed Processing

The main areas of concern in the feed processing area are feed manufacturing cost, particle size of the grain, and diet form (pellet or meal) being fed.

Feed Manufacturing Costs

On-farm feed manufacturing costs from a study of 17 Kansas Swine farms conducted by the Grain Science and Agricultural Economics Departments at K-State are listed in Table 6 (Herrman *et al.*, 1997). First, note the large range in costs of $11.85 per ton between the highest cost farm and lowest cost farm. This represents $4.38 difference per pig. Secondly, observe that the difference in feed manufacturing costs from 1 standard deviation (SD) above to 1 SD below the average is $2.59 per pig. The impact of the differences in feed manufacturing costs is examined in the last two columns. The first column is based on the assumption of a farm with average feed manufacturing costs having the same profitability as the 10-year average profitability from the Iowa State swine records summary. Note that if it is assumed that the farm has the lowest feed manufacturing cost, profit will increase by 10.4%. Conversely, farms with the highest cost will have 17.6% lower profit than farms with average feed manufacturing costs. An alternative scenario using a profit of $5 per pig for the category with average feed manufacturing cost is examined in the last column. As profit margins decrease, the importance of lower manufacturing costs becomes magnified.

Table 6. Feed Manufacturing Costs from 17 Kansas Swine Farms in U.S. Dollars[1] .

Category	$/Ton	$/Pig Marketed	$/cwt Live	Average Profit Change Impact	Low Profit Change Impact
Highest	$ 15.49	$ 5.73	$ 2.29	-17.6%	-55.0%
Plus 1 SD	$ 11.56	$ 4.28	$ 1.71	-8.3%	-25.9%
Average	$ 8.06	$ 2.98	$ 1.19	0.0%	0.0%
Minus 1 SD	$ 4.56	$ 1.69	$ 0.67	8.3%	25.9%
Lowest	$ 3.64	$ 1.35	$ 0.54	10.4%	32.7%

[1]Feed manufacturing ($/ton) costs reported by Herrman *et al.*, 1997. The $/pig marketed assumes that 335 kg of feed is required to produce 1 market pig. The $/cwt assumes an average live market weight of 114 kg. The profit change scenarios were calculated using the average profit per pig for the 1985-96 10 year Iowa State University Swine records.

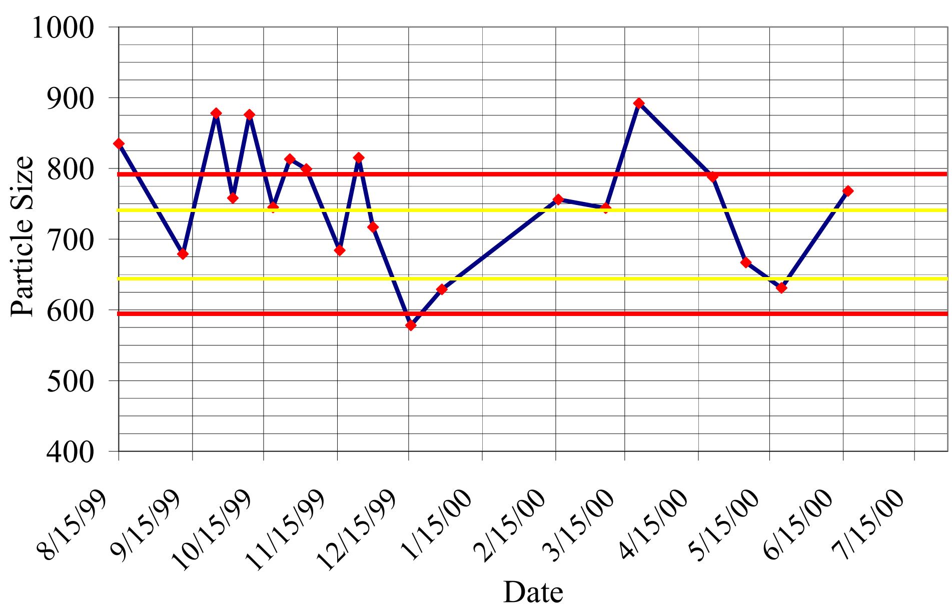
Particle Size

Another opportunity area for improving net return is grain particle size reduction. A summary of research from Kansas State (KSU Swine Nutrition Guide) indicates that for every 100 micron decrease in average particle size, feed efficiency improves by 1.2%. This results in approximately a $0.40 to $0.50 improvement in feed cost per pig for every 100 micron reduction in average particle size. The research is clear that reducing particle size improves energy utilisation and feed efficiency. However, implementation of the proper particle size is a problem in many feeding programs. Without continual monitoring, particle size is difficult to maintain in the optimum range of 600 to 800 microns. Listed in figure 2 are the particle size analysis results for 9 months from one production system. Based on these analyses this production system incurred approximately $50,000 in lost opportunity because of particle size in excess of 750 microns.

Diet form

Producers often have questions on the value of pellets versus meal for G/F pigs. Literature indicated that pelleting the diet will improve ADG from 3 to 8% and feed efficiency from 5 to 8% in the G/F phase in pigs fed corn and soybean meal-based diets. If byproducts such as wheat shorts are used, these effects are slightly larger. Pelleting allows a greater range of ingredients to be used in the diet. The biggest problem with pellets in the field is pellet quality. In experiments of Stark *et al.* (1994), feed efficiency tended to decrease as the amount of pellet fines was increased in the diet until pigs fed diets with high concentrations of fines (between 20 and 40%) were no more efficient than pigs fed the meal control. In a similar experiment, Amornthewaphat *et al.* (1999) reported a linear decrease in efficiency of growth of G/F pigs as pellet fines was increased from none (7% greater gain/feed than the meal control) to 50% (2% greater gain/feed compared to the meal control). The problem with fines is that pigs sort the pellets from the fines and fines build in the feed trough and feed wastage is increased. The buildup of fines is less for wet/dry feeders than for dry feeders. Thus, the decision on whether to pellet diets is complicated by the ability to properly adjust feeders. The advantage in ADG and feed efficiency to pellets is clear, as long as pellet quality does not cause a feeder adjustment problem.

Figure 2. Particle Size Monitoring



V. Feed Delivery

The main areas to review under feed delivery are feed budgets and the impact of trucking costs on profit. Feed budgets are essential to minimise overfeeding or underfeeding of particular diets. Feed budgets can be altered for individual production units to match the mixer or truck size to make the delivery process more efficient. If multiple phase diet programs are used, feeding by feed budget is more accurate than feeding by time or by trying to estimate weights for dietary changes. Kansas State University has a simple feed budget program that can be used to estimate amount of feed required for various weight ranges. It adjusts the budget based upon feed efficiency and weight ranges from past closeouts. An example of the amount of feed required for various weight ranges is shown in Table 7. This table can be used to determine feed requirements for a dietary phase. For example, if the feed efficiency from 20 to 110 kg is 2.80 and the diet weight range is from 20 to 45 kg, the quantity of feed required per pig is 54.6 kg (10.0 + 10.4 + 10.9 + 11.4 + 11.9).

Table 7. Quantity of feed (kg) needed for each 5-kg increment at various F/G values.

Weight, kg		Feed efficiency from 20 to 110 kg				
Initial	Final	2.40	2.60	2.80	3.0	3.2
20	25	8.6	9.3	10.0	10.7	11.4
25	30	9.0	9.7	10.4	11.2	11.9
30	35	9.4	10.1	10.9	11.7	12.5
35	40	9.8	10.6	11.4	12.2	13.0
40	45	10.2	11.0	11.9	12.7	13.6
45	50	10.6	11.5	12.3	13.2	14.1
50	55	11.0	11.9	12.8	13.7	14.6
55	60	11.4	12.4	13.3	14.2	15.2
60	65	11.8	12.8	13.8	14.7	15.7
65	70	12.2	13.2	14.2	15.2	16.3
70	75	12.7	13.7	14.7	15.7	16.8
75	80	13.1	14.1	15.2	16.2	17.4
80	85	13.5	14.6	15.7	16.8	17.9
85	90	13.9	15.0	16.1	17.3	18.5
90	95	14.3	15.4	16.6	17.8	19.0
95	100	14.7	15.9	17.1	18.3	19.5
100	105	15.1	16.3	17.6	18.8	20.1
110	115	15.5	16.8	18.0	19.3	20.6
115	120	15.9	17.2	18.5	19.8	21.2
120	125	16.3	17.7	19.0	20.3	21.7
125	130	16.7	18.1	19.5	20.8	22.3

Delivery Costs

The impact of truck size on delivery cost is depicted in Table 8. This data is based on costs reported by Baumel (1997). The delivery cost per mile increases linearly as the truck size increases from 6 to 24 tons. However, the cost per ton-mile (cost per mile/truck size) decreases in a curvilinear fashion. Based on these data the cost per ton-mile is decreased by 43% when comparing a truck size of 12 to 24 tons. While the advantage is going to depend greatly on the distance of feed transport, for a 15 mile delivery this translates into a $0.62 per ton and $0.23 per pig decrease in feed cost for when using the 24 ton compared to the 12 ton trucks. These figures also illustrate that the savings in transportation costs are significant when utilising on-farm produced grains and feed manufacturing.

Table 8. Influence of feed truck size on delivery costs.

	Capacity of truck, tons			
Delivery cost	6	12	18	24
Cost/mile, $	$ 1.07	$ 1.14	$ 1.18	$ 1.29
Cost/ton/mile, $/ton	$ 0.178	$ 0.095	$ 0.066	$ 0.054
Cost for 1000 head, $[a]	$2,136	$1,140	$792	$648
Cost per pig, $ [a]	$ 2.14	$ 1.14	$ 0.79	$ 0.65

[a]Assumes a delivery 20 miles from the feed mill (40 miles round trip).

VI. Application In The Barn

The nutrition program is not complete when the feed is delivered to the feed bin. Application in the barn centres on three areas, feeder adjustment, bin management, and pig monitoring.

Feeder adjustment

Feed wastage from poor feeder adjustment is a problem in most G/F barns. Improvements in feed efficiency from the reduction in feed wastage directly reduce cost per kg of gain and per pig. For example, feed cost is lowered over $1.00 per pig in the finisher and $0.40 per pig in the nursery by reducing feed efficiency by 0.1. Feed efficiency improvements of 0.1 to 0.2 (ex. 3.0 to 2.9 or 2.8) have been accomplished frequently in the field by improving feeder adjustments. Many times the improper adjustment is the result of difficulty that management has communicating to personnel adjusting the feeders as to what proper adjustment should look like. Posting laminated pictures in every room of every G/F and nursery facility has been an effective tool to communicate proper feeder adjustment. The pictures serve as constant motivational reminders to help reduce feed wastage.

Bin management

The goal in bin management is to always have high quality feed available for every pig in the barn. As part of this, you do not want to decrease the quality of the feed delivered from the feed mill by moisture buildup or bridging of feed in the bins. The other aspect is to not run bins empty for extended periods of time, such that pigs are without feed. Consistent availability of feed is a key for reducing ulcer and ileitis problems in the G/F barn.

Pig monitoring

Visual monitoring of pigs for normal growth, comfort (absence of vices such as tail biting, etc.), and freedom of disease needs to be conducted on a daily basis. Problems or mistakes in the nutrition program are often found first by the critical eye of an excellent stockperson in the barn. The nutritionist and feed manufacturer relies on the person in the barn to communicate concerns or problems as quickly and thoroughly as possible to determine the cause and remedy the situation.

VII. Simplification

As production systems have grown in size and a higher proportion of the labour in the feed mill and G/F barns has little practical agricultural background, steps must be taken to reduce the complexity of the feeding program to reduce errors. Any decision to add additional ingredients to the diet must include an understanding of the ability of the feed mill to handle the extra ingredient and consistently add it to the diet at the desired level. Any decision to add additional diets to the feeding program must consider the potential impact on reducing the efficiency of the feed mill and increasing cost of milling and delivery. Decisions on trace mineral and vitamin levels in each diet often must be made considering the limitation in the feed mill concerning the number of premixes that can be stocked and rotated in a reasonable timetable. Increasing the number of premixes in the mill also increases the potential that the wrong premix will be used.

In order to simplify the nutritional program, consider limiting the number of ingredients and number of diets as much as possible. For example, the same diets could be used for barrows and gilts, but different feed budgets can be used to accomplish the goal of split-sex feeding. If you are working with numerous feed mills, reduce the frequency of changes in diet formulation. Many mistakes that occur in the field can be traced to mistakes in entering diets into the computer in the feed mill or in errors in diet formulation. Reducing dietary changes and having a system to review diet formulas after changes have been made can reduce problems.

CONCLUSIONS

The most economical feeding programs are much more than a set of diet formulations based on a set of nutrient levels. Determining the correct amino acid and energy levels are a very important part of a nutrition program. However, other factors, such as ingredient procurement, feed processing, budgeting, delivery, and feeder adjustment are just as important in determining the success of the nutrition program. The various areas of the nutrition program are not independent of each other and must be considered in unison. For example, the ingredient purchaser must interact and communicate with the nutritionist as to which ingredients are available. Nutritionists must communicate the feeding value of the ingredient to the purchaser so the purchaser can base decisions of different ingredients on a similar nutritional value. Farm management must communicate a common message on the importance of feed management in the barn. The nutritionist and feed mill manager must work together to simplify the nutrition program and prevent problems from occurring. Finally, the person in the G/F barn must communicate potential concerns or problems to the nutritionist and feed mill personnel. The various aspects reviewed in this paper help provide tools to review all aspects of the nutrition program.

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