Extension Bulletin E-1065, Sept. 1984

pork industry handbook

COOPERATIVE EXTENSION SERVICE • MICHIGAN STATE UNIVERSITY

Energy for Swine

Authors
Palmer Holden, Iowa State University
Lowell Frobish, Clemson University
James Pettigrew, University of Minnesota

Reviewers
Herbert M. Barnes, Ohio State University
Bill G. Diggs, Mississippi State University

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 only if included in the diets in excess of animals' requirement for protein synthesis.

The value of a feedstuff is based on several factors besides its energy content. Among these are: acceptability (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 swine producer buy corn, wheat, or oats as a feed ingredient? This will depend primarily on the cost of these ingredients and their value as sources of energy and other nutrients for the pig.

Definition 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 their 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 1 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

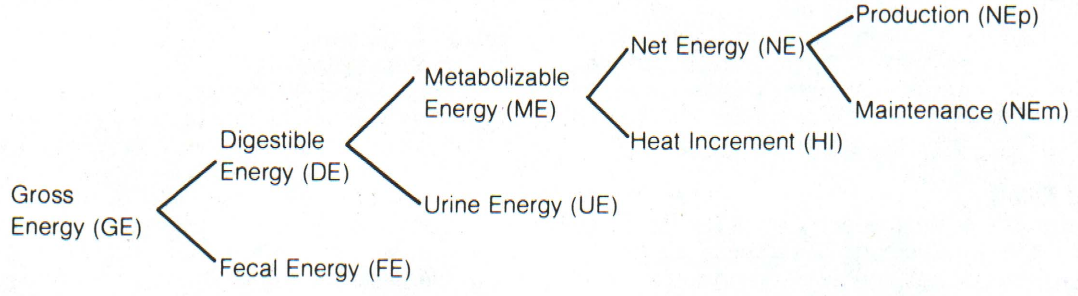

Figure 1. Partition of energy in nutrition.

Cooperative Extension Work in Agriculture and Home Economics, State of Indiana, Purdue University and U.S. Department of Agriculture cooperating. H. A. Wadsworth, Director, West Lafayette, IN. Issued in furtherance of the Acts of May 8 and June 30, 1914. It is the policy of the Cooperative Extension Service of Purdue University that all persons shall have equal opportunity and access to its programs and facilities without regard to race, color, sex, religion, national origin, age or handicap.

(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 easily can be made.

Some energy is released as heat as a result of inefficiencies in the metabolism of the nutrients. This is called the heat increment (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, grain sorghum (milo), barley, wheat, oats, and their by-products. Cereal grains are high in carbohydrates (starch), palatable, and highly digestible. They usually contain less lysine and other amino acids, minerals, and vitamins than swine require; therefore, the diets 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.

Grain sorghum is similar in quality to corn and can completely replace corn in swine diets. Its energy value is about 95% the value of corn except for some bird resistant varieties which may be only 80-90% the value of corn. Grinding is recommended since the grain is rather small and hard.

Barley contains more protein and fiber than corn. High quality barley has 90-100% of the feeding value of corn, but may be less palatable.

Wheat is equal to corn in feeding value and is very palatable. But because of its use in human diets, it may be too expensive to use 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. Oats are useful in farrowing diets because they are bulky and have a laxative effect.

Fats and Oils

Fats and oils contain about 2.25 times as much metabolizable energy per pound as cereal grains, but 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 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 also 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 reduces pellet hardness. These problems increase as the fat level increases and become severe when the added fat exceeds 6% of the feed. A level of 1 to 2% 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 will cause softening of carcass fat.

Pigs' response to fat may be greater in warm or hot environments than in thermoneutral or 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 decreases. However, animals' need 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 also should be increased.

The decision to add fat to swine diets is an economic one. If improvement in growing-finishing swine performance more than offsets the cost of adding fat, it is economical. Under most pricing conditions this occurs only during the summer.

When piglet survival rate is below average, supplementing 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 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 may increase weaning weights due to increased fat in the milk.

Return to estrus following weaning may be delayed if sows do not consume enough energy during lactation. Supplementing lactation diets with fat may hasten the return to estrus. This is particularly true if feed intake is inadequate in a very warm farrowing house.

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 can usually 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.

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

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 grains when efficiency is measured on a dry matter basis. Free choice feeding of grain and supplement often results in poorer efficiency.

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.

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

Ingredient (air dry)	Metabolizable energy kcal/lb.	Relative feeding value vs. corn,%[2]	Maximum recommended percent of complete diets[3]: Gestation	Lactation	Starter	Grow-finish	Remarks
Alfalfa meal (dehydrated)	1,050	75-85	50	10	0	5	Good source of B vitamins
Alfalfa meal (sun-cured)	890	60-70	50	10	0	5	Unpalatable to baby pigs
Animal fat (stabilized)	3,550	185-210	10	5	5	10	High energy, reduces dust
Bakery surplus material	1,650	95-110	40	40	20	40	High energy, variable salt content
Barley (48 lb./bu.)	1,275	90-100	80	80	25	85	Corn substitute, lower energy
Barley (West Coast)	1,330	95-100	80	80	25	85	Corn substitute, lower energy
Beet pulp, dried	1,020	70-80	10	10	0	0	Bulky, high fiber, laxative
Brewers' dried grains	1,000	90-100	40	10	0	10	High fiber, B-vitamin source, low lysine
Buckwheat	1,200	80-90					Bulky, high fiber, laxative
Corn (yellow)	1,500	100	80	80	60	85	High energy, low lysine
Corn (high lysine)	1,520	100-105	90	90	60	90	Lysine analysis recommended
Corn and cob meal	1,300	80-90	70	0	0	0	Bulky, low energy
Corn distillers' dried grains w/solubles	1,540	115-130	40	10	5	10	B-vitamin source, low lysine
Corn gluten feed	1,400						Low lysine
Corn grits by-product (hominy)	1,400	100-105	60	60	0	60	Subject to rancidity
Corn silage (25-30% D.M.)		20-30	90	0	0	0	Bulky, low energy, feed to mature animals only
Emmer	1,140	80-90					
French fry waste (48% D.M.)			20	0	0	20	Bulky, low energy
Grain sorghum (milo)	1,425	95-100[4]	80	80	60	85	Low lysine
Millet (Proso)	1,230	90-95	80	80	60	85	Low lysine
Molasses (77% D.M.)	1,060	55-65	5	5	5	5	Low energy, partial grain substitute
Oats (36 lb./bu.)	1,220	85-95	80	10	0	20	Low energy, partial grain substitute
Oats (high protein)		90-100	80	15	20	50	Low energy, partial grain substitute
Oat groats	1,500	115-125	0	0	20	0	Palatable
Potatoes (22% D.M.)	370	20-25	80	0	0	30	Should be cooked, low protein
Rice grain	1,070	75	40	15	0	20	Low energy, low lysine
Rye	1,300	90	20	20	0	25	Possible ergot toxicity, low palatability
Spelt	1,180	85	40	15	0	25	Low energy, low lysine
Sugar	1,383	70-80	0	0	5	0	High palatability, no protein
Triticale	1,450	90-95	80	80	20	85	Possible ergot
Wheat, hard	1,515	100-105	80	80	60	85	Low lysine
Wheat, soft	1,500	90-95	80	80	60	85	Low lysine
Wheat, high protein	1,500	100-105	80	80	60	85	Low lysine
Wheat bran	890	60-65	30	5	0	0	Bulky, high fiber, laxative
Wheat middlings	1,300	125-140	30	5	0	10	Partial grain substitute
Whey, dried	1,445	135-145	5	5	20	5	High lactose content, variable content

[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 % of complete diets. Relative values based on metabolizable energy, lysine and phosphorus content using simultaneous equations. Example:

ME		Lysine		Phosphorus		Price
1500X	+	0.25Y	+	0.25Z	=	$/cwt. corn
1465X	+	2.90Y	+	0.60Z	=	$/cwt. soybean meal (44%)
0X	+	0 Y	+	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.
[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 5% and feed efficiency from 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 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 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 2. Relative Feeding Values of Protein Sources[1]

Ingredient (air dry)	Metabolizable energy kcal/lb.	Relative feeding value vs. 44% soybean,%[2]	Maximum recommended percent of complete diets[3] Gestation	Lactation	Starter	Grow-finish	Remarks
Blood meal, flash dried	1,330	185-200	5	5	5	5	Low isoleucine
Buttermilk, dry	1,400	75-85	0	5	20	5	Good amino acid balance
Canola meal (solvent)	1,200	75-85	5	5	5	10	Toxic problem at high levels
Corn gluten meal	1,395	40-60	5	5	0	5	Low lysine
Cottonseed meal, solvent	1,150	65-75	5	5	0	5	Gossypol toxicity, low lysine
Distillers dried solubles (corn)	1,180	65-70	5	5	5	5	B-vitamin source, low lysine
Feather meal, hydrolyzed	1,000	60-70	3	3	0	3	Low lysine
Fish meal, anchovy	1,400	140-165	5	5	5	5	Excellent amino acid balance
Fish meal, menhaden	1,420	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	1,280	55-65	5	5	5	5	Low lysine
Meat & bone meal	1,100	95-110	10	5	5	5	Low lysine, tryptophan & methionine, good phosphorus
Peanut meal, expeller	1,400	70-80	5	5	0	5	Low lysine
Skim milk, dried	1,600	95-100	0	0	20	0	Excellent amino acid source, palatable
Sorghum gluten meal	1,460	40-55	5	5	0	5	Low lysine
Soybeans, whole cooked	1,700	90-100	30	25	40	30	Similar to soybean meal, but may produce soft pork
Soybean meal solvent	1,475	100	25	20	35	22	Same as soybean meal, dehulled
Soybean meal, solvent, dehulled	1,520	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	1,400	100-105	3	3	3	3	Source of B-vitamins

[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 % of complete diets. Relative values based on metabolizable energy, lysine and phosphorus content using simultaneous equations. Example:

ME		Lysine		Phosphorus		Price
1500X	+	0.25Y	+	0.25Z	=	$/cwt. corn
1465X	+	2.90Y	+	0.60Z	=	$/cwt. soybean meal (44%)
0X	+	0 Y	+	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.

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

MICHIGAN STATE UNIVERSITY
CES
COOPERATIVE EXTENSION SERVICE
0-15052

Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Gordon E. Guyer, Director, Cooperative Extension Service, Michigan State University, E. Lansing, MI 48824.

Revision 9:84-2M-UP, Price 25¢, Single copy free to Michigan residents.