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Dietary Energy for Swine  
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Cooperative Extension Service

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# pork industry handbook

Michigan State University Extension

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Pigs require energy to maintain normal body processes, to grow and to 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 to a lesser extent. Amino acids, or protein, may serve as an energy source if included in the diets in excess of animals' requirement for protein synthesis.

The value of a feedstuff is based on several factors: palatability (how well the material will be consumed by an animal), availability of energy and the feed's contribution of other nutrients (protein or amino acids, vitamins, minerals). Should a pork producer buy corn, wheat, or oats as a feed ingredient? This depends primarily on the cost of these ingredients and their value as sources of energy and other nutrients for the pig.

### Measurement of Energy

To make sound decisions in 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 for pigs' growth

and production. 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 (Fig. 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 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.

Metabolizable 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 represents approximately 95% of the digestible energy content, so the conversion from DE to ME can be made easily.

Some energy is released as heat as a result of inefficiencies in the metabolism of the nutrients. This is called the heat incre-

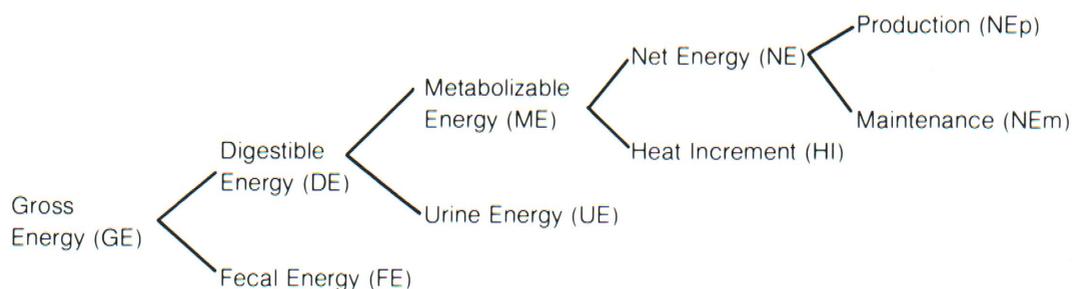


Figure 1. Partition of energy in nutrition.

ment (HI). It can be used only to keep the animal warm; heat increment produced beyond that needed to maintain body temperature is wasted. The remaining energy is called net energy (NE) and is used for maintenance (NEM) and production (NEP). Determination of NE values requires special equipment and/or animal feeding trials.

## 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 usually is increased, the protein quality often is rather poor.

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

Sorghum grain is similar in quality to corn and can completely replace corn in swine diets. Its energy value is about 95% 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 90% to 100% of the feeding 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 rations. Wheat can completely replace corn in swine diets.

Oats contain more protein than corn, but their value in swine diets is only 90% of corn because of their higher fiber and lower energy content.

### Fats and Oils

Fats and oils contain about 2.25 times as much metabolizable energy per pound as cereal grains, but they are more expensive. Fats are available commercially in products such as bleachable fancy tallow, prime tallow, yellow grease, hydrogenated vegetable fat and various dry fat products which include fat and a dry carrier. Fat sources should be protected from rancidity by an antioxidant. There do not appear to be major differences in dietary value among the fat sources, except for very young pigs which may not utilize the harder animal fats as well as softer vegetable fats. Vegetable oils and the dry fat products tend to be more expensive than animal fats.

Supplemental fat is difficult to mix in on-farm mixing facilities, especially in cold weather. Fat changes the physical characteristics of a swine feed. Feed containing added fat is somewhat sticky and therefore tends to bridge in bulk bins and feeders. It tends to "oil out" of paper bags and reduce pellet hardness. These problems increase as the fat level increases and become severe when the added fat exceeds 6% of the feed. Added fat reduces dustiness and therefore improves the environment in swine buildings.

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

Pigs' responses to fat may be greater in warm or hot environments than in cool environments. Fat has a lower heat increment than carbohydrates and proteins and is less likely to cause reduced feed intake during heat stress.

When fat is added to a swine diet, the amount of feed consumed usually decreases. However, animals' needs for other nutrients remain 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 an economic one. If improvement in growing-finishing swine performance more than offsets the cost of adding fat, it is economical. Typically, adding 1% fat to the diet results in approximately 2% better efficiency.

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 lb. to 2.5 lb. of fat to each sow 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 40 lb. and heavier usually can tolerate up to 5% of a high-fiber feed such as alfalfa in their diet without a noticeable effect on performance. As pigs mature, more and more low energy-high fiber feeds can be fed, especially to sows during gestation and post-weaning. 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.

Fiber has a high heat increment and during cold stress this heat can be utilized to maintain body temperature, thus, less is wasted. 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.

### Moisture Content

High-moisture grains contain less energy per pound of feed because of the water content. More pounds of high-moisture grain must be used to get the same amount of dry matter. Studies with high-moisture grains fed in complete diets indicate similar performance to dried grain when efficiency is measured on a dry matter basis. 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 or barley. Finer grinding usually results in improved efficiency, although finely ground corn increases the incidence of ulcers in finishing swine. Fine grinding is most advantageous for pigs under 40 lb. Wheat is very palatable when it is medium to coarsely ground in complete rations since high levels of finely ground wheat in diets has been associated with lowered palatability due to pastiness of the meal. See PIH-71, *Physical Forms of Feed*.

### Pelleting

Pelleting a diet may increase gains by 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 home again.

## Relative Value

In selecting energy sources for swine diets, also consider protein quality and content. Because the amino acids lysine, tryptophan, threonine and methionine can be limiting in swine diets, levels of these amino acids on 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 most economical feed sources available in swine diets. The relative 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 4.5 cents per pound (5.0 cents x 90%). If barley can be purchased for less than this, it is a better buy.

Table 1. Relative feeding values of energy sources<sup>1</sup>.

Ingredient (air dry)	Metabolizable energy kcal/lb.	Relative feeding value vs. corn, % <sup>2</sup>	Maximum recommended percent of complete diets <sup>3</sup>				Remarks
			Gestation	Lactation	Starter	Grow-finish	
Alfalfa meal dehydrated	775	70-80	50	5	0	5	Good source of B vitamins
Alfalfa meal sun-cured	800	60-70	50	5	0	5	Unpalatable to baby pigs
Animal fat stabilized	3585	185-210	10	6	5	10	High energy, reduces dust
Bakery surplus material	1650	95-110	40	40	20	40	High energy, variable salt content
Barley (48 lb/bu)	1380	90-100	80	80	25	85	Corn substitute, lower energy
Beet pulp, dried	1020	70-80	10	5	0	0	Bulky, high fiber, laxative
Brewers dried grains	1000	90-100	40	5	0	10	High fiber, B-vitamin source, low lysine
Buckwheat	1200	80-90	50	0	0	50	Not to light colored pigs outdoors
Corn yellow	1550	100	80	80	60	85	High energy, low lysine
Corn (high lysine)	1520	100-105	90	90	60	90	Lysine analysis recommended
Corn and cob meal	1300	80-90	70	0	0	0	Bulky, low energy
Corn distillers dried grains with solubles	1540	115-130	40	10	5	10	B-vitamin source, low lysine
Corn gluten feed	1285	74	90	5	5	25	Low lysine
Corn grits by-product (hominy)	1400	100-105	60	60	0	60	Subject to rancidity
Emmer	1140	80-90 <sup>4</sup>	20	0	0	0	
Sorghum grain (milo) <sup>4</sup>	1480	95-100 <sup>4</sup>	80	80	60	85	Low lysine
Millet (Proso)	1230	90-95	80	80	60	85	Low lysine
Molasses (77% D.M.)	1060	55-65	5	5	5	5	Low energy, partial grain substitute
Oats (36 lb/bu)	1240	85-95	80	5	0	20	Low energy, partial grain substitute
Oat groats	1550	115-125	0	0	20	0	Palatable
Potatoes (22% D.M.)	370	20-25	80	0	0	30	Must be cooked, low protein
Rice grain	1070	75	40	0	0	20	Low energy, low lysine
Rye	1300	90	20	0	0	25	Possible ergot toxicity, low palatability
Spelt	1180	85	40	0	0	25	Low energy, low lysine
Sugar	1383	70-80	0	0	5	0	High palatability, no protein
Triticale	1450	90-95	80	80	20	85	Possible ergot
Wheat, hard	1475	100-105	80	80	60	85	Low lysine
Wheat, soft	1500	90-95	80	80	60	85	Low lysine
Wheat, high protein	1500	100-105	80	80	60	85	Low lysine
Wheat bran	980	60-65	30	5	0	0	Bulky, high fiber, laxative
Wheat middlings	1340	125-140	30	5	0	10	Partial grain substitute
Wheat, dried	1405	135-145	5	5	20	5	High lactose content, variable content

<sup>1</sup>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.

<sup>2</sup>When fed at no more than maximum recommended % of complete diets. Relative values based on metabolizable energy, lysine and phosphorus content using simultaneous equations. Example:

ME	Lysine	Phosphorus	Price
1550X +	.024Y +	0.25Z =	\$/cwt. corn
1460X +	2.90Y +	0.60Z =	\$/cwt. soybean meal (44%)
0X +	0Y +	18.50Z =	\$/cwt. dicalcium phosphate

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

<sup>3</sup>Higher levels may be fed although performance may decrease.

<sup>4</sup>Some bird resistant sorghums are 80-90% vs. com.

Table 2. Relative feeding values of protein sources<sup>1</sup>.

Ingredient (air dry)	Metabolizable energy kcal/lb.	Relative feeding value vs. 44% soybean, % <sup>2</sup>	Maximum recommended percent of complete diets <sup>3</sup>				Remarks
			Gestation	Lactation	Starter	Grow-finish	
Blood meal, flash dried	1200	185-200	5	0	5	5	Low isoleucine, unpalatable
Buttermilk, dry	1400	75-85	0	5	20	5	Good amino acid balance
Canola meal (solvent)	1200	75-85	5	5	5	10	Toxic problem at high levels
Corn gluten meal	1395	40-60	5	5	0	5	Low lysine
Cottonseed meal, solvent	1150	65-75	5	5	0	5	Gossypol toxicity, low lysine
Distillers dried solubles (corn)	1180	65-70	5	5	5	5	B-vitamin source, low lysine
Feather meal, hydrolyzed	1000	60-70	3	3	0	3	Low lysine
Fish meal, anchovy	1120	140-165	5	5	5	5	Excellent amino acid balance
Fish meal, menhaden	1500	140-165	5	5	5	5	Excellent amino acid balance
Fish solubles (50% solids)	780	50-60	3	3	3	3	Excellent amino acid balance
Linseed meal	1280	55-65	5	5	5	5	Low lysine
Meat and bone meal	1035	95-110	10	5	5	5	Low lysine, tryptophan and methionine, good phosphorus
Peanut meal, expeller	1400	70-80	5	5	0	5	Low lysine
Skim milk, dried	1620	95-100	0	0	20	0	Excellent amino acid source, palatable
Sorghum gluten meal	1460	40-55	5	5	0	5	Low lysine
Soybeans, whole, cooked	1640	90-100	30	25	40	30	Similar to soybean meal, but may produce soft pork
Soybean meal, solvent	1460	100	25	20	35	22	Similar to soybean meal, dehulled
Soybean meal, solvent, dehulled	1535	110-112	22	18	30	20	Good amino acid balance with corn
Tankage (meat meal)	980	115-130	10	5	0	5	Low digestibility, unpalatable
Yeast, brewers dried	1400	100-105	3	3	3	3	Source of B-vitamins

<sup>1</sup>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.

<sup>2</sup>When fed at no more than maximum recommended % of complete diet. Relative values based on metabolizable energy, lysine and phosphorus content using simultaneous equations. Example:

ME	Lysine	Phosphorus	Price
1550X +	0.24Y +	0.25Z =	\$/cwt. corn
1460X +	2.90Y +	0.60Z =	\$/cwt. soybean meal (44%)
0X +	0Y +	18.50Z =	\$/cwt. dicalcium phosphate

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

<sup>3</sup>Higher levels may be fed although performance may decrease.