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pork industry handbook

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Dietary Energy for Swine

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Pigs require energy to maintain normal body processes, grow, and reproduce. Feeds supplying energy are major components of all swine diets, and the quantity of diet voluntarily consumed by pigs is related to its energy content. Carbohydrates from cereal grains are the most abundant energy source in swine diets. Fats and oils contain more energy than carbohydrates per unit weight but are included in the diet to a lesser extent. Amino acids, or protein, may serve as an energy source if included in the diets in excess of the requirement for protein synthesis.

The value of a feedstuff is based on several factors: palatability (how well an animal will consume the material), availability of energy and its contribution of other nutrients (protein or amino acids, vitamins, and minerals). Selection of ingredients depends on the cost of the ingredient and its value as a source of energy and other nutrients for the pig.

Measurement of Energy

To make sound decisions when selecting feed ingredients, it is desirable to have an understanding of the system by which feedstuffs are rated for energy content and the use of these ratings toward meeting the energy requirements of the pig for growth or reproduction. The gross energy (GE) of a feed ingredient is defined as the heat produced when a substance is burned. It is expressed as calories per unit weight. A calorie is the amount of heat required to raise the temperature of one gram of water from 14.5 to 15.5 degrees C. A kilocalorie (kcal) is 1,000 calories, and a megacalorie (Mcal) is a million calories.

Not all of the feed consumed is digested and absorbed. Some energy is lost in the fecal material (Figure 1). Thus, GE is a poor estimate of energy for the pig. The amount of energy remaining after subtracting the fecal energy loss from total energy intake is designated as apparent digestible energy (DE). The difference between GE and DE may be large. The greater the digestibility of energy (DE/GE), the greater its value as a source of energy to the animal. DE is a more meaningful measure for livestock producers than GE.

Metabolized energy (ME) is the "usable" energy of a feed for the pig to live and grow and is obtained by subtracting the urinary energy loss from the DE. In most cases, metabolizable energy of complete swine diets is approximately 96% of the digestible energy content, so the conversion from DE to ME can be easily made.

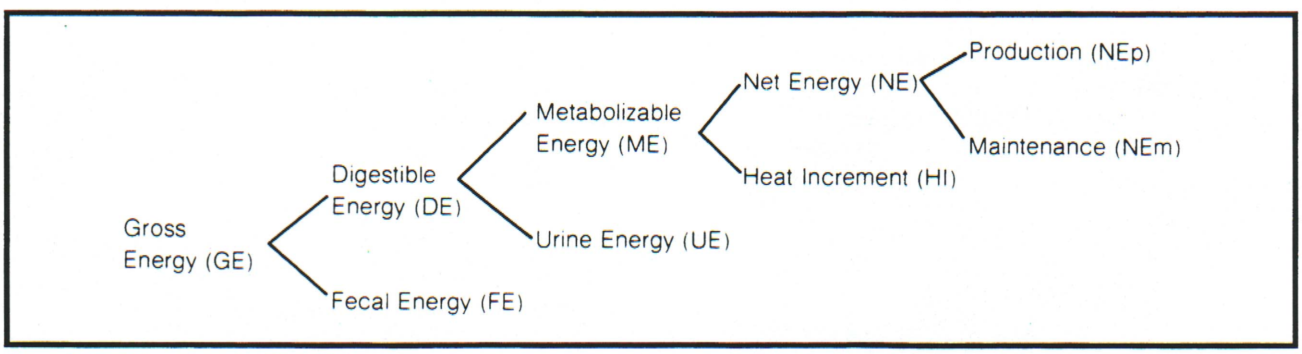

Figure 1. Partition of energy in nutrition.

Major Revision, destroy old 10/00, 500, KMF/CW, $1, for sale only

Some energy is released as heat as a result of inefficiencies in the metabolism of nutrients. This is called the heat increment (HI). It is used only to keep the animal warm and heat increment produced beyond that needed to maintain body temperature is lost. The remaining energy, called net energy (NE), is used for maintenance (NEm) and production (NEp). Determination of NE values requires measurement of heat production or energy gain and an estimate of maintenance requirements. Special equipment is required for the determination of NE content of feed ingredients. Therefore, DE and ME are currently the most widely used measures to classify the energy content of feedstuffs.

Major Energy Sources

Cereal Grains

The basic energy sources for swine are the cereal grains: corn, sorghum grain (milo), barley, wheat, oats, and their by-products. Cereal grains are high in carbohydrates (starch), palatable, and highly digestible. Usually they contain less lysine and other amino acids, minerals, and vitamins than swine require. The diets therefore must be supplemented with other feeds to increase these nutrients to recommended levels.

Grain by-products have many characteristics of their original source but tend to be bulkier and have less metabolizable energy. Although their protein content is usually increased, the protein quality often is poor.

Corn contains less protein but more energy than the other cereals. Like all cereals, variety, growth conditions, method of harvesting, and storage influence the composition of corn. Because of its abundance and high energy digestibility, corn is used as the base grain for comparing the nutritive value of other cereal grains.

Sorghum grain is similar in quality to corn and can completely replace corn in swine diets. Its energy value is 92% to 94% of the value of corn except for some bird-resistant varieties which may be only 80% to 90% of the value of corn. Grinding is recommended because the grain is rather small and hard.

Barley contains more protein and fiber than corn. High quality barley has 105% to 113% of the nutrient value of corn, but it may be less palatable. Wheat is equal to corn in feeding value and is very palatable when it is medium to coarsely ground in complete diets. Wheat can completely replace corn in swine diets. Oats contain more lysine than corn, but its nutrient value in swine diets is only 90% of corn because of its higher fiber and lower energy content.

Fats and Oils

Fats and oils contain about 2.25 times more metabolizable energy per unit of weight compared to carbohydrates in cereal grains, but they are more expensive. Fats are available commercially in products such as choice white grease, bleachable fancy tallow, prime tallow, yellow grease, hydrogenated vegetable fat, corn oil, soybean oil and various dry fat products that combine fat a with a dry carrier. Fat sources should be protected from rancidity by an antioxidant. Vegetable oils are generally higher in DE and ME than animal fats. Furthermore, very young pigs do not utilize the harder animal fats as well as vegetable oils, but vegetable oils and the dry fat products tend to be more expensive than animal fats.

Supplemental fat is difficult to add to the diet using on-farm mixing facilities, especially in cold weather. Most fat is handled in a liquid form, often in a special tank requiring supplemental heat during colder weather to keep it in a liquid form. Feed containing added fat is somewhat sticky and tends to bridge in bulk bins and feeders, tends to "oil out" of paper bags, and reduces pellet hardness. These problems increase as the fat level increases and become severe when more than 6% added fat is included in the diet. Fat changes the physical characteristics of a swine feed, reduces dustiness, and improves the air quality in swine buildings.

Certain biological effects can also be expected when fat is added to diets of starting, growing, and finishing pigs. These include: improved palatability, reduced feed consumption and improved feed efficiency due to the increased energy density, a slight increase in growth rate, and increased carcass fatness at high fat levels. High levels of vegetable oils can cause a softening of carcass fat.

The response of the pig to fat may be more favorable in warm or hot environments than in cool environments. Fat has a lower heat increment than carbohydrates or proteins and is less likely to cause reduced energy intake during heat stress.

When fat is added to a swine diet, the amount of feed consumed usually decreases. However, the requirement of the pig for other nutrients remains relatively constant when expressed on a daily basis. Therefore, to maintain performance when fat is added to the diet, the concentration of other nutrients should be increased.

The decision to add fat is largely based on economics. If the value of the improvement in growing-finishing feed conversion is greater than the cost of adding fat, it is economical to use. Typically, adding 1% fat to the diet results in approximately 2% improvement in feed conversion. Fat is often added to the diet of early grower (40 to 80 lb) and lactation diets because energy intake is often limiting to support maximal performance.

When the piglet survival rate is below 85%, supplementing the sows' diet with fat during late gestation may improve survival rate. The added fat must provide at least 2.0 to 2.5 lb of fat to each sow within the two weeks prior to farrowing. This appears to be a response to fat and not to increased energy intake. The added fat increases the fat content of the colostrum and milk which is responsible for the increased survival rate. Adding fat to lactation diets increases voluntary ME consumption, but only slightly reduces the weight loss in the sows. It increases weaning weights of the litters due to increased fat in the milk. There is no evidence that added fat improves subsequent reproductive performance of sows.

Fiber Content

Some energy sources are relatively high in fiber and reduce gain and efficiency if fed at excessive levels. Pigs weighing 40 lb and heavier usually can tolerate up to 5% of a high-fiber ingredient, such as alfalfa, in their diet with minimal effects on performance. As pigs mature, more and more low energy-high fiber ingredients can be fed, especially to sows during gestation and post-weaning. High fiber feeds, such as wheat bran and beet pulp, may be useful in gestation and farrowing diets because of their laxative effects, but should constitute no more than 5% of a lactation diet because they increase the volume of feed needed to meet the sow's energy requirement.

Fiber has a high heat increment, and during cold stress this heat can be utilized to maintain body temperature. Therefore, there is a smaller difference in relative values between fibrous grains (such as barley or oats) and corn in cold weather. Conversely, in hot weather the high heat increment becomes a problem for the pigs' cooling ability and feeding fibrous feeds should be avoided.

Moisture Content

High-moisture grains contain less energy per unit of weight because of the increased water content. More units of high-moisture grain must be fed to get the same amount of dry matter intake. Studies with high-moisture grains fed in complete diets indicate similar performance to dried grain when efficiency is measured on a dry matter basis. However, free-choice feeding of grain and supplement often results in poorer efficiency. See PIH-73, "High Moisture Grains for Swine."

Grinding

With the exception of high-moisture corn, grinding improves feeding efficiency for all grains, especially high-fiber grains such as oats and barley. Finer grinding results in improved efficiency, although finely ground corn (less than 600 microns) may increase the incidence of gastric ulcers in finishing pigs and sows. Generally a grain particle size range between 600 and 800 microns is recommended as optimum. Fine grinding is most advantageous for pigs under 40 lb. Wheat is very palatable when it is medium to coarsely ground but high levels of finely ground wheat in diets have been associated with lowered palatability due to dustiness and pastiness of the meal. See PIH-71, "Physical Forms of Feed."

Table 1. Relative feeding values of energy sources [1].

Ingredient (air dry)	Digestible Energy kcal/lb	Metabolizable Energy kcal/lb	Net Energy kcal/lb	Relative feeding value vs. corn, %[2]	Maximum recommended percentage of complete diets[3]
Animal fat, stabilized	3734	3585	1900	130-155	8
Bakery waste, dried bakery product	1791	1682	1098	102-103	40
Barley (48 lb/bu)	1386	1323	1064	105-113	95
Beet pulp, dried	1302	1180	710	83-106	10
Brewers' grain, dried	995	891	740	107-157	40
Buckwheat	1284	1200	736	84-106	50
Corn, yellow	1602	1555	1089	100	95
Corn, yellow, high oil	1677	1610	1125	104-105	90
Emmer	1333	1280	750	78-86	20
Hominy feed	1525	1505	940	93-102	60
Lactose	1602	1500	1130	77-92	20
Millet (Proso)	1373	1341	952	88	85
Molasses, cane (77% DM)	948	910	435	32-37	5
Oat groats (dehulled oats)	1677	1575	1050	106-118	30
Oats, grain	1259	1232	800	82-94	90
Oats, grain, naked	1582	1550	982	100-113	30
Potatoes (22.7% DM)	385	370	250	25-27	80
Rice, grain	1115	1070	860	83-87	40
Rice, grain, polished and broken	1620	1523	1043	98-101	85
Rice bran	1409	1295	927	106-127	30
Rye	1486	1391	1045	103-111	25
Sorghum, grain	1536	1518	1025	92-94[4]	95
Soybean oil	3977	3450	2500	171-205	8
Spelt	1229	1180	700	72-80	40
Sugar (sucrose)	1725	1670	1255	86-103	5
Triticale	1509	1445	1100	108-116	85
Wheat bran	1100	1034	636	84-112	30
Wheat middlings	1398	1375	709	88-112	30
Wheat, hard red spring	1545	1477	875	90-100	95
Wheat, soft winter	1568	1502	1091	103-115	85
Whey, dried delactosed	1516	1450	1007	132-171	30
Whey, dried,	1384	1255	785	140-211	30

1 Based on an air-dry basis unless otherwise noted. High moisture feedstuffs must be converted to an air-dry equivalent of 88-90% dry matter to determine energy and substitution rates. Complete data on all ingredients are not available.

2 When fed at no more than maximum recommended percentages of complete diets. Relative values based on net energy, lysine and available phosphorus content using simultaneous equations. Example:

NE		Lysine		Avail. Phos.	Price
1089 X	+	0.26 Y	+	0.04 Z =	\$/cwt. corn
918 X	+	2.83 Y	+	0.16 Z =	\$/cwt. soybean meal, dehulled, solvent
0 X	+	0 Y	+	18.7 Z =	\$/cwt. dicalcium phosphate

Determine values for X, Y, and Z and multiply them times the NE (kcal/lb), % lysine, and % available phosphorus of ingredient in question and sum the values.

3 Higher levels may be fed although performance may decrease.

4 Some bird resistant sorghums are 80-90% vs. corn.

Pelleting

Pelleting a diet may increase gains by as much as 5%, and feed efficiency by 5% to 10%. A high-energy cereal such as corn or sorghum benefits less from pelleting than fibrous feeds like barley or oats. When a complete diet is purchased, pelleted diets may be more economical than meal diets. However, the advantage of pelleting probably will not offset the cost of hauling grain from the farm to a pelleter and back to the farm.

Relative Value

In selecting energy sources for swine diets, protein quality and content also should be considered. Because the amino acids lysine, tryptophan, threonine, and methionine can be limiting in swine diets, levels of these amino acids in cereal grains affect their overall value. Although sugar, molasses, and fats or oils are energy sources, they provide little or no protein to the diets.

The amount of feed per unit of gain is not the most important factor in swine nutrition. Cost per unit of gain is more important; therefore, it is necessary to use the mos economical feed sources available in swine diets. The relaive feeding values shown in Tables 1 and 2 can be used to determine which ingredient is most economical. For example, if corn costs 5.0 cents per pound, barley is worth about 5.5 cents per pound (5.0 cents x 110%). If barley can be purchased for less than this, it is a better buy.

Table 2. Relative feeding values of protein sources [1].

Ingredient (air dry)	Digestible Energy kcal/lb	Metabolizable Energy kcal/lb	Net Energy kcal/lb	Relative feeding value vs. SBM, % [2]	Maximum recommended percentage of complete diets [3]
Alfalfa meal, dehydrated, 17% CP	830	750	414	30-35	50[4]
Blood meal, spray	1528	1335	939	190-210	5
Blood plasma, spray dried	1760	11	26	200-215	8
Buttermilk, dry	1380	880	85-91	0	20[5]
Canola meal, solvent	1308	1200	732	72-74	5
Corn distillers dried grain w/solubles	1451	1282	939	45-50	10
Corn gluten feed	1356	1184	791	40-50	50[4]
Corn gluten meal, 60% CP	1916	1741	1046	55-65	5
Cottonseed meal, solvent	1168	1052	602	60-65	5
Feather meal	1356	1130	1023	75-85	3
Fish meal, anchovy	1465	1225	770	160-170	5
Fish meal, menhaden	1710	152	1061	170-175	10
Fish solubles, (51% DM) condensed	866	739	452	59-61	5
Linseed meal	1388	1232	836	55-60	5
Meat and bone meal	1106	1011	616	125-140	10
Meat meal (tankage)	1106	1011	616	150-160	10
Peanut meal, mech. ext.	1766	1618	1036	65-70	5
Poultry byproduct meal	1401	1300	884	120-130	5
Skim milk, dried	1805	1689	1073	105-110	20[5]
Soybean meal, dehulled, solvent	1671	1536	918	100	45[5]
Soybean meal, solvent	1583	1445	880	95-96	48[5]
Soybeans, full-fat, cooked	1787	1677	1309	90-95	60[5]
Sunflower meal, sol. ext., 27% CP	911	832	559	40-42	10
Yeast, dried brewers	1508	1375	943	115-118	3

[1] Based on an air-dry basis unless otherwise noted. High moisture feedstuffs must be converted to an air-dry equivalent of 88-90% dry matter to determine energy and substitution rates. Complete data on all ingredients are not available.

[2] When fed at no more than maximum recommended percentages of complete diets. Relative values based on net energy, lysine and available phosphorus content using simultaneous equations. Example:

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0 X	+	0 Y	+	18.7 Z	=	$/cwt. dicalcium phosphate

Determine values for X, Y, and Z and multiply them times the NE (kcal/lb), % lysine, and % available phosphorus of ingredient in question and sum the values.

[3] Higher levels may be fed although performance may decrease.

[4] Levels may be higher for gestating sows.

[5] Diets other than those fed in the nursery would normally contain lower levels.