Alternative Feed Ingredients in Swine Diets

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Introduction

Increasing feed grain and supplement costs and the potential for feed grain inventories to be depleted due to increased demand are significant issues for producers in the pork industry. Historically, feed costs have represented 65 -75 percent of the variable costs of swine production, but for many producers this figure is higher now. As a result, feed costs play a major role in determining the profitability of a swine enterprise.

While corn and soybean meal have been industry standards for supplying energy and protein, there are many suitable alternatives that meet nutritional requirements while reducing the cost of the diet and these may be included cost effectively as demand for corn and soybeans increases or as actual inventory shortages develop. Energy and protein are the main nutrient components in a swine diet. Grains such as corn, barley, wheat, sorghum and oats have traditionally supplied energy, while protein has come from meals produced from oilseeds such as soybeans and canola.

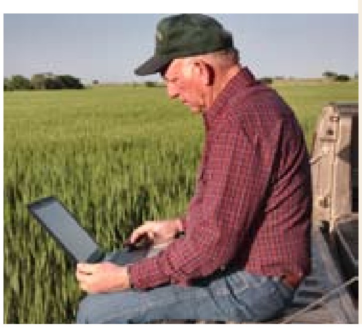
Price relationships between traditional and alternative feed ingredients vary greatly depending on season, availability, and global and local markets. Pork producers must be able to evaluate the cost effectiveness and nutritional value of all available feed ingredients to supply a nutritionally-balanced diet at a minimal cost.

Least-cost computer formulation programs are available to design diets that meet minimal nutritional requirements at the least cost. Feed manufacturers and producers should use these programs effectively to purchase and maintain inventories of ingredients.

Many alternative feeds that may be cost effective and useful in swine diets are produced by the industries involved in grain milling, baking, brewing, distilling, packing, rendering, fruit and vegetable processing, vegetable oil refining, dairying, and egg and poultry processing. By-products from these industries are regularly used in manufactured feed to provide nutrients at a reduced cost.

Many of the by-products from these processes can readily substitute a portion of the energy or protein in a complete feed. The appropriate amount to use will depend on the cost, nutrient availability (digestibility), quality of protein, amino acid profile, palatability, presence of anti-nutritional factors, storage life and age of the pig for which the feed is intended.

Cost



Cost is one of the most difficult factors to determine when considering the use of alternative feeds. A producer must take into account the amount of nutrients supplied by the replacement feed. This can be extremely difficult because most feeds cannot be directly compared due to nutrient variability. As a result, relative values are often used for comparison purposes. However, the ultimate cost of any diet change also must consider other factors such as transportation, special processing needs and storage. This is particularly important when evaluating high moisture products such as liquid whey, distillers grains and high moisture corn. The value of alternative ingredients should be based on their actual contribution of digestible energy and nutrients to the diet. Historically, rations were least-cost balanced based on protein levels because protein was the most expensive nutrient in the diet. However, in many current economic environments, energy may now be more expensive per unit than protein. Rations should be reformulated to recognize this scenario and reformulated often as feed ingredient costs change.

Relative Value

The relative value of a feed ingredient is used to compare the value of that feed to the price of the industry's standard energy and protein-supplying ingredients. Table 1 lists relative values of feeds compared to corn or soybean meal. They reflect the value of the ingredient as it relates to the three most expensive nutrients in a swine ration - energy, lysine and phosphorus. Note that these relative values do not consider the suggested limits on inclusion rates. The values are based purely on a comparison between the nutrient levels in the alternative feed and the nutrient standards - corn, soybean meal and dicalcium phosphate - and their respective costs.

Feed Ingredient	Dry Matter (percent)	Dry Matter Basis			Suggested Maximum** Inclusion Rate (percent of Total Diet)		Relative Value (Compared to...)
		DE kcal/kg	Protein (percent)	Lysine percent	Grower/ Finisher	Nursing/ Dry Sows	
Energy Feeds							**Corn**
Alfalfa Meal	92	1989	18.5	0.80	10	NR/60	80-90
Bakery Waste, dried	91	4330	11.9	0.30	40	10	100-110
Barley	89	3427	12.7	0.46	80	80	95-105
Beet Pulp, dried	91	3148	9.5	0.57	10	10	90-100
Brewer's Grains, dried	92	2283	28.8	1.17	10	10	110-120
Corn	89	3961	9.3	0.29	80	80	100
Corn, high moisture	72	3961	9.3	0.29	40	40	80-90
Corn Distillers, dried grains with solubles	93	3441	29.8	0.67	20	40	100-110
Corn Distillers, dried solubles	92	3614	29.0	0.89	20	?	135-145
Corn Gluten Feed	90	3322	23.9	0.70	25	5/90	110-130
Corn Gluten Meal	90	4694	66.9	1.13	5	5	150-160
Corn Hominy	90	3728	11.4	0.42	80	80	100-110
Fats and oils	100	8000	0.0	0.00	6	6	175-210
Flax	90	3400	37.3	1.38	5	5	150-155
Oats	89	3112	12.9	0.45	20	20	85-90
Oats, hulless	86	4047	19.9	0.55	95	95	110-115
Potato Chips	90	5833	7.2	0.34	25/10	25	125-150
Rye	88	3716	13.4	0.43	40/77	NR/25	100-105
Sucrose	99	3833	0.0	0.00	33	?	85-95
Sorghum	89	3380	9.2	0.22	80	80	95-98
Soybean Hulls	89	1025	14.0	0.98	10	30	60-70
Triticale	90	3689	13.9	0.43	77	25	90-105
Wheat, hard red spring	88	3864	16.0	0.43	80	80	105-115
Wheat, soft white winter	89	3820	13.3	0.37	80	80	100-105
Wheat Bran	89	2719	17.6	0.72	10	15	110-120
Wheat Middlings	89	3455	17.9	0.64	40	40	110-130
Wheat Shorts	88	3392	18.2	0.80	40	40	120-125
Whey, dried	96	3474	12.6	0.94	15	10	130-140
Whey, liquid	7	3571	12.9	1.17	30	?	140-150
Protein Feeds							**Soybean Meal**
Beans, cull	84	3600	26.4	1.45	12	12	55-65
Brewer's Grains, dried	92	2283	28.8	1.17	10	10	40-50
Canola Meal	90	3206	39.6	2.31	15	15	75-85
Corn Distillers, dried grains with solubles	93	3441	29.8	0.67	20	40	45-55
Corn Distillers, dried solubles	92	3614	29.0	0.89	20	?	55-60
Corn Gluten Feed	90	3322	23.9	0.70	25	5/90	45-55
Corn Gluten Meal	90	4694	66.9	1.13	5	5	55-70
Fababeans	87	3730	29.2	1.86	20	10	65-75
Fish Meal, menhaden	92	4098	67.7	5.23	5	5	160-170
Flax	90	3400	37.3	1.38	5	5	60-65
Lupins, sweet white	89	3876	39.2	1.73	20	20	70-80
Meat Meal	94	2867	57.4	3.27	5	5	120-130
Meat and Bone Meal	94	2440	51.5	2.51	7.5	7.5	120-130
Milk, skim (dried)	96	4146	36.0	2.98	10	10	100-110
Milk, whole (dried)	88	5667	27.5	2.50	10	10	100-105
Peas	89	3860	25.6	1.69	20/35	40	65-75
Soybean Meal, 44 percent	89	3921	49.2	3.18	35	35	100
Soybean Meal, 48 percent	90	4094	52.8	3.36	35	35	100-105
Soybeans, roasted	90	4600	39.1	2.47	10	25	90-100
Sunflower meal	90	2010	26.8	1.01	20	10	50-60

NR = not recommended | ? = not enough information for a recommendation to be made | ** = Maximum that can be used

Protein Quality

Protein quality refers to the amino acid concentration and balance of the feed ingredient. Because lysine usually is the most limiting indispensable amino acid in corn-soybean meal-based diets, it is important to consider lysine when valuing alternative ingredients. For example, corn gluten and wheat middlings have a high concentration of protein relative to the amount of lysine. If a diet was prepared with these ingredients based solely on the protein concentration, the pigs would not be provided sufficient lysine to support optimum performance. Diets for swine should be balanced according to the level of lysine instead of crude protein. However, because the pig has a need for all indispensable amino acids, if just one amino acid is present in a concentration that is below the requirement of the pig, performance will be impaired. Diets should therefore, be formulated based on all indispensable amino acids.

Energy and Nutrient Digestibility (Availability)

Energy and nutrient digestibility is a measure of the availability of energy and nutrients in a feed ingredient. In all practical feed ingredients, only a portion of the energy and nutrients are absorbed from the intestinal tract of the pig, whereas some of the energy and the nutrients are excreted in its feces. Only the part that is absorbed from the intestinal tract is available for utilization by the pig. This part is called the digestible part of the feed and is described by digestibility values or digestibility coefficients for energy and each nutrient. Digestibility values for energy and nutrients can vary considerably among feed ingredients and should be taken into account when a feed ingredient is valued. In general, the greater the concentration of fiber in a feed ingredient is, the lower is the digestibility of energy and most nutrients. As an example, the digestibility of energy and most nutrients is much greater in dehulled soybean meal than in alfalfa meal, because alfalfa meal has a much higher concentration of fiber than soybean meal.

Anti-Nutritional Factors

Anti-nutritional factors are factors in a feed ingredient that interfere with nutrient digestibility and utilization. These include trypsin inhibitors, tannins, lectins, glucosinolates and others. For example, raw whole soybeans contain a trypsin inhibitor. As a result, they must be heat-processed or they will cause a decrease in performance due to decreased protein digestibility and absorption.

Palatability

Palatability is the term used to describe the extent to which a pig likes to eat a feed ingredient or ration. As pigs grow older flavor preferences change just as they do in humans. Pigs, in fact, have more taste buds than humans (15,000 vs 9,000) so flavors, or off-flavors, can have an impact on what feed alternatives are feasible. In pig rations, for example, dried whole milk is very palatable while triticale has poor palatability at high inclusion levels.

Inclusion Rate

Inclusion rate will vary for ingredients depending on palatability, nutrient availability, protein quality, nutrient interrelationship, and the method of processing and feeding. The maximum inclusion rates in Table 1 vary for each class of pigs and are based on limiting factors. If the ingredient is fed above the maximum suggested inclusion rate, animal performance and pork quality can be compromised. Table 2 lists specific feed ingredients and factors that limit their inclusion in swine rations.

Table 2. Factors Affecting Inclusion Rate of Alternative Feed Ingredients in Swine Rations

Feed Ingredient	Factors Affecting Inclusion Rate	Ease of Storage/ Handling[1]
Alfalfa meal	• High fiber content • Low energy • Good source of carotene and B vitamins • Low digestibility • Poor palatability It is not recommended that alfalfa meal be fed to nursery or grower pigs or lactating sows due to excess crude fiber and low energy concentration. Limited levels of alfalfa meal can be fed to finishing pigs. Alfalfa meal is best suited for gestating sow rations and up to 60 percent of the diet can be supplied by alfalfa meal depending on the economic viability.	10
Bakery waste, dried	• Variable in nutrient content depending on the proportion of bread, cakes, dough, tarts or pies • High in energy • Similar to corn in protein and lysine content • Salt content can be high Diets including bakery waste usually require additional protein for most pig classes, but typically should not produce negative effects on growth or carcass merit compared with corn.	25
Barley	• Higher fiber • Lower digestibility than corn • Test weight and nutrient profile vary more than corn Barley can be two-rowed or six-rowed and hulled or hulless and there are differences in their use in swine feeding programs. Producers should monitor test weights and nutritional profile closely because barley can vary significantly based on variety and growing conditions. These differences can translate into notable differences in growth rates, feed intake and feed efficiency. Two-rowed barley produces fewer but larger kernels per plant than six-rowed barley, so it generally has better feed efficiency, but lower grain yields per acre. Hulless barley has higher crude protein and lower crude fiber than hulled barley, as the hull contains a large portion of the crude fiber. Barley is particularly well suited in growing-finishing diets because even though barley-based diets are lower in energy than corn-based diets, pigs are able to compensate by eating more. Even so, producers may find it advantageous to use barley in combination with higher energy grains, such as corn or wheat. Barley also can be used as the sole cereal grain in sow diets. Several experiments have shown that nursery pigs fed diets containing barley perform better than pigs fed diets based on corn or wheat.	100
Beans, cull	• Significant anti-nutritional factors - must be heat treated before fed to pigs • Extrusion or steaming is the most effective heat treatment • Low in palatability particularly in nursery and grower diets	80

Feed Ingredient	Factors Affecting Inclusion Rate	Ease of Storage/ Handling[1]
Beet pulp, dried	• High fiber content • Low digestibility • Acts as a laxative. Dried beet pulp is a palatable alternative to grain, particularly for finishing pigs and gestating sows. Pig performance and carcass quality is usually not negatively affected in rations with up to 20 percent dried beet pulp. Some studies have shown that litter size will increase if gestating sows are fed dried sugar beet pulp.	20
Brewer's grains, dried	• High fiber content • Low energy • Low lysine • Source of B vitamins	25
Canola meal	• Higher fiber than soybean meal • 35-40 percent crude protein • Less palatable to younger pigs • Anti-nutritional factors • Less lysine, but more sulfur-containing amino acids than soybean meal. Canola is produced primarily in Canada and in the northern states, but production is expanding. Canola meal is the by-product of vegetable oil processing from canola. Some older varieties of canola (rapeseed) contain high levels of a toxic compound, glucosinolate, which affects thyroid functioning and are not advisable in swine diets. However, new cultivars of low-glucosinolate rapeseed (< 1 mg/g) are available. Reduced palatability, high fiber, and low digestible energy have been causes of slightly poorer performance of pigs fed diets containing canola meal compared with diets containing soybean meal.	90
Corn	• High energy • Low lysine • High digestibility • Palatable	100
Corn, high moisture	• Higher moisture concentration (28 percent vs. 15 percent for dry corn) • Low lysine • Diet should be balanced on a dry matter basis. • Rapid feeding is required or molding and spoilage of the mixed feed will occur due to moisture content of complete feed.	5

Feed Ingredient	Factors Affecting Inclusion Rate	Ease of Storage/ Handling[1]
Corn distillers, dried grains with solubles (DDGS)	• High fiber • High fat • Low lysine • High phosphorus and high phosphorus digestibility When fed to livestock, the impact of DDGS on growth performance has been inconsistent due to product variability, use of different drying methods, different levels of residual sugars, and different amounts of solubles added to the product. Also, palatability of DDGS may vary between sources and can influence performance. DDGS may be included in diets fed to gestating sows in up to 50 percent and to lactating sows in up to 30 percent without impacting performance. Thirty percent DDGS can be used in diets fed to weanling and growing pigs, but diets fed to finishing pigs should only contain 20 percent DDGS. DDGS have been shown to impact carcass quality and characteristics when fed to growing-finishing pigs. And when included in finishing pig diets, an increase in carcass fat softness and reduction in belly firmness is usually observed	50
Corn distillers, dried solubles	• Excellent source of B vitamins • Better balance of amino acids than other distillers products • Most desirable of the distillers products for swine	40
Corn gluten feed	• Low lysine • High fiber • Low energy • Variable nutrient concentration • Unpalatable • Bulky	50
Corn gluten meal	• Low lysine • Low fiber concentration • Variable nutrient content	50
Corn hominy	• Slightly higher fiber and protein than corn Corn hominy feed is a mixture of corn bran, corn germ, and part of the starchy portion of either white or yellow corn kernels. Corn hominy feed has feeding characteristics similar to corn grain and is very palatable.	80
Faba beans	• High fiber concentration • Anti-nutritional factors in some varieties • Low vitamin concentration	80
Fats and oils	• Moisture should not exceed 1 percent, impurities 0.5 percent, unsaponifiable material 1 percent, and total MIU 2.5 percent • Total fatty acids should be at least 90 percent while free fatty acids should be no greater than 15 percent • Initial peroxide value provides an indication of rancidity potential and should be below 5 meq (milliequivalents)	10

Feed Ingredient	Factors Affecting Inclusion Rate	Ease of Storage/ Handling[1]
Fish meal	• Variable nutrient concentration depending on the source • High in lysine, methionine, calcium and phosphorus • High digestibility of amino acids and phosphorus • Inclusion in diets for finishing pigs can result in "fishy" flavor in pork Fish meal is traditionally recognized as a highly digestible protein source with a high concentration of amino acids that helps stimulate feed intake. However, the quality of fish meal varies depending on the type and species of fish, the freshness of the fish before processing, and the processing of the meal. Select Menhaden fish meal is currently considered a high quality protein source for nursery pig diets. "Special Select™" menhaden fish meal is a common source used in starter diets in the United States.	50
Flax	• High in oil (35 percent) • High in protein (37 percent) • High in omega-3 fatty acids and lignans Flax can be used to increase energy density, reduce dust, eliminate fines and to aid in feed processing, such as when pelleting because of its high oil content.	35
Lupins, sweet white	• High fiber concentrations • Anti-nutritional factors • Low availability of lysine	50
Meat meal	• High in lysine, calcium, and phosphorus • Variable protein quantity and quality • Lower digestibility and availability of protein than in soybean meal	50
Meat and bone meal	• Excellent source of calcium and phosphorus • High digestibility of phosphorus • Often very low in tryptophan and methionine. There is potential for great variation in the quality of meat and bone meal. Excessive heating during processing of meat and bone meal may decrease its digestibility and value as a protein source.	50
Milk, skim or whole (dried)	• High quality protein • Very palatable • Highly digestible • High lysine concentration Milk products are highly digestible forms of energy, amino acids, and phosphorus. However, milk products are difficult to store and handle and are usually relatively expensive for use in swine diets.	5

Feed Ingredient	Factors Affecting Inclusion Rate	Ease of Storage/ Handling[1]
Oats	• High fiber • Low energy • Very palatable Oats can be a valuable ingredient in swine diets, but there are limits on the amount that can be fed. The high crude fiber concentration makes oats desirable for gestating sow diets where limiting energy intake is beneficial for maintaining reproductive health. Oats may compose up to 90 percent of the diet in this situation. Small pigs and lactating sows have difficulty consuming enough feed to meet their energy requirements when oats are more than 35 percent of the diet. High-test weight oats (greater than 36 lb/bu) can be used for up to 35 percent of the diet for weanling pigs and 35 percent for lactating sows. Oats can compose up to 40 percent of the diet of growing-finishing swine. A study in deep-bedded hoop barns at Iowa State University found no differences in animal performance or carcass measurements when oats replaced 20 and 40 percent of the corn in a swine finishing diet. Oats are often added to swine diets for reasons other than energy. At 5 to 15 percent of the diet, oats can help minimize diarrhea common in recently weaned and small feeder pigs. Oats also can protect against constipation in sows and ulcers in growing pigs. Oats should be finely ground to prevent the pigs from separating out the hulls.	90
Oats, hulless	• Lower fiber and higher energy then regular oats • Very palatable • Variable protein content • Typically too expensive to use in swine diets Hulless oats is used only in diets fed to nursery pigs. Pigs tolerate hulless oats very well, and hulless oats may be used as the sole grain source in diets fed to weanling pigs.	100
Peas	• Good source of lysine • Relatively low in methionine and tryptophan. • Relatively high in energy • High palatability • Contain low levels of the anti-nutritional factor, trypsin inhibitor. Field peas are an excellent feed ingredient for pigs. Peas may be included in concentrations of up to 66 percent in diets fed to weanling and growing pigs. In corn-based diets fed to growing and finishing pigs, field peas may be used as the sole source of protein. Up to 24 percent field peas may be used in diets fed to sows. The trypsin inhibitor is usually in low enough concentrations that it does not impact palatability or performance and it can be deactivated by heating.	100
Potato chips	• High energy • Contain considerable vegetable fat taken up in cooking	20

Feed Ingredient	Factors Affecting Inclusion Rate	Ease of Storage/ Handling[1]
Rye	• Similar to wheat in nutrient content • Susceptible to ergot contamination • Anti-nutritional factors • Dusty and unpalatable if ground too finely. Rye acreage harvested for grain production in North America is fairly small relative to barley, oats, and wheat. Rye's market potential is limited by the perception that it contains toxic factors that reduce its nutritive value. While some reasons for this discrimination are valid, many are unfounded. Rye is particularly susceptible to ergot infection, which is a major concern with frequent rainfall during spring and early summer. Since these conditions are prevalent in most corn growing regions, extreme caution should be used when feeding rye produced in these areas. It is recommended that ergot-free rye be substituted for no more than 50 percent of the corn in a growing-finishing diet. Rye is not recommended as a feedstuff for weanling pigs as it may be of lower palatability. Because maximum feed intake is critical for nursing sows, rye should not be fed to lactating sows either. Very little rye feeding research has been conducted with breeding stock, but if rye is to be included in the diet of sows it must be ergot-free. Dustiness may be a problem but a coarsely ground meal or the addition of fat or vegetable oil will reduce the problem.	100
Sorghum	• High energy • Low lysine • High digestibility • Palatable Often economical compared to corn in areas where grown. Can be used to replace the entire cereal grain portion of the diet with minimal impacts on performance. Only so-called low-tannin varieties of sorghum should be used.	100
Soybean hulls	• High fiber • Low energy feed Availability in many areas of the United States makes their use favorable, especially in gestating sow diets. The nutrient composition can vary from plant to plant, so nutrient analysis should be conducted routinely.	80
Soybean meal	• Protein with hulls, 44 percent • Without hulls, 48 percent • Good amino acid balance in combination with corn • Palatable Generally limited to 15-20 percent of the diet up to 25 lbs, and then can be used as the sole protein source after 25 lbs of weight.	90

Feed Ingredient	Factors Affecting Inclusion Rate	Ease of Storage/ Handling[1]
Soybeans, roasted	• High protein • High fat On-farm roasting or extruding of “full-fat” soybeans can be a relatively low-cost way of adding fat to swine diets. Because of the economic relationship between soy oil and soybean meal, and the cost of other fat sources and incorporating them into your feed mill, it may be more economical to utilize full-fat soybeans instead of selling the beans and buying back soybean meal and oil. Because whole or full-fat soybeans have less protein and lysine than soybean meal (32 to 37 percent protein and 2.1 to 2.4 percent lysine), it is necessary to add 20 to 25 percent more whole soybeans to have a similar lysine level to soybean meal in the diet. At the same time, this will supply approximately 3 percent more fat to the diet which will improve feed efficiency approximately 3 to 5 percent.	90
Sucrose	• Very palatable • Very digestible • Increases feed intake	25
Sunflower meal	• High fiber concentration (22 to 24 percent) • Should be utilized in limited quantities in swine diets • Relatively low in lysine • High in sulfur-containing amino acids in comparison to soybean meal Sunflower meal is produced by extraction of the oil from sunflower seeds. Sunflower meal containing high levels of oil will produce soft pork. Only dehulled sunflower meal should be used in diets fed to swine.	50
Triticale	• High protein and lysine content com Large variation in nutrient content between varieties • Some varieties have anti-nutritional factors and poor palatabilitymmmnnnn • Feed refusal has been observed Triticale is a small, synthetic grain produced by crossing durum wheat with rye. Triticale varieties typically contain the combination of the high crude protein and digestible energy of wheat and the hardiness, disease resistance and protein quality of rye. Research has shown considerable variation among triticale varieties in agronomic traits, ergot susceptibility and nutrient composition. Limited triticale feeding research has been done with starter diets. Iowa State University recommends including it at a maximum of 25 percent in starter pig diets. A limit of 25 percent of the total diet is suggested for breeding stock. Ergot-infested triticale should not be fed to the breeding herd and triticale with more than 0.1 percent ergot should not be fed to growing-finishing swine without diluting it with other grains. Screening has allowed the selection and development of triticale varieties with low ergot susceptibility. In some studies, growing and finishing pigs fed triticale performed similarly to pigs fed corn-based and barley-based diets when they were balanced for lysine concentration with soybean meal or synthetic lysine.	100

Feed Ingredient	Factors Affecting Inclusion Rate	Ease of Storage/ Handling[1]
Wheat, hard red spring	• Lower in energy than corn • Similar to corn in digestibility and palatability • Higher protein but similar lysine to corn • Dusty and unpalatable if ground too finely Wheat can be used as the sole cereal grain in growing and finishing swine diets. It is recommended that wheat occupy no more than 85 to 90 percent of the diet for the breeding herd and 45 percent of small pig diets. From both grain production and animal feed perspectives, hard red winter and soft red winter are best suited for the Corn Belt. From an animal feed perspective, there are few differences between red or white wheats. Slight differences between hard and soft wheats. Hard wheat tends to have more protein, a higher content of essential amino acids (though a slightly less desirable profile), and less energy than soft wheat. However, feeding trials of soft and hard wheat have generally found equal performance in growing-finishing pig diets. Wheat should be sampled and analyzed by proximate analysis for moisture, crude fat, crude protein, and crude fiber. It also is recommended to analyze a sample for available lysine and phosphorus.	100
Wheat, soft white winter	• Higher in energy than corn • Similar to corn in digestibility, palatability and protein • Dusty and unpalatable if ground too finely See previous discussion.	100
Wheat bran	• Variable protein concentration • High fiber • Low energy • Low digestibility • Acts as a laxative	60
Wheat middlings and shorts	• Contain higher levels of fiber, protein, and minerals than the parent grain • Reduced amounts of starch and energy • Product variability is a concern and should be monitored Wheat middlings can be included in diets fed to growing finishing pigs and sow in up to 20 percent without impacting animal performance. Because of the high fiber concentration, inclusion in nursery diets should be limited to less than 10 percent.	80
Whey, dried or liquid	• Good quality protein • Dry product can be expensive bu attractive in weanling pig diets. • Feeding liquid whey increases manure volume by 2 to 3 times	5

[1] Relative ease of storage and handling compared to corn grain: 0 most difficult, 100 least difficult.

Nutrient Variability

Nutrient variability refers to the variation in nutrient concentration of different samples of a given ingredient. Many alternative feeds, such as bakery waste, are extremely variable in their nutrient content. This variability makes these feeds more difficult to use and ensure that the ration is properly balanced. Testing of repeated samples can be useful in assessing nutrient variability in a given feed ingredient. A relatively low inclusion rate also will reduce the risk of impairing performance of pigs fed such diets.

Stability

Stability is the extent to which a nutrient or feed ingredient will remain intact in its original form. For example, vegetable oils that are not stabilized with an antioxidant will go rancid quickly. Rancid oils are very unpalatable and compromise feed intake.

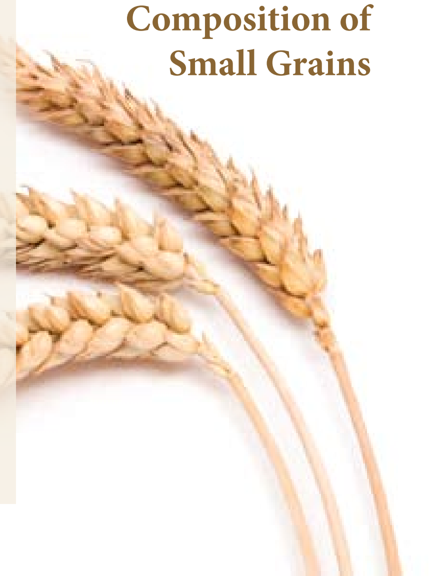
Small Grains for Swine

Small grains, such as barley, oats, rye, triticale and wheat can be useful feedstuffs in swine feeding programs. In many instances, pigs fed well-balanced small grain-based diets can perform as well as those fed corn-based diets. Nutritionally, small grains are similar to corn in some aspects, but there are differences depending on the grain. Small grains are higher in crude protein than corn and, more importantly, they are higher in lysine, the first limiting amino acid in cereal grain based swine diets. Testing for lysine concentration is important because improper protein supplementation is a major cause of problems when feeding small grains. Small grains are also higher in digestible phosphorus than corn, but tend to be lower in energy concentration. When viewed in the context of an integrated crop and livestock system, several additional attributes also make small grains attractive. Addition of an extra crop to the corn-soybean rotation typical of the U.S. Corn Belt can reduce costs, improve distribution of labor and equipment, improve yields of corn and soybeans, provide better cash flow, and reduce weather risks. Lengthening the time between the same crops on the same ground can decrease the prevalence of some pests, most notably soybean cyst nematode and corn rootworm. Small grains also provide environmental benefits, such as erosion control and improved nutrient recycling. Proper grain testing and diet formulation are important aspects of maximizing the performance of small grains as swine feed. Growing and harvesting conditions can greatly influence the nutritional composition of small grains even within the same variety.

Nutrient Composition of Small Grains

Small grains contain more crude protein than corn and greater levels of several essential amino acids, including lysine, threonine, and tryptophan (See Table 1). The higher lysine concentration in small grains is especially important since lysine is the first limiting amino acid in many swine diets. Balancing the diet on the basis of lysine content usually provides adequate levels of the other essential amino acids. Compared to corn, small grains contain 30 to 50 percent more lysine, which reduces the need for soybean meal in small grain-based finishing diets by about 100 lb/ton. This increases the feed value of small grains relative to corn by 5 to 7 percent. Balancing a diet on crude protein alone is often ineffective because the amount of lysine relative to protein varies among small grains and corn. If lysine concentration is unknown, substituting small grains for corn on an equal weight basis would be a conservative approach for constituting swine diets.

The phosphorus (P) in small grains is more available to swine than that in corn, which provides both economic and environmental benefits. However, much of the P is chemically bound within phytate and since pigs lack the enzymes needed to remove P from phytate, inorganic P must be added to the diet to meet the pig's requirement for this mineral. Dicalcium phosphate, the most common P source, is an expensive ingredient. Feeding grains (with more available P) reduces the amount of inorganic P



Nutrient Composition of Small Grains *(cont.)*

supplementation in the diet, which minimizes negative environmental impacts connected with excessive P in swine manure.

Since the P in small grains is more available than that in corn, there may be up to 30 percent less P secreted by animals fed small grains. Phosphorus availability is 10 to 15 percent in corn, 20 to 30 percent in barley and oats and 45 to 50 percent in triticale and wheat.

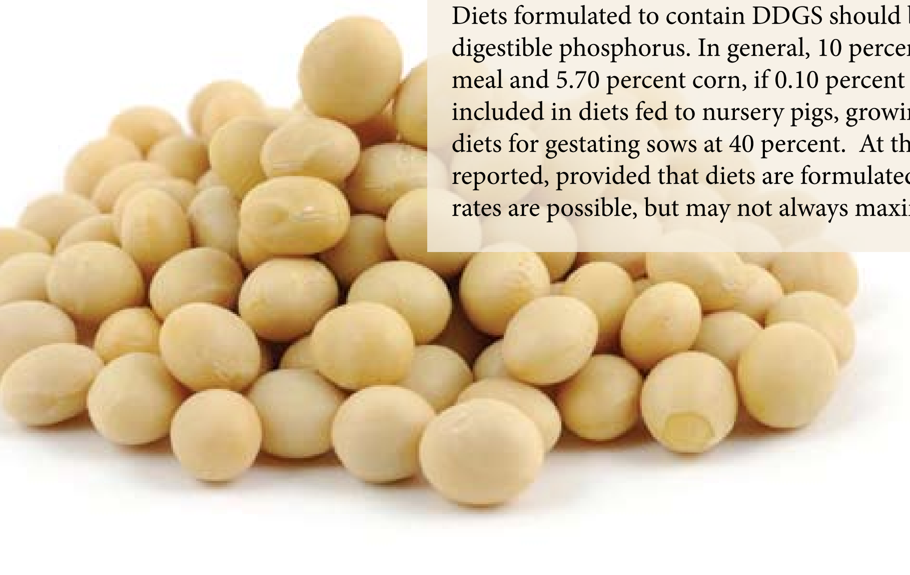
Small grains are lower in fat, higher in fiber, and typically contain less metabolizable energy than corn. Rye, triticale, and wheat contain 5 to 10 percent less energy than corn, but these differences do not appear to have negative effects on average daily gains when fed in finishing diets. In many studies, these grains have successfully replaced 100 percent of the corn used in control diets. The lower energy has affected feed efficiency in some instances because pigs on small grain diets tend to eat more than pigs on corn-based diets. When palatable, pigs generally consume higher amounts of small grains to meet their energy requirements. Barley and oats have higher fiber content than other small grains because the kernels are encased in a hull. The higher fiber content of barley does not appear to negatively affect gains in growing-finishing swine if plump, high-test weight grain is fed. However, high fiber content lowers oats' feed value to about 80 percent of that of corn. Lower energy limits the use of oats to only a portion of swine diets, but the high fiber can be useful for adding bulk to the diets of gestating sows. Barley and oats also have relatively high heat increment content. Heat increment is the increase in heat production from digestion of feed. High heat increment of a feedstuff can help keep an animal warm in cold environments, hence feeding oats and barley during the winter may be advantageous. However, in hot conditions, feeding oats and barley may decrease feed intake.

DDGS for Swine

Corn distillers dried grains with solubles (DDGS) are produced from the ethanol industry and are available for inclusion in diets fed to swine. During recent years, several research projects have been completed to investigate the feeding value of DDGS in diets fed to swine. Crude nutrient concentrations, energy and nutrient digestibility values, and effects of including DDGS in diets fed to different categories of swine have been investigated.

The concentration of energy in DDGS is greater than in corn, but because of a lower digestibility of energy in DDGS than in corn, there is no difference in the concentration of digestible and metabolizable energy between both ingredients. The apparent and standardized ileal digestibility of amino acids in DDGS does vary among sources but, with the exception of lysine, the variability is no greater than what has been reported for other feed ingredients. Lysine in DDGS may be damaged if excessive heating is used during the drying process, which in turn leads to a low digestibility of lysine. To exclude heat damaged products from swine feeding, it is recommended that producers calculate the lysine to crude protein ratio and only use DDGS if this ratio is greater than 2.80 percent. The digestibility of phosphorus in DDGS is approximately 59 percent, greater than in corn. Therefore, if DDGS is included in the diet, less inorganic phosphorus is needed and less phosphorus will be excreted in the manure.

Diets formulated to contain DDGS should be formulated on the basis of digestible amino acids and digestible phosphorus. In general, 10 percent DDGS can replace approximately 4.25 percent soybean meal and 5.70 percent corn, if 0.10 percent crystalline lysine is included in the diet. DDGS can be included in diets fed to nursery pigs, growing finishing pigs, and sows in amounts of 20 percent and in diets for gestating sows at 40 percent. At these inclusion rates, excellent performance of pigs has been reported, provided that diets are formulated on the basis of digestible amino acids. Greater inclusion rates are possible, but may not always maximize pig performance.



Field Peas for Swine

Field peas (*Pisum sativum L.*) have a nutrient profile that is intermediate between corn and soybean meal. The digestibility of most nutrients in field peas is similar to that in soybean meal, and the concentration of digestible energy in field peas is similar to that in corn. Although the digestibility of most nutrients may be improved by thermal treatment, field peas are usually fed to swine without prior heat treatment. Pigs tolerate field peas well and the palatability of diets containing field peas is not different from diets containing only corn and soybean meal.

Recent research with U.S.-grown field peas indicates that field peas may be included in diets fed to nursery pigs from two weeks post-weaning at an inclusion level of 15 to 20 percent. At this concentration, no negative effects on pig performance have been reported but research is needed to determine if higher inclusion levels may be used.

In diets fed to growing and finishing pigs, field peas may be included at levels sufficient to replace all of the protein supplied by soybean meal in the diets. The inclusion of field peas does not influence feed intake, average daily gain or the gain to feed ratio. Lower carcass drip losses and a more desirable color of the longissimus muscle have been reported for pigs fed diets containing field peas. The palatability of pork chops and ground pork patties are not changed by the inclusion of field peas in the diets.

Limited research has been conducted in the United States on the use of field peas to feed sows. However, based on data from studies conducted in Europe, field peas may be included in diets fed to gestating and lactating sows at levels of up to 24 percent.

Based on the current body of research, it is recommended that if field peas are competitively priced, they may be included in diets fed to all categories of swine. The price that can be paid for field peas depends on the price of both corn and soybean meal.

Further Resources and References

For more information, consult the following resources:

http://www.pork.org/PorkScience/NutritionalEfficiency.aspx?c=Home

http://www.porkgateway.com

This document was adapted from:

Feeding Small Grains to Swine, Iowa State University Extension, Online. http://www.extension.iastate.edu/Publications/PM1994.pdf

Murphy, J. Comparative Feed Values of Swine. Ontario Ministry of Agriculture, Food and Rural Affairs. Online. http://www.omafra.gov.on.ca/english/livestock/swine/facts/03-003.htm

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Thacker, P.A. and Kirkwood, R.N. Non-traditional Feed Sources for Use in Swine Production. Butterworth. Stoneham, Mass. 1990.

Murphy, J. Nutrient Testing. Ontario Ministry of Agriculture, Food and Rural Affairs. Online. http://www.omafra.gov.on.ca/english/livestock/swine/facts/03-007.htm

H. H. Stein. Distillers dried grains with solubles (DDGS) in diets fed to swine. Online: http://www.livestocktrail.uiuc.edu/porknet/paperDisplay.cfm?ContentID=9747

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