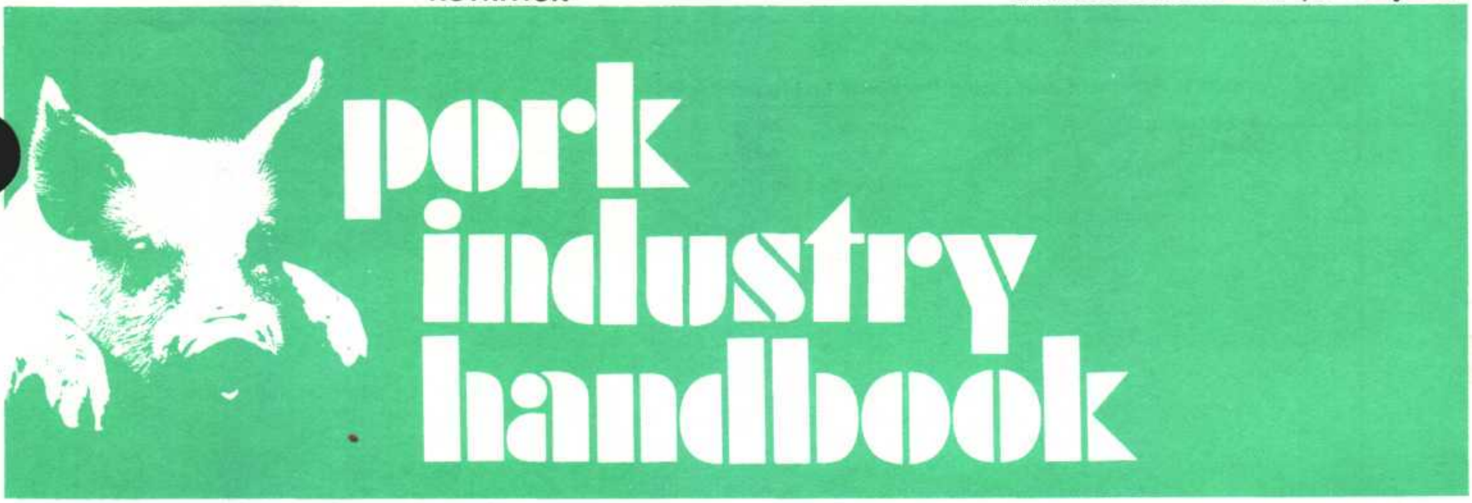
Fact Sheet 19.47.10
Extension Bulletin E-1464, January 1981



COOPERATIVE EXTENSION SERVICE • MICHIGAN STATE UNIVERSITY

Physical Forms of Feed—Feed Processing for Swine

Authors
Maynard Hogberg, Michigan State University
Don Mahan, Ohio State University and OARDC
Robert Seerley, University of Georgia

Reviewers
Keith Behnke, Kansas State University
Roger Haugen, North Dakota State University
Dean Zimmerman, Iowa State University

Approximately 65-70% of the total cost of producing a market hog can be attributed to feed. As such, it is desirable for the swine producer to find the most economical feeding method to achieve the lowest cost per unit gain.

Feeding and processing methods should be evaluated both individually and collectively as to their potential to improve the economics of swine production. Nutrient availability and balance are important in diet formulation and are dependent not only on the feedstuff but may be altered by processing methods. Diets based strictly on least-cost formulations do not always result in the lowest cost of production. Consequently, this fact sheet deals with feedstuff ingredients, specific nutrient limitations and the physical forms of these feedstuffs. All are essential to maximizing profits in the hog industry.

Why study feeds?

Producers must understand the various processing techniques and associated feeding problems to make a system usable for their operation. For example, feedstuffs may be more acceptable to the pig in one physical form than another, thus improving feed intake. The digestibility of the nutrients within each feedstuff may be improved if the surface area is increased to allow greater exposure to digestive enzymatic activity, thus enhancing nutrient availability; but in other cases, altered feed surface areas may reduce diet acceptance. Processing could lower the availability of nutrients in grains, such as the destruction of vitamins; but in other cases, it could increase their use by the pig. Although a laboratory-conducted nutrient analysis of a feedstuff may not be changed, the digestibility and availability of nutrients may be enhanced or hindered by various processing methods. Thus, nutrient analyses coupled with an understanding of the effects of feed-processing are essential to insure optimum performance.

Free-Choice vs. Complete Feeds

In free-choice feeding, different components of the diet, such as grain and supplemental protein fortified with vitamins and minerals, are provided in separate compartments of a self-feeder. This compartmentalization allows the pig to eat as much of each component as desired. Thus the pig makes the choice in balancing the diet.

While free-choice feeding offers the greater simplicity for swine producers, more supervision is usually required to insure an adequate intake of all nutrients and optimum performance. Overeating or undereating of the protein-mineral-vitamin supplement may occur if the grain or supplement varies in acceptability to the pig. Generally, when feedstuffs are of poor quality (e.g., molds, extreme dryness, etc.), a depression in intake is observed and a corresponding increase in the consumption of the other components results. Maintaining quality is more important with grain as grain varies more in quality than most processed supplement sources. Supplement intake can sometimes be controlled, however, by keeping the number of feeder holes containing the supplement low, but adequate, relative to those containing grain.

The free-choice system usually produces a slower rate of gain than feeding a completely mixed diet, especially with younger pigs to 100 lbs. bodyweight. If free-choice feeding is not properly monitored, poor feed efficiency can easily occur.

Complete mixed feeds or those with the proper balance of nutrients mixed and supplied in one batch are the most common methods of feeding swine. Complete mixed swine feeds are generally more satisfactory for most swine operations.

Limit-fed gestating sows will perform equally well when fed their diet components (grain and supplement) separately or as a completely mixed feed. It is advisable to feed

MICHIGAN STATE UNIVERSITY
CES COOPERATIVE EXTENSION SERVICE

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.

1P-5M-1:81-UP, Price 10 cents. Single copy free to Michigan residents.

O-12715

Michigan State University Printing

Table 1. Effects of processing feedstuffs on pig performance.

Processing method	Type of grain	Growth rate	Change in feed intake	Feed conversion	Comments
Grinding	Corn	Improved 3-5%	No effect	Improved 3-5%	Medium screen (¼-⅜ in.). Generally most acceptable.
	Grain sorghum	Improved	No effect	Improved	Too fine of grind can reduce palatability.
Pelleting	Corn, Grain sorghum	Improved 3-6%	Reduced 1-3%	Improved 5-8%	
	Barley, Oats, Alfalfa, Wheat, Bran	Improved 3-6%	Reduced 1-3%	Improved 7-10%	Greater improvement with higher fibrous materials.
Paste	Corn	Improved 10-15%	Increased 10-15%	No change	Feed:water ratio of 1.2 - 1.5:1. Advantage with G-F pigs but not weanlings.
Liquid	Corn	Improved	Increased	Improved	Water:feed ratio of 2.1. Advantages with limit-fed systems. Full-fed levels fail to improve performance.
Roasting	Corn	No change	No change	Slightly improved	Processing cost greater than improvement return.
	Soybeans	No change	Decreased	Improved 4-6%	Necessary for adequate performance. Comparisons made with SBM.
Steam flaking	Corn, Grain sorghum	No change	No change	No change	
Micronizing	Corn, Grain sorghum	No change	No change	Variable	Availability of amino acids may be reduced.
Extruding	Wheat, Grain sorghum	No change	No change	No change	
	Soybeans	No change	Decreased	Improved 4-6%	Comparison made with SBM—necessary for adequate performance.

the supplement prior to the time the grain is fed to insure an adequate intake and balance of nutrients.

Grinding

Most feeds are processed in some way before distribution and consumption (Table 1). For example, some grinding and/or rolling is necessary in completely mixed rations to prevent ingredient sorting by the pig and to break the hard grain kernel into smaller particles of uniform size. The degree of grinding varies from finely to coarsely ground material.

Feedstuffs' passage rate through the digestive system of pigs is slightly faster with finely ground feeds. Normally, feedstuffs which have passed through a 1/8-3/16-in. screen or smaller are considered to be finely ground. The screen size and area through which the feed is passed, along with hammer tip speed, will determine the fineness of a feedstuff from grinding. Young pigs (weaning to 100 lbs.) appear to perform better on a finely ground feed, while finishing pigs perform as well with more coarsely ground grains. Finely ground feed is more subject to wind losses when filling the feeders and "bridging" problems in self-feeders. Excessive dusty conditions in confinement facilities can be largely attributed to finely ground feed. Feeding finely ground feed has also been found to increase the incidence of gastric ulcers. Fine grinding of some grains, such as wheat and grain sorghum, may result in a product with a powder or floury texture, reducing acceptability of the product to the pig.

A medium textured feed, passing through a ¼-⅜-in. screen, appears to be generally more ideal for complete mixing of dietary ingredients since it eliminates the above-mentioned problems associated with finely ground grain and achieves good pig performance. Generally, a medium grind will improve feed efficiency over a coarsely ground feed with little, if any, improvement in rate of gain. Coarsely ground (½-in. screen or larger) dry feeds are generally used less efficiently in pigs when compared to finer grinds.

With high moisture grain, maximum performance can be obtained by feeding the grain either rolled or coarsely ground. Care should be taken that the high moisture grain does not become moldy. It should be fed the same day it is prepared or must be treated with an organic acid at the time of processing to prevent spoilage. Acid-treated high-moisture corn can be ground or rolled and mixed in a complete feed with satisfactory results. One should be aware, however, that the acid contact with metal feeding equipment will hasten deterioration unless some protective coating is applied to the metal. Wooden or concrete feeding equipment can be effectively used with acid-treated grains.

Pelleting

Pelleting is used extensively in commercially prepared rations. Feeds that are pelleted are initally ground fine or medium, then steamed and formed into a pellet by extrusion through a die. Steam in the pelleting process increases pellet durability and produces less starch damage in the grain. Pellets can be made of different lengths, diameters and degrees of hardness. The kind and quantity of ingredients in a ration can influence the hardness of the pellet. Wheat-based diets usually result in a hard pellet. Young pigs generally prefer a pelleted over a meal ration if given a choice of the two forms of feed, but they do not like a hard pellet. Few consumption differences are noticed between pelleted and non-pelleted feeds when fed separately and when pigs are not allowed to choose.

Reground pelleted feeds have been shown, in some instances, to improve feed conversion over an unpelleted meal ration. This fact suggests that energy digestibility is enhanced during the pelleting process, owing to a partial gelatinization of starch (rupture of starch molecule), making it more susceptible to enzymatic digestion. Pelleting high-fiber diets increases digestible energy by 10-15 percent. No improvement in protein digestibility by pelleting has been observed.

Various studies on the effect of pelleting indicate that growth rate and feed efficiency of pigs are improved by pelleting the diet along with a slight reduction in feed consumption. The decreased feed intake may be partially attributed to a lowered amount of feed wastage compared to a meal diet. This improvement is generally associated more with dietary formulations containing more fiber than with diets based on corn-soybean meal.

Other advantages of pelleted diets are:

- Reduced dustiness
- Reduced storage space
- Reduced feed wastage
- Less wind loss
- Less "settling out" of fine particles during transportation
- Reduced sorting of ration ingredients and particles

However, disadvantages of pelleting include:

- Increased cost
- Reduced acceptance of hard pellet by the young pig
- Fine grinding requirement of cereal grains before pelleting
- Difficulty in pelleting high fat diets (greater than 6% fat)
- Possible occurrence of spoilage if improper pelleting is used

Paste Feeding

The development of a feed-water mixture (paste) feeding system for growing-finishing swine has resulted in improved performance. Paste-fed swine have consistently shown increased growth rates and feed intakes by 10-15%, but no improvement has been noted for feed conversion.

The paste is formed by mixing one part dry diet with 1.2-1.5 parts water by weight. This paste mixture is then pumped and piped to a specially-constructed feeder which is timed to release the paste to the pigs when the trough sections are emptied. The feeder is not, however, commercially available. Because of the high water content of the diet and its use of special equipment, it is essential that where freezing temperatures occur, the system be used only in complete confinement facilities.

Although this paste system has resulted in improved performance of growing-finishing swine, no benefits have been shown with weanling pigs.

Liquid Feeds for Swine

There are several commercial systems available to provide liquid-feed mixtures for all phases of swine production (i.e., gestating and lactating sows, early weaned pigs and growing-finishing hogs). Various liquid feeders operate differently, but the principle of providing feed is similar. The feed and water are combined either before delivery or at the trough. Swine may be either limit- or full-fed. The ratio of feed to water can be adjusted by the setting of the equipment controls desired by the swine producer. Control settings will vary depending on the desired consumption level for the various swine production phases.

Although water is provided in the mixture at the trough, continual access to additional water is essential. Some producers have found it desirable, however, to limit the access to the waterer during the initial phase to encourage feed consumption. Pigs adapt readily to the liquid feeding system with few problems. The use of liquid-feed mixtures also reduces the dust accumulation in the buildings, and feed wastage is minimized when the equipment is properly adjusted.

Swine performance, particularly in young pigs and growing-finishing hogs, has resulted in varied responses with this feeding system. When growing-finishing hogs are limit-fed, gains and feed conversion are improved when fed liquid feed as compared to those fed a dry ration. When the diet is provided at full-fed levels, performance of pigs is similar, regardless of the type of feeding system.

Heating Feed Ingredients and Feeds

Cereal grains and many feed byproducts are not normally heat processed before mixing into swine diets except to prepare them for safe long-term storage. Some feed ingredients, such as alfalfa, bermuda grass and meat scraps must be dried for use in swine feeds.

Other feed sources, however, must be heat-treated to be effectively used by swine. Soybeans are an excellent example. The major objectives in the processing of soybeans for use by swine are (1) to destroy the trypsin inhibitor, (2) to destroy the urease enzyme, (3) to inactivate the toxic hemagglutinin, and (4) to increase the nutrient availability. Attempts to achieve these objectives have employed a wide range of processing conditions. The primary factors involved are cooking temperature and time, moisture content of the seeds, particle size, such as whole vs. flaked, and equipment used to process the beans.

Soybeans are initially processed to remove the oil for other uses with the resulting meal then being heated to improve its quality. Heating time, temperature and moisture level must be regulated for maximum product quality. In general, longer heating time is required with low temperatures. The nutritive value of soybean meal has been improved when the length of heating is increased from 4 to 15 min. at 250 F. (121 C.). However, when heating time is increased beyond 15 min. there is a rather drastic decline in the nutritional value of the meal. Overheating of soybean meal destroys some of its vitamins and reduces the availability of the amino acids, particularly methionine and lysine. The regulation of the water content during the heating process can partially prevent the damaging effects of overheating. Moisture is added in the form of steam after the oil extraction and before the toasting of solvent processed soybean meal. The added moisture aids in quick distribution of heat during toasting, thereby minimizing heat damage.

Whole Cooked Soybeans

Research has established that properly heated whole soybeans are a good feed source for swine. Growing and finishing pigs have been able to use the protein and fat in the whole full-fat (oil) beans as efficiently as the protein in soybean meal. However, the oil in whole soybeans is not efficiently used by the weanling pig. Carcasses of pigs fed heat-treated whole soybeans tend to be softer with a higher percentage of unsaturated fatty acids. These differences are small, however, with no apparent problems, especially in meat-type animals.

Whole cooked soybeans are lower in protein and carbohydrates and higher in fat than solvent-extracted soybean meal (Table 2). Because of this lower protein concentration, additional quantities of heat-treated soybeans must be added to swine diets to provide equivalent amounts of protein provided from the soybean meal (Table 3). Whole soybeans contain 18 times more fat than soybean meal. This fat or oil is 2.25 times as concentrated in energy as the carbohydrate or starch from corn. Since this oil can be used by pigs as a source of energy, the energy level of diets using whole, heated soybeans is higher than diets using commercial soybean meal (Table 3). Because of this greater energy concentration, there is a 4-6% improvement in feed conversion when feeding heat-treated whole soybeans compared to soybean meal.

Table 2. Comparative nutritive values of whole soybeans and solvent extracted soybean meal.

Content	Whole soybeans	Soybean meal
Crude protein, percent	37.0	44.0
Crude fat, percent	18.0	1.0
Carbohydrate, percent	30.0	40.0

Table 3. Rations comparing soybean meal and heat-treated soybeans.

Ingredients	Soybean meal	Heat-treated whole soybeans
Corn	1650	1520
Soybean meal, 44%	300	--
Soybeans, heat-treated	--	430
Min-Vit. premix	50	50
Total	2000	2000
Percent protein	14.0	14.8
Metabolizable energy, Kcal./lb.	1432	1478

The protein (amino acid) needs of the pig are directly related to the amount of energy in the diet. Pigs fed higher energy-containing diets will not consume as much feed. Hence, with higher levels of dietary energy provided from the whole treated soybeans, additional protein must be supplied to keep the protein:calorie ratio at an optimum level. Therefore, diets containing whole soybeans must also contain more protein than comparable diets using soybean meal. Examples of diets using soybean meal and full-fat heated soybeans are presented in Table 3.

Feedlot performance achieved with soybean meal or cooked soybeans depends primarily upon the quality of the beans initially used and upon proper processing techniques used in their preparation. Commercially processed soybean meal is periodically checked for product quality, whereas it is more difficult for swine producers and small processors to know the quality of their heated whole soybeans.

On-the-farm heating methods include dry cooking (infrared and microwave) and extruding of the soybean which generates friction (i.e., heat) by forcing the soybeans through a restricting die under high pressure (extrusion). For optimum quality, soybeans cooked by the dry heating method (roasted) should be heated for 3-5 min. at an exit temperature of 240-260 F. (115-127 C.). Extruded soybeans should have an exit temperature of 280 F. (138 C.) to achieve maximum feedlot performance.

The merits of using whole heat-treated soybeans in farm mixing situations versus commercially prepared soybean meal depends upon several factors. Pig performance can be expected to be about equal with both products. Thus, the decision must be in relation to cost savings. Home-grown soybeans may be grown and used on the farm or purchased at harvest when they are normally lower in cost. However, this process must outweigh the disadvantages, which include increased storage bin capacity, equipment to heat the beans, energy costs of cooking and available labor. Normally, the added energy gain in swine by feeding full-fat soybeans is offset by the energy cost of processing the soybeans for use. Dietary cost advantages will vary from year to year and by locality.

Cooked Grains

The introduction of units designed primarily for cooking soybeans has stimulated interest in the use of such units for heating feed grains. No consistent improvement has been shown in performance when pigs are fed diets containing heated or cooked corn. No differences have been observed in carcasses as a result of feeding roasted corn.

Extruding Grains

The extruding process has been used to process corn, grain sorghum and wheat for pig diets. Little research has been conducted to compare the nutritional value of extruded corn with ground corn. Extruding does not improve either rate or efficiency of gain among pigs fed either milo or wheat as a grain source. Extruding has been shown to improve the digestibility of both energy and protein in extruded milo diets.

Steam Flaking—Micronizing

Steam flaking is a process where the grain is heated to approximately 200 F. in a steam chamber for 20 min. and then flattened through rollers. Micronizing consists of heating grain to 300 F. for 20 sec. before being rolled and converted into flakes. The dry heat used is supplied by infrared radiation. The micronizing process ruptures the cell wall and causes partial gelatinization of the starch, which increases its availability.

The steam flaking of grains has generally not improved growth rate or feed efficiency in pigs. However, micronizing certain hard-shelled grains, such as milo, may improve growth rates while reducing the amount of feed necessary per unit of gain. No consistent improvement in pig performance has been noted by micronizing corn. The use of high temperatures to process grains may result in a lowered lysine availability and other amino acids. Thus, diets containing grain which has been processed at high temperatures may need additional lysine supplementation to achieve similar performance.

Drying Grain for Storage

It is a common practice to dry corn by artificial heat to a lower moisture content for storage. Corn dried at normal temperatures supports gains and feed efficiencies in pigs similar to those obtained with field-dried corn. Research has indicated that temperatures up to 230 F. for drying corn to a moisture content of 12-15 have no detrimental effect on pig performance. Drying grain at temperatures greater than 300 F., however, reduces the acceptability of the corn when fed to growing-finishing pigs. Drying temperature does not affect the content of carotene (vitamin A precursor), riboflavin or niacin, but pantothenic acid and thiamine may be decreased. If, during the harvesting and/or handling process, the grain kernel is cracked and then dried, nutrient destruction is enhanced. This destruction is particularly true for carotene and vitamin E.

NEW 5/80