Alternative Feed Ingredients for Swine Rations

Introduction

Increasing feed grain and supplement costs, along with the potential for feed grain inventories to be completely depleted due to increased demand, are significant issues for producers in the pork industry. Feed costs have historically represented 65 percent-75 percent of the variable costs of swine production and are even more now for many producers. 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 ration 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 ration. Grains such as corn, barley, wheat and oats have traditionally supplied energy, while protein has come from meals produced from oilseeds such as soybeans

Price relationships vary greatly depending on seasonal variability, global and local markets. Pork producers must be able to evaluate the cost effectiveness and nutritional value of various feed ingredients in order to supply a nutritionally-balanced diet at a minimal cost.

Least-cost computer ration formulation programs are available to design rations that meet minimal nutritional requirements for the least cost. Feed manufacturers and producers should use these programs effectively to purchase and maintain inventories of ingredients. Many producers do not have the storage or processing facilities to include a large number of ingredients in the ration.

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

Many of the by-products from these processes can readily substitute for a portion of the energy or protein supply 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 since most feeds cannot be directly compared due to nutrient variability. As a result, relative values are often used for comparison purposes. However, note that the ultimate cost of any ration change must also 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 feeds should be primarily based on their actual nutrient contribution to the ration with regard to digestibility and cost. Historically, rations were least cost balanced based on protein levels because protein was the most expensive primary ingredient. 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 standard energy and protein supplying ingredients delivered to the farm. Table 1, Nutrient Composition and Suggested Maximum Inclusion Rates of Alternative Feed Ingredients for Swine, lists relative values of feeds when 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 that are listed. 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.

Table 1. Nutrient Composition and Suggested Maximum Inclusion

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
** = Rates up to and including the maximum can be used

Protein Quality

Protein quality refers to the amino acid content of the feed ingredient. Since lysine is the most limiting essential amino acid in corn-soybean meal based rations, it is important to consider lysine when valuing replacement feeds. For example, corn gluten and wheat contain a high level of protein relative to the amount of lysine. If a ration was prepared with these ingredients based solely on the protein concentration, the pigs would not be provided with sufficient lysine to support optimum performance. As a result, rations for swine should be balanced according to the level of lysine instead of crude protein.

Nutrient Availability (Digestibility)

Nutrient availability, or digestibility, is the extent to which a nutrient can be used by a pig. A feed such as alfalfa meal may be relatively high in protein but this protein is not available to the pig due to the high fiber content of the feed.

Anti-Nutritional Factor

Anti-nutritional factors are factors in a feed ingredient that interfere with nutrient digestibility. These may include trypsin inhibitors, tannins, lectins or glucosinolates. 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 pig 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, Factors Affecting Inclusion Rate of Alternative Feed Ingredients for Swine, lists specific feed ingredients and the corresponding factors that will limit their inclusion in a swine ration.

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

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 is fed to nursery or grower pigs or lactating sows due to excess crude fiber and low energy concentration. Limited levels of alfalfa meal could be fed to finishing pigs. Alfalfa meal is best suited for gestating sow rations and up to 60 percent of the diet could 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 to corn.	25
Barley	• Higher fiber • Lower digestibility than corn • Test weight and nutrient profile vary more than corn. While millions of pigs are fed annually on barley-based diets, there is great	100

	variability in the types of barley used for swine feeding programs. Barley can be two-rowed or six-rowed and hulled or hulless. These differences between barley types can equate to 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 since feed intake is usually not a limiting factor and pigs are able to perform as well as on corn-based diets. Performance is comparable to corn based diets. Even though the barley-based diets are lower in energy than corn-based diets, pigs are able to compensate by eating more. They will simply eat enough to meet their energy requirements. Even so, producers may find it advantageous to use barley in combination with higher energy grains, such as corn or wheat. Barley can also be used as the sole cereal grain in sow diets during gestation. However, low energy density suggests limiting the use of barley to 85 percent of the cereal grain in lactating sow and 25 percent in weanling pig diets unless it is pelleted. Producers should monitor test weights closely because barley can vary significantly based on variety and growing conditions (in both test weight and nutritional profile).	
Beans, cull	• Significant anti-nutritional factors - must be heat treated to feed to pigs • Extrusion or steaming is the most effective heat treatment • Low in palatability particularly in nursery and growers.	80
Beet Pulp, dried	• High fiber content • Low digestibility • Acts as a laxative. Dried beet pulp is a palatable alternative to grain, particularly for finish pigs and gestating sows. Pig performance and carcass quality is usually not negatively affected in rations with up to 20 percent dried 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 • Less palatable to younger pigs • Anti-nutritional factors. Canola meal is the by-product of vegetable oil processing from canola. Because it is well adapted to cool season growing conditions, canola is produced primarily in Canada and the northern states. Its oil contains a high level of unsaturated fats, and production is expanding throughout the United States. Canola meal averages between 35 and 40 percent crude protein and has less lysine but more sulfur-containing amino acids than soybean meal. Some older varieties of canola (rapeseed) contain high levels of a toxic compound, glucosinolate, which effects thyroid functioning. However, new cultivars of low-glucosinolate rapeseed (< 1 mg/g) have been developed and are commonly referred to as canola meal to	90

	distinguish it from the older varieties of high-glucosinolate rapeseed. It is not advisable to feed meals from the cultivars of high glucosinolate rapeseed. Reduced palatability, high fiber, and low digestible energy have been causes of slightly poorer performance of pigs fed diets containing canola meal.	
Corn	• High energy • Low lysine • High digestibility • Palatable	100
Corn, high moisture	• Higher moisture content (28 percent vs 15 percent for dry) • 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
Corn Distillers, dried grains with solubles	• High fiber • High fat • Low lysine When fed to livestock, the impact of DDGS on growth performance has been inconsistent due to product variability in drying methods, levels of residual sugars, or grain quality with respect to batch-to-batch variation. It has been theorized that variation in DDGS palatability between sources can influence performance. Dried distillers grain with solubles also has been shown to impact carcass quality and characteristics when fed to grow-finish pigs. Specifically, feeding DDGS has been shown to reduce percent yield and carcass weight, increase carcass fat softness, and reduce belly firmness.	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 content • Unpalatable • Bulky	50
Corn Gluten Meal	• Low lysine • Low fiber content • 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, or a mixture thereof. Corn hominy feed has feeding characteristics similar to corn grain and is very palatable.	80
Faba beans	• High fiber content	80

	• Anti-nutritional factors in some varieties • Low vitamin content	
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
Fish Meal	• Variable nutrient content depending on the source • High in lysine, methionine, calcium and phosphorus • High inclusion can result in fishy flavor in pork. Fish meal is traditionally recognized as a digestible protein source with a high content of amino acids that help 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	• Because flax is high in oil (35 percent) it is considered an excellent energy as well as protein (37 percent) in livestock rations. • Flax oil are used to increase energy density, reduce dust, eliminate fines and to aid in processing, such as pelleting. • Flax is rich in omega-3 fatty acids and lignans.	35
Lupins, sweet white	• High fiber content • 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 soybean meal	50
Meat and Bone Meal	• Excellent source of calcium and phosphorus. • Often very low in tryptophan and methionine. Because there is considerable variation in the type and quality of the raw materials used, there is potential for greater variation in the quality of meat and bone meal. Excessive heating during the processing of meat and bone meal may also decrease its digestibility and value as a protein source.	50
Milk, skim or whole (dried)	• High quality protein • Very palatable • Highly digestible • High lysine content • Expensive	5

Oats	• High fiber • Low energy. Oats can be an effective addition to swine diets, but there are limits on the amount that can be fed. Although oats are very palatable, they have more fiber content and lower energy density relative to corn and other small grains. The high crude fiber content 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 5 percent of the diet. However, high-test weight oats (greater than 36 lb/bu) can be used for up to 5 percent of the diet for weanling pigs and 15 percent for lactating sows. Oats can compose up to 20 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 problems common in recently weaned and small feeder pigs. Oats can also 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 routinely in swine diets.	100
Peas	• Good source of lysine • Relatively low in methionine and tryptophan. • Relatively high concentration of energy because of the high concentration of starch. Like raw soybeans, field peas contain the anti-nutritional factor, trypsin inhibitor. The trypsin inhibitor concentration can be deactivated by heating, but it is usually in low enough concentrations not to worry about in diet formulation.	100
Potato Chips	• High energy • Contain considerable vegetable fat taken up in cooking	20
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 is most commonly grown for bread and whiskey production with a small amount fed to livestock. 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. If rye is to be included in the	100

	diet of sows it must be ergot-free.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. Dustiness may be a problem with rye. A coarsely ground meal or the addition of fat or vegetable oil will reduce the problem. 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.	
Sorghum	• High energy • Low lysine • High digestibility • Palatable. Often economical compared to corn in regional areas where grown. Can be used to replace all of cereal grain portion of the diet with minimal impacts on performance.	100
Soybean Hulls	• High fiber • Low energy feed Availability in many areas of the United States makes their use favorable, especially in sow diets. The nutrient composition can vary form plant to plant, so nutrient analysis should be conducted.	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
Soybeans, roasted	• If properly done, on-farm processing by roasting or extruding raw soybeans results in excellent sources of protein. On-farm roasting or extruding yield “full-fat” soybeans, which, in some instances, are a relatively low-cost means 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 than soybean meal to have a similar lysine level in the diet. At the same time, this will supply approximately 3 percent added 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 content (22 to 24 percent)	50

	• Should be utilized in limited quantities in swine diets • Relatively low in lysine, yet 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 because of the oil's unsaturated fatty acid content.	
Triticale	• High protein and lysine content compared to corn • Large variation in nutrient content between varieties • Some varieties have anti-nutritional factors and poor palatability. Triticale is a synthetic small 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. In most production environments, triticale yields are superior to both wheat and rye making it a practical and economical feedstuff. In studies from Florida, Georgia, North Carolina, and Canada, 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. Testing has shown considerable variation among triticale varieties in agronomic traits, ergot susceptibility and nutrient composition. Ergot-infested triticale should not be fed to the breeding herd and triticale with ergot above 0.1 percent 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. Although widely available, forage triticale varieties generally make poor choices for grain production. Older varieties may contain levels of trypsin and chymotrypsin inhibitors. Most recently developed varieties have acceptable levels of these antinutritional factors. Feed refusal has been observed in a few swine feeding trials with triticale. Swine producers are advised to try triticale diets with small groups of pigs before committing to unknown sources or varieties. Limited triticale feeding research has been done on starter diets. Currently, Iowa State University recommends including triticale at a maximum of 25 percent of starter pig diets. Until more research is conducted to determine the nutritive value of triticale for breeding stock, a limit of 25 percent of the total diet is suggested.	100
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 is grown primarily for human food and used in livestock diets only when it is economical. When viewed in the context of cash grain markets, wheat appears to be an expensive feed grain in the Corn Belt. It often brings a substantially higher price per bushel than corn and most wheat is produced outside the region, which makes transportation costs a deterrent to its use. However, wheat can have a positive role in integrated crop-livestock system when it is fed on or near the farm where it is produced. When viewed within this perspective, wheat becomes a much more desirable option in the Corn Belt. 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	100

	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 is also recommended to analyze a sample for available lysine and phosphorus.	
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 content • 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	80
Whey, dried or liquid	• Good quality protein • Dry product can be expensive • 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 content 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.

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 content. 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 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 ate 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.

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:

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