Swine Technology – Nutrition: Swine Feeds and Feeding
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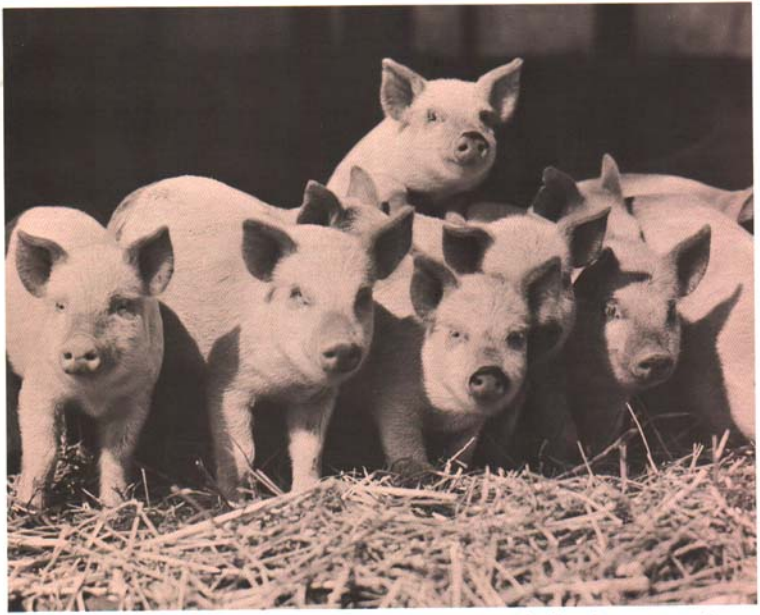
Nutrition: SWINE FEEDS AND FEEDING



Sound nutrition from farrowing to market is the keystone of profitable swine management.

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SWINE FEEDS AND FEEDING

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Feed costs represent 65 to 80 percent of the total cost of producing hogs on Michigan farms. Therefore, a producer must have a thorough working knowledge of swine nutrition if the enterprise is to be managed efficiently. The fundamentals of animal nutrition and the nutrient requirements of swine are discussed in Extension Bulletin 536.

It is the purpose of this publication to show how the basic principles of nutrition can be applied to ration formulation.

Corn is the basic feed for hogs in Michigan, although it is deficient in many of the essential nutrients which they require. Correcting the deficiencies of corn and other cereal grains is the major concern in ration formulation.

Fortunately, producers have a wide variety of ingredients to choose from in formulating rations when price and availability justify. Each ingredient varies in quality and quantity of nutrients contained. But it should be emphasized that the pig has a requirement for *nutrients*, not particular ingredients. It makes no difference to a pig what the source of a nutrient is so long as it is present in the ration in adequate amounts and in a usable, palatable form. Therefore, judgment must be exercised in selecting the combination of ingredients which will be "least-cost" but nutritionally adequate.

Another consideration is that a particular feed may vary in composition. Corn produced this year is probably different from corn grown last year, even thought both crops were harvested from the same field. The nutrient content of grains is affected by soil and climatic conditions during the growing period, stage of maturity at harvest, time in storage, etc. Animals, too, vary in their nutrient requirement. A ration that is nutritionaly adequate for one hog may be grossly inadequate for another. Thus, in ration formulation we are constantly dealing with **variables** and must base decisions on **averages.** Rations are usually over-fortified as an insurance factor to provide for the variation that exists in both feeds and animals.

ENERGY FEEDS

CORN

Corn is an excellent energy feed for all classes of swine. It is an ideal finishing feed because it is high in digestible carbohydrate (starch), low in fiber, and is a very palatable, safe feed that can be fed in a variety of ways. It may be fed shelled, ground, mixed, or free-choice, or even as ear corn. It may be dry or high moisture. It makes little difference to the pig; he likes corn any way it is offered.

In spite of its virtues, corn alone will not keep pigs alive. Corn contains 7 to 9 percent protein, but the protein is deficient in practically all of the essential amino acids required by the weanling pig, especially lysine and tryptophan. It is also so deficient in cal-

Figure 1. — Good nutrition pays. These three littermate pigs were fed on different rations. Note how the performance has been affected.

cium and other minerals, and so inadequate in vitamin content that pigs will die if they are limited to a ration containing only corn. So corn must be supplemented with a protein that makes up its amino acid deficiencies. Equally important are the needed minerals and vitamins. Properly supplemented corn is an excellent energy feed for all classes of swine.

Corn is now being bred that is much higher in lysine and tryptophan and hence has a better balance of amino acids for growing swine. The high-lysine corn (called opaque-2) is also higher in total protein than normal corn. Unfortunately, it will be some years before it is available commercially in large quantity.

It should be noted that corn is higher in fat than barley or wheat (4.0% vs. less than 2.0%). This fat not only contributes to the high energy content of corn, but also improves its palatability and feeding properties in general.

Yellow corn is usually the cheapest source of energy, but price fluctuations frequently justify consideration of other feeds. The relative values of various feeds that may be used as complete or partial replacements for yellow corn in the swine ration are discussed below.

BARLEY

Barley is an excellent energy feed when corn is not available. Because of its higher fiber content (6%), barley has more bulk and is slightly lower in energy. It contains more protein (11.5%) than corn, but the amino acid balance is not good. In feeding value it is worth about 90 percent of corn.

Barley should be ground to a medium degree of fineness or rolled for swine. When fed in this manner it can replace all or part of the corn in a swine ration. It is somewhat less palatable than corn. Thus, it is best to mix the ground barley with protein supplement rather than feed it free-choice. Pigs are less likely to overeat on protein supplement when fed by this method.

Moderate infestation of barley with scab renders it very unpalatable and may even be poisonous to pigs. Scabby barley should not be fed to lactating sows and small pigs.

OATS

As an energy feed, oats are handicapped by their high fiber content (10 to 15 percent). This bulk makes oats a better feed for breeding animals than for young pigs or finishing animals where high energy rations are needed for fast gains. Protein content averages about 12 percent.

Oats vary greatly in test weight, and hence the feeding value ranges from 70 to 85 percent that of corn. Fine grinding or removal of the hull improves the feed efficiency. When ground oats comprise no more than 30 percent of the total ration, the growth rate of growing pigs will be reduced very little, if at all. Oats have a lower feeding value on pasture, because the pasture forage is also bulky and fibrous.

If the hulls are removed and the groats rolled, the product is an excellent feed, particularly in starter rations for baby pigs.

WHEAT

For all practical purposes, wheat is equivalent to corn as a source of energy and is slightly superior in protein (quality and quantity). It can be used as a pound-for-pound substitute for corn, but because of cost, it is not widely used in swine feeding. Low quality wheat not suitable for milling, as well as damaged wheat, can be profitably utilized by swine.

Figure 2. — Corn is an excellent energy feed in a variety of forms for swine. As swine feed, it can provide an economical utilization of surplus corn supplies.

Wheat should be ground coarsely or rolled for hogs. When ground too finely, it has a tendency to form a pasty mass in the mouth and becomes less palatable.

GRAIN SORGHUMS (MILO)

Grain sorghums are the corn equivalent of the Southwest and other areas, where it has production advantages over corn. Because it has many of the same virtues and deficiencies as corn, it can replace corn in all swine rations. The kernel is hard and small and should be ground and mixed with other ingredients. The feeding value is approximately 95 percent that of corn.

RYE

Rye is a rather unpalatable cereal grain that should not make up more than 20 percent of the swine ration. Since its kernels are smaller and harder than those of corn, the best results will be obtained by feeding it ground rather than whole. When good quality ground rye is limited to one-fifth of the ration, it is worth about 90 percent as much as corn.

Rye is often infested with the fungus, ergot. Since ergot may cause abortion, rye infested with it should never be fed to pregnant sows. The fungus reduces feed consumption and growth rate when fed to growing-finishing swine.

NOTE OF CAUTION

The percent of protein in barley, oats, wheat, milo, and rye averages about 11.5, 12.0, 12.7, 10.5 and 11.5, respectively. Although these percentages are considerably above that found in corn, the protein is generally of the same poor quality as in corn. Therefore, in formulating rations we must consider these grains as having about the same protein content as corn. If this is not done, the protein supplementation of the ration will not be sufficient to furnish adequate quantities of essential amino acids. All of the cereal grains also have about the same vitamin and mineral deficiencies.

Thus, the relative replacement value of cereal grains for corn in the ration is based on the equivalent energy content and not on protein, vitamins or minerals furnished.

CULL BEANS

Frequently cull beans are available in quantity and can serve as another feed for hogs. They should be boiled or cooked by steam to improve the palatability and feeding value.

Beans should not comprise more than one-third of the grain ration (dry weight before cooking) for pigs weighing up to 100 pounds. They may be increased later to one-half the ration, and when very cheap, may constitute the main part of the growing-finishing ration. When cooked and used to replace not more than two-thirds of the corn in the ration, cull beans are worth about 90 percent the value of corn. The labor and cost of cooking must be included when determining how much to pay for them.

Although beans are fairly rich in protein (20 to 23 percent) the protein is of very poor quality. At least one-half pound of a good protein supplement should be fed per head daily to growing-finishing pigs to correct the deficiencies of beans.

CULL POTATOES

Potatoes contain only about 23 percent as much dry matter as shelled corn, and the dry matter contains little except carbohydrates (starch). Hogs over 100 pounds in weight make the most satisfactory use of potatoes. For best results, potatoes should be cooked. Add salt to the water in which the potatoes are cooked to increase the palatability. The potatoes should be cooked thoroughly and the water drained off before feeding. Since potatoes contain practically no protein, a good protein supplement should be fed along with vitamins and minerals. When cooked potatoes are fed in a ratio of 3 pounds of potatoes to 1 pound of grain, they are worth about 25 percent as much as corn.

BAKERY WASTE

Stale bread, bakery crumbs, etc. are high carbohydrate products that may or may not contain a considerable amount of added fat. The protein content averages about 10 percent, but no reliable amino acid analysis figures are available. These products should be considered energy substitutes for corn up to about 50 percent of the ration. When cheap enough, they may replace all the corn. In this case, the value is about 75 percent that of corn. Protein, mineral, and vitamin supplementation recommendations are the same as for the cereal grains. It is usually advisable to moisten the products with water at feeding time.

FAT, TALLOW, GREASES

These products are now available as very high energy sources. The amount used in swine rations is usually less than 5 percent. Adding a higher percentage of fat to the ration may result in fatter carcasses and a depression of feed intake. Feed efficiency is improved when fat is added because of its very high digestible energy (DE), but since energy is its only contribution, the need for proper supplementation is increased. There are no proteins (amino acids), min-

erals, or vitamins in fats. Rancidity in fats should be prevented by including an antioxidant.

MOLASSES

Molasses, either cane or beet, is a carbohydrate source that can be substituted for a part of the grain. It should be limited to about 5 percent of the ration and when used in this manner is worth approximately 60 percent as much as corn. Too much molasses causes scours. A small percentage is often included in commercial feeds to serve as a binder, to reduce dustiness and to prevent waste in feeding.

CALCULATING COST OF CORN SUBSTITUTES

To calculate the relative value of a corn substitute in terms of dollars and cents, first determine the price of corn per pound. When corn costs $1.30 per bushel (56 lbs.) a pound will be worth 2.32 cents (1.30 divided by 56) or $2.32 per hundred pounds.

Assuming that barley is worth 90 percent of corn, 100 pounds of barley would be worth $2.09 ($2.32 times .90 = $2.09).

Table 1. — Value of Corn Substitutes in Swine Rations.

Feed	Maximum recommended replacement (percent)	Relative value (percent)
Yellow corn, ground	100	100
Complete substitutes		
Barley, ground	100	90
Wheat, ground	100	100
Sorghum (milo), ground	100	95
Oats, dehulled	100	107
Partial substitutes		
Oats, ground	30	80
Rye, ground	20	90
Bakery waste	50	95
Cull beans	65	90
Cull potatoes	25	25
Tallow	5	240
Lard	5	230
Molasses, blackstrap	5	60

PROTEIN FEEDS

Protein is made up of 22 or more nitrogenous compounds called amino acids. Protein feeds vary in the kind and amount of amino acids they contain. During the digestion process, the protein in feed is broken down into the various amino acids and the pig recombines them into the kind of protein needed for muscle development, repair of worn-out tissue, etc. Thus, the real need of the pig is for amino acids and not protein, as such.

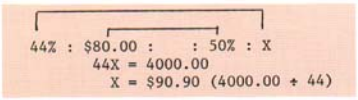
The pig can synthesize some of the amino acids so they are not required in the diet. However, ten of the amino acids are termed "essential" because the body cannot manufacture them in sufficient quantity to permit maximum growth and performance. It is important that ingredients rich in the essential amino acids be used in formulating the ration.

Although it is a common practice to refer to "percent protein" in a ration, this term has little meaning unless there is knowledge concerning the amino acids present. A protein feed is considered to be of good quality when it contains all the essential amino acids in the proportion and amount needed by the pig.

SOYBEAN MEAL

Soybean meal is the most economical source of good quality protein available to Michigan swine producers and is the basic ingredient in commercial protein supplements. It is marginal in methionine but otherwise very well-balanced in amino acids. Soybean meal must be supplemented with minerals and vitamins, and usually cannot be fed free-choice because of its high palatability. Pigs are inclined to eat more than is needed to meet their protein needs.

Producers have a choice of buying either a 44 or 50 percent soybean meal. The 50 percent meal is the most desirable to use in pre-starter and starter rations because much of the hull has been removed. Thus, it has less fiber (3%), is higher in energy, and more palatable. Growing-finishing pigs can utilize both meals about equally. The price per unit of protein will determine which is the best buy. The following example explains how to calculate the comparative advantage: Assuming that 44 percent meal can be purchased for $80.00 per ton, what would a ton of 50 percent meal be worth?



Thus, on a protein equivalent basis, a 44 percent soybean meal costing $80.00 per ton would be equal in value to a ton of 50 percent meal costing $90.90 per ton.

However, there is another factor to take into consideration. It requires fewer pounds of 50 percent meal to balance a ton of complete feed than it does of 44 percent meal. In most cases the difference will figure about 50 pounds. This means that a ton of total ration supplemented with 50 percent meal will contain 50 pounds more corn. The cost of the extra corn must be charged against the 50 percent meal when calculating which meal is the most economical. Thus, if corn is worth two cents per pound (50 x .02 = $1.00), a ton of 50 percent soybean meal would be

worth only $89.90 ($90.90 — $1.00) in the example above.

Raw soybeans are not recommended for swine because of the high oil content and the low protein value. The heat used in extracting the oil and processing the meal greatly increases the availability and value of the protein.

MEAT AND BONE MEAL, TANKAGE, FISH MEAL

These animal proteins are standard sources of protein widely used in swine rations. They are deficient in the amino acid tryptophan, so they should not be used as a single source of protein. When priced low enough, these proteins can furnish up to 50 percent of the protein in a supplement. They are good sources of calcium and phosphorus, but are not as palatable as soybean meal.

MILK PRODUCTS

No single feed contains more of the nutrients in which cereal grains are deficient than do many dairy by-products. They are extremely palatable and highly digestible, and are especially valuable as feed for pigs prior to and for a few weeks after weaning. When fed at the rate of ½ to 1 gallon per pig daily, 100 pounds of liquid skim milk or buttermilk are about equal in value to one-half bushel of corn.

Liquid whey contains only 0.9 percent protein and is worth about half as much as skim milk for hogs over 100 pounds in weight. For young pigs, a protein supplement should be fed in addition to the whey. Whey should be fed either sour or sweet regularly, rather than changing from one to the other, as this may induce scours.

Semisolid or condensed buttermilk usually contains about 65 to 70 percent moisture and 10 or 11 percent protein. It is somewhat more valuable for young pigs than for heavier ones. A pound is worth about half as much as a pound of tankage or meat and bone meal.

Dried skim milk and dried buttermilk contain 33.5 and 32.0 percent of protein, respectively, but are usually too expensive to be economical protein supplements for swine. Both are good sources of B vitamins. Because of their palatability and nutrient content, both of these products are especially good ingredients in pre-starter and starter rations.

LINSEED MEAL

Linseed meal is too deficient in lysine to be used extensively as a protein supplement with cereal grains. It is fairly well-liked and, because of its slightly laxative properties, it is used in limited amounts in brood sow rations. It contains almost twice as much calcium as cottonseed and soybean meal, and is about the same in B vitamin content. Linseed meal should not make up more than 20 percent of the total protein supplement.

COTTONSEED MEAL

This protein is not widely used in swine feeding because of gossypol, a toxic substance present in variable amounts in some cottonseed meals. If the amount of free gossypol is known to be low, cottonseed meal can be used to supply 20 percent of the supplemental protein. The protein of cottonseed meal is deficient in lysine and marginal in isoleucine, threonine, and tryptophan. Cottonseed meal is low in calcium, fairly high in phosphorus (but of questionable availability), and fair in B vitamin content. It is not a very palatable supplement for pigs.

Table 2. — Relative Value of Various Sources of Protein*.

Source of protein	Relative value (percent)
Soybean meal (44% protein)	100
Cottonseed meal	85
Linseed meal	80
Distillers solubles, dried	77
Fish meal (Menhaden)	115
Meat and bone meal (50% protein)	100
Tankage (60% protein)	110
Blood meal	123
Skim milk, dried	100

**The relative values listed above are based upon the amount of supplements required in a 16 percent protein ration containing 50 percent of the recommended level of 44 percent soybean meal. In general, the values reflect the ability of the supplement to provide the essential amino acid, lysine.*

Table 3. — Recommended Protein Levels and Approximate Daily Feed Intake.

	Percent protein in ration	Average daily feed intake
Growing:		
Creep rations (suckling) 10 to 30 lbs.	18	0.4 lbs
Grower - 30 to 125 lbs.	16	4.0
Finisher - 125 lbs. to 215 lbs.	12	7.0
Breeding season:		
Gilts	12	7.0
Sows	12	6.0
Gestation:		
Gilts	12	5.0*
Sows	12	4.0*
Lactation:		
Gilts and sows	16	12.0
Breeding boars	16	6.0

**These amounts can be reduced to 4.0 and 3.0 pounds if on pasture.*

ALFALFA MEAL (DEHYDRATED)

Although it contains 17 to 20 percent protein, alfalfa meal is not fed as a source of protein. It is a substitute for pasture and is a good source of carotene

(vitamin A) and the B vitamins (riboflavin, pantothenic acid, niacin). Because of its high fiber (25 to 30 percent) and low palatability, it is used in limited amounts in growing-finishing rations (2 to 5 percent).

VITAMINS

Many of the vitamins required by swine are present in adequate amounts in natural feedstuffs, so they are not of practical concern. Those that are likely to be deficient can be divided into two groups:

Fat Soluble Vitamins

Vitamin A
Vitamin D

Water Soluble Vitamins

Riboflavin
Nicotinic Acid
Pantothenic Acid
Choline
Vitamin B_{12}

There are two of the above vitamins which should receive special attention. Yellow corn contains the pigment, carotene, which can be converted to biologically active vitamin A in the intestinal wall of the pig. However, swine are not efficient converters of carotene to vitamin A, and much of the carotene may be destroyed in storage. Therefore, in formulating swine rations, the carotene content of yellow corn is disregarded.

Similarly, nicotinic acid in yellow corn, and certain other cereal grains, exists in a bound form that is largely unavailable to swine. For this reason, yellow corn is not credited with containing any nicotinic acid. If the ration is rich in the amino acid, tryptophan, it can be converted by the pig to nicotinic acid.

Table 4. — Recommended Vitamin Levels for Dry-Lot Swine Rations.

Vitamin	Creep and starter ration	Grower ration	Finisher ration	Breeder ration
Fat-soluble vitamins				
Vitamin A, IU per lb.	1,500	1,500	750	2,500
Vitamin D, IU per lb.	500	300	300	300
Water-soluble vitamins				
Riboflavin, mg. per lb.	1.5	1.4	1.0	1.5
Nicotinic acid, mg. per lb.	10.0	8.0	5.0	8.0
Pantothenic acid, mg. per lb.	6.0	5.0	5.0	6.0
Choline, mg. per lb.	500.0	400.0	350.0	350.0
Vitamin B_{12}, mg. per lb.	10.0	7.0	5.0	5.0

NATURAL SOURCES OF VITAMINS

A (or carotene) — Alfalfa meal, good pasture, fish liver oils.

D — Irradiated yeast, suncured meals and hays, sunshine.

Water soluble vitamins (other than B_{12}) — Alfalfa meal, distillers solubles, condensed fish solubles, milk by-products, good pasture.

B_{12} — Animal proteins, condensed fish solubles, and distillers solubles.

SYNTHETIC VITAMINS

In addition to the natural sources of vitamins listed above, many companies are supplying synthetic vitamin concentrates which are relatively inexpensive. The vitamins may be purchased individually or in combinations.

MINERALS

Minerals constitute a small percentage of the swine ration, but their importance to the health and well-being of the pig cannot be overemphasized. The ones that are most likely to be lacking in swine rations and practical sources are:

Figure 3. — The pig at the left received no riboflavin in the diet, while the littermate, right, received 3 milligrams of the vitamin per kilogram of solids.

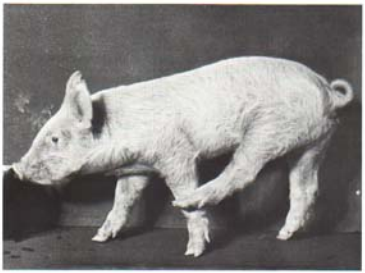


Figure 4. — Pantothenic acid-deficient pig showing the characteristic "goosestepping". The condition is due to deterioration of the sciatic nerves when the supply of the vitamin, pantothenic acid, is not adequate.

Mineral	Source
Calcium	Bone meal, dicalcium phosphate, feeding limestone
Phosphorus	Bone meal, dicalcium phosphate
Sodium and Chlorine	Salt
Trace Minerals	
Iron	
Copper	Best provided in a special swine
Iodine	trace-mineral salt.
Manganese	
Zinc	

Table 5. — Amounts of Calcium, Phosphorus and Trace-Mineral Salt That Should be Present in the Total Ration of hogs of various ages.

Mineral	Creep, percent	Breeder and grower, percent	Finisher, percent
Calcium	0.80	0.75	0.50
Phosphorus	.60	.50	.40
Trace-mineral salt	.50	.50	.50

ANALYSIS OF MINERAL SOURCES

Limestone — 38% calcium

Dicalcium phosphate — 24% calcium, 18% phosphorus

Steamed bonemeal — 26% calcium, 14% phosphorus

CALCIUM AND PHOSPHORUS FORTIFICATION

The ingredients of swine rations vary widely in mineral content. Corn and soybean meal are particularly low in calcium. Feed grains contain phosphorus, but it is largely phytin phosphorus, which may be poorly utilized by swine. Corn-soybean meal rations, must therefore be supplemented with both calcium and inorganic phosphorus.

Feeds of animal origin such as meat and bone meal, tankage, and fishmeal are quite high in calcium and phosphorus. The level of calcium, and especially phosphorus supplementation, should be reduced as feeds of animal origin replace soybean meal in the swine ration.

The following mineral mixture will adequately supplement a ton of complete corn-soybean feed for growing pigs. It can also be fed free-choice to all ages of swine.

MINERAL MIXTURE

20 lb. — Limestone

20 lb. — Dicalcium phosphate or steamed bone meal

10 lb. — Trace-mineral salt (high zinc — .8%)

It will contain 26 to 27 percent calcium, 5.5 to 7.0 percent phosphorus, and 20 percent salt.

ZINC SUPPLEMENTATION

The natural feedstuffs in a ton of conventional growing-finishing ration will supply approximately 30 to 35 parts per million of zinc. Adding 10 pounds of trace-mineral salt containing .8 percent zinc will furnish an additional 40 parts per million of zinc to the diet. Normally, this quantity of zinc is adequate to prevent a mange-like skin condition known as *parakeratosis*. Symptoms of this condition are slow growth, unthriftiness, harsh dry hair coat, development of reddened areas, and a thickening and encrusting of the skin on the legs, ears, hams and belly.

High levels of calcium (over .75 percent) in the ration increase the requirement of zinc. Early weaned pigs (3 weeks) also appear to have a greater requirement for zinc than older pigs. Under these conditions, an additional supplementation of 40 parts per million of zinc may be needed, in addition to that

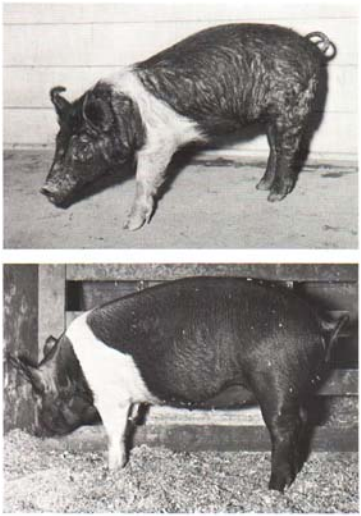


Figure 5. — The 10-weeks old pig (top) exhibits the typical symptoms of "parakeratosis" resulting from a zinc-deficient diet. The same pig (bottom) at six months after receiving a ration containing 100 parts per million of zinc.

supplied by the natural feeds and trace mineral salt, to prevent parakeratosis. The compounds listed in Table 6 may be used for any needed zinc fortification.

Table 6. — Recommended Zinc Compounds and the Amount Needed to Furnish 40 Parts Per Million of Zinc.

Compound	Zinc content (percent)	Grams to add per ton of complete ration
Zinc oxide (ZnO)	80	46
Zinc carbonate ($ZnCO_3$)	56	65
Zinc sulphate ($ZnSO_4.7H_2O$)	23	158

PRECAUTIONS ON MINERAL FEEDING

Many nutrients such as certain vitamins can be fed in excessive amounts without affecting the performance of the pig. Only the farmer's pocketbook is hurt. This is not true in the case of minerals. Excessive feeding or an improper balance of minerals will depress rate of gain and general performance of pigs as much as feeding inadequate amounts.

Never mix additional minerals with a commercial protein supplement unless the need is specified on the tag. A good mineral mixture can be fed free-choice without danger, if there is any question about adequate mineral fortification.

WATER

Water is so common we seldom think of it as a nutrient. But water is the largest single part of nearly all living things. Hogs need to have plenty of clean, fresh water at all times. It is particularly important to supply suckling pigs with water if a high intake of creep ration is to be obtained. Rate of gain and milk flow are also affected by water consumption.

Table 7. — Approximate Daily Water Consumption as Affected by Season.

Weight of pig pounds	Spring pounds	Fall pounds
25	3.3	2.5
50	5.5	4.5
75	8.5	7.0
100	9.0	7.5
150	10.0	9.0
200	9.0	9.6
250	7.5	7.5

(Source of data — Swine Production by Carroll, Krider, and Andrews)

FEED ADDITIVES

Additives used in swine rations include (a) antibiotics, (b) arsenicals, and (c) copper compounds. These are not true nutrients, since they are not required for normal growth. They apparently have an influence on the intestinal microorganisms and improve the health of the animal.

All farms have an "environmental disease level". The greater the disease build-up, the greater the response to feed additives. Pigs up to 100 pounds in weight usually give a greater response than older hogs.

Continuous feeding of the same additive gradually decreases its effectiveness. Periodic changing of drugs seems to be the best approach. The best time to rotate additives is when major changes are made in the ration, such as going from a grower to a finishing ration.

Certain feed additives may be absorbed and retained in the meat in quantities harmful to man. The

Figure 6. — Calcium-deficient pig with advanced rickets. Pig was scarcely able to walk. Back becomes arched and eyes protrude because soft tissue growth has outdistanced skeletal growth.

Food and Drug Administration is responsible for approving the use of drugs in meat animal rations and establishing the tolerances, or the maximum quantity of a chemical that can be present in food. To avoid contamination of the meat, some drugs must be withdrawn from the ration prior to slaughter. Therefore, it is important that producers follow the directions stated on the package of all drugs used. Tables 8 and 9 list the recommended levels for feed additives in swine rations.

Table 8. — Recommended Antibiotic and Arsenical Levels.

Ration	Grams per ton of complete feed		
	Antibiotic	Arsanilic acid*	3-Nitro*
Creep	40	90	22
Grower	10 to 20	90	22
Finisher	10	90	22
Therapeutic	100 to 200	90	22
Supplement	50 to 100	450	100

**Never use both arsenicals in a single ration at the levels indicated.*

Copper compounds probably have the greatest value as a therapeutic treatment for intestinal disorders that do not respond satisfactorily to antibiotics or arsenicals. Copper is toxic when fed in excessive amounts (250 parts per million or more) or for prolonged periods. Copper compounds should not be added to hog rations if a lagoon manure disposal system is being used. The copper will seriously interfere with the bacterial action in the lagoon.

Table 9. — Recommended Levels of Copper Compounds for Growing-Finishing Swine*.

Copper compound	Percent of copper	Grams per ton
Cupric carbonate ($CuCO_3$)	50	250
Cupric oxide (CuO)	80	160
Cupric sulphate ($CuSO_4 \cdot 5H_2O$)	25	500

**Amount to add per ton of complete ration to furnish 125 parts per million of copper.*

There are numerous drugs on the market which can be used alone or in combination for the promotion of growth and the control of swine diseases. Table 10 is a partial list of available drugs, the use level that has been approved by the Food and Drug Administration, and the limitations which must be followed. Unless stated otherwise, the recommended level to feed refers to grams per ton of complete feed.

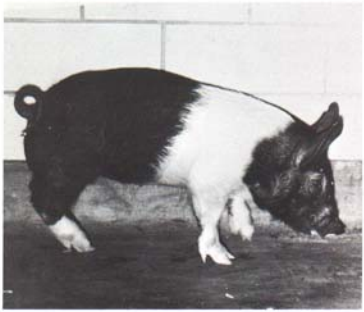


Figure 7. — Vitamin D-deficient baby pig exhibiting rickets. Limbs are shortened, pasterns are weak, legs are crooked and the pig can barely walk. Pig received adequate levels of all nutrients with the exception of vitamin D.

Table 10. — Partial List of Feed Additives, Use Levels and Limitations Imposed.*

Drug	Use level	Limitation
Promote growth and improve feed efficiency		
Aureomycin (chlortetracycline) alone or in combination with:	10-50 gm/ton	
Arsanilic acid	0.005-0.01%	withdraw 5 days
Furazolidone with or without	0.00083%	before slaughter
Nitrofurazone and/or	0.0056%	"
3 Nitro-4-Hydroxphenyl-arsonic acid.	0.0025-0.0075%	"
Sodium arsanilate	45-90 gm/ton	"
Terramycin (oxytetracycline) alone or in combination with:	25-50 gm/ton 7.5-10 gm/ton	10-30 lb. pigs 30-200 lb. pigs
Oleandomycin	2 gm/ton	
Arsanilic acid, or	0.005-0.01%	withdraw 5 days
Sodium arsanilate, or	0.005-0.01%	before slaughter
3-Nitro-4-Hydroxphenyl-arsonic acid	0.0025-0.0075%	"
Sodium arsanilate	45-90 gm/ton	"
Arsanilic acid or	0.005-0.01%	withdraw 5 days
Sodium arsanilate	45-90 gm/ton	before slaughter
alone or in combination with:		
Penicillin or	Max. 50 gm/ton	"
Streptomycin or	Max. 50 gm/ton	"
Bacitracin or	Max. 50 gm/ton	"
Bacitracin methylene disalicylate	Max. 50 gm/ton	"
Zinc bacitracin with or without penicillin	10-50 gm/ton	
Tylosin	20-100 gm/ton	pigs, up to 40 lb.
	20-40 gm/ton	pigs, 41 to 100 lb.
	10-20 gm/ton	pigs, 101 to market
Prevention and treatment of bacterial scours		
Aureomycin	50-200 gm/ton	
Terramycin	50-100 gm/ton	
Aureomycin plus	100 gm/ton	
Terramycin	100 gm/ton	
Terramycin plus	50 gm/ton	
Neomycin base	35 gm/ton	
Bacitracin plus	50 gm/ton	
Penicillin	50 gm/ton	
Bacitracin methylene disalicylate	50 gm/ton	
plus penicillin	50 gm/ton	
Zinc bacitracin plus	50 gm/ton	
Penicillin	50 gm/ton	To sows - 1 wk. before and 2 wks. after farrowing
Furazolidone, or	200 gm/ton	Pigs-for 2 wks.

Table 10. — Partial List of Feed Additives, Use Levels and Limitations Imposed.

Furazolidone, or	150 gm/ton	Pigs-for 3 wks.
Furazolidone	100 gm/ton	Pigs-for 5 wks.
Penicillin plus	7.5015 gm/ton	Feed not more
Streptomycin	37.5-75 gm/ton	than 14 days; withdraw 2 days before slaughter
Sulfaquinoxaline	0.025-0.05%	For 2 - 5 days
Treatment of vibrionic dysentery		
Tylosin	0.25 gm/gal drinking water Followed by 40-100 gm/ton feed	3-10 days
Furazolidone	300 gm/ton	2-6 wks. Feed for 10-14 days. Withdraw 5 days before slaughter
Terramycin	100 gm/ton	
Aureomycin plus	100 gm/ton	Withdraw 7 days
Sulfamethazine plus	100 gm/ton	before slaughter
Penicillin	50 gm/ton	
Prevention and treatment of atrophic rhinitis		
Aureomycin plus	100 gm/ton	Withdraw 7 days
Sulfamethazine plus	100 gm/ton	before slaughter
Penicillin	50 gm/ton	
Aid in treatment and spread of leptospirosis		
Aureomycin	200 gm/ton	Feed continuously
	400 gm/ton	Feed at least 14 days
Terramycin	500 gm/ton	Feed 7 to 10 days, approximately 1 mo. before farrowing.

*Source of information - 1967 Feed Additive Compendium.

RATION FORMULATION

A swine producer has two alternatives when it comes to developing his hog feeding program. He can formulate his own rations, or buy a ready-prepared commercial product to supplement his home-grown grains. Both methods can be equally successful. The decision will depend on (1) his knowledge of nutrition, (2) availability and price of ingredients, (3) equipment for grinding and mixing, (4) available storage, and (5) volume of feed required.

Many producers who have elected to formulate their own rations have found that they have been able to reduce feed costs materially. Another big advantage is that the operator knows exactly what he is feeding. He has the freedom to schedule and make changes as desired. This is particularly advantageous in the case of medication.

To formulate a ration accurately, a producer should become familiar with the metric system of measurement. Many nutrients such as vitamins and trace minerals are required in the ration in quantities of less than a pound per ton. The metric system provides units which permit small quantities to be broken down into fractions of a pound. Weight conversions are shown in Table 11.

Table 11. — Commonly Used Weight Conversions.

1 pound (lb.)	=	453.59	grams (gm.)
1 ounce (oz.)	=	28.35	grams
1 kilogram (kg.)	=	1,000	grams
1 gram	=	1,000	milligrams (mg.)
1 milligram	=	1,000	micrograms (mcg.)
1 mg. per lb.	=	2	gm. per ton
1 mcg. per lb.	=	2	mg. per ton
1 mg. per lb.	=	2.2046	parts per million (p.p.m.)
.01 percent	=	90.8	gm. per ton

A nutritional term having common usage is "International Unit" (I.U.). This term refers to the quantity of a biological (such as a vitamin) that produces a particular biological effect agreed upon as an international standard. International units are used to designate the activity of vitamins A and D.

MSU SYSTEM OF FORMULATION

The Michigan State University system of swine formulation involves the use of (1) a vitamin-trace mineral premix, (2) a fortified swine supplement, and (3) farm-grown grains. These three are combined to make two rations — MSU 16 (16 percent protein) and MSU 12 (12 percent protein) — that will meet the needs of all swine after they weigh 30 pounds.

Table 12. — Michigan State University Vitamin-Trace Mineral Premix.

Nutrient	Amount in 10 lb. of premix
Vitamin A, million	3.0 I.U.
Vitamin D_2, million	0.6 I.U.
Riboflavin	3.0 gm.
Nicotinic acid	16.0 gm.
d-pantothenic acid	12.0 gm.
Choline chloride	100.0 gm.
Vitamin B_{12}	18.0 mg.
Zinc	68.0 gm.
Manganese	34.0 gm.
Iodine	2.5 gm.
Copper	9.0 gm.
Iron	54.0 gm.
Antioxidant*	45.0 gm.
Carrier (Ground yellow corn)	To bring total to 10 lb.

Suggested ingredients: Vitamin A palmitate in gelatin, vitamin D_2, riboflavin, calcium pantothenate, nicotinic acid or nicotinamide, choline chloride, vitamin B_{12} supplement, manganous carbonate, ferrous carbonate, cuprous hydroxide, calcium iodate, zinc carbonate.

**Butylated hydroxyanisole (BHA) and/or butylated hydroxytoluene (BHT).*

The Michigan State University Vitamin-Trace Mineral Premix has purposely been over-fortified so that one premix can suffice for all ages of swine. The quantity of vitamins that are commonly present in the basal feeds has been disregarded because of the uncertain amounts that may be present.

The swine producer should plan to purchase the vitamin-trace mineral premix already mixed from a commercial supplier. A number of brokers or companies are prepared to market such premixes, manufactured to the customer's specifications, for less cost than they can be prepared by the farmer. No more than 3 to 6 month's supply should be purchased at one time, and the premix should be stored in a cool, dry place.

The Michigan State University Swine Supplement is designed for those farmers who have an automatically controlled grinder-mixer with a proportioning device. If a batch mill is used, these ingredients may

Table 13. — Michigan State University Swine Supplement.

Ingredient	Amount
Salt	10 lb.
Limestone (38% calcium)	20 lb.
Dicalcium phosphate	20 lb.
MSU vitamin-trace mineral premix	10 lb.
Carrier - ground yellow corn	40 lb.
	100 lb.

NOTE: The addition of two pounds of fat in place of a like amount of corn will reduce dustiness and may prevent some separation. Antibiotics and/or other feed additives should be included in the above supplement as warranted by individual farm conditions.

Table 14. — Michigan State University "16 Percent" and Michigan State University "12 Percent" Complete Feeds.

Ingredient	MSU 16	MSU 12
Corn	1,480 lb.	1,710 lb.
Soybean meal (44%)	420 lb.*	190 lb.*
MSU supplement	100 lb.	100 lb.
	2,000 lb.	2,000 lb.

**50 percent soybean meal can be substituted for the 44 percent meal by reducing the amounts to 360 and 160, respectively, and replacing it with corn.*

be added individually to the ground corn and soybean meal required to make MSU 12 and MSU 16 percent complete feeds.

Michigan State University 16 percent ration — can be used for the following classes of swine:

Lactating sows and gilts
Boars
Growing pigs 30 to 125 pounds

Michigan State University 12 percent ration — can be used for:

Replacement gilts — 200 pounds to breeding
Bred sows and gilts
Finishing pigs — 125 pounds to market

FACTORS TO CONSIDER BEFORE STARTING A HOME-MIXING PROGRAM

1. Some nutritional knowledge is essential if any formulation decisions are to be made. There must also be time to study, interpret and plan.

2. The operation must be large enough to justify the investment of capital to save labor and improve efficiency. Several estimates place the minimum feed volume between 100 and 150 tons annually. This amount is needed for the output of 15 to 20 sows on a 2-litter program. When 100 tons are processed, fixed and operating costs are estimated at $3.00 to $4.00 per ton. This compares with $4.00 to $4.50 cost per ton when these processing services are purchased.

3. Equipment needs include a grinder-mixer, storage bins, small mixer, scales, augers, etc.

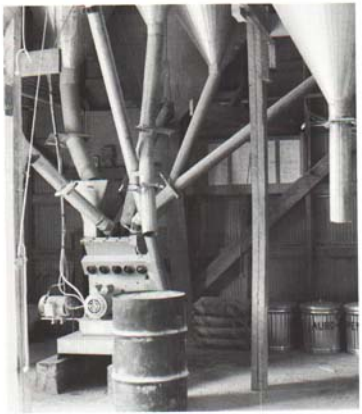


Figure 8. — This kind of grinding, metering, and mixing equipment requires a sizeable volume to be economical.

4. Fixed investments mean some loss of flexibility. Investment in feed processing equipment is a commitment to stay in the livestock business, for only by steady use over a period of time can the investment be recovered.

5. Feed costs should include labor, depreciation, taxes, insurance, and interest on investment as well as ingredient costs.

6. There must be a readily available supply of ingredients (soybean meal, premixes, vitamins, antibiotics, drugs, etc.) at a fair price. Bulk buying in volume at discount prices is essential to the success of a home-mixing program.

7. Inventory, quality control, and nutrient storage losses may cause problems and costs. Storage time should not exceed 3 to 6 months.

8. The vitamins, minerals, and antibiotics to fortify a ton of Michigan State University 16 percent complete feed should not cost more than $5.00 to $6.00.

9. When all factors are considered, unless the ingredients which go to make up a protein supplement can be purchased for about $20.00 cheaper than a good commercially prepared supplement, there will be little advantage in a home mixing program. This will leave enough to cover interest on investment, taxes, labor, and other overhead costs.

DETERMINING THE PROPORTION OF CORN TO PROTEIN SUPPLEMENT TO USE IN RATIONS

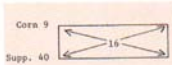
Below is a simple method of determining how much grain and how much protein supplement to use to make a mixture with a certain protein content. In this example, a mixture containing 16 percent protein is to be made from corn containing approximately 9 percent protein and supplement containing 40 percent protein.

Draw a square. In the center of the square, put the protein content desired in the final mixture.

At the upper left-hand corner of the square, write "corn" and its protein content (9); at the lower left-hand corner, write "supplement" and its protein content (40).

Subtract diagonally across the square (the smaller from the larger), and enter the results at the corners on right-hand side ($16 - 9 = 7$; $40 - 16 = 24$).

The number at the upper right-hand corner gives the parts of corn, and the number at the lower right-hand corner, the parts of supplement needed to make a mixture with 16 percent protein.



24 parts corn or 77%
(24 ÷ 31 = .77 x 100 = 77%)

7 parts supplement or 23%
(7 ÷ 31 = .23 x 100 = 23%)

31 parts

Therefore, a mixture of 77 pounds of corn and 23 pounds of protein supplement would make a ration containing 16 percent protein.

Calculating the protein content of a ration

Ingredient	% Protein in feed
1,524 lb. ground corn	times 0.09 = 137.16
150 lb. soybean meal	times 0.44 = 66.00
100 lb. meat and bone meal	times 0.50 = 50.00
200 lb. alfalfa meal	times 0.17 = 34.00
6 lb. dicalcium phosphate	
10 lb. salt	
10 lb. vitamin-trace mineral premix	
2,000 lb.	287.16

287.16 ÷ 2,000 = 0.143 x 100 = 14.3% protein

FEEDING THE SOW HERD

PRE-BREEDING AND BREEDING SEASON

Gilts retained for breeding purposes should be removed from the feedlot at 175 to 200 pounds (5 months of age) and hand-fed a 12 percent ration (MSU 12) until they are 7.5 months of age. Usually 4 to 5 pounds of feed per day will keep them in a good growing condition. If on good pasture, this amount can be cut to 2 to 3 pounds.

At 7.5 months of age, start flushing the gilts by hand-feeding 7 pounds of a 12 percent protein ration (MSU 12), or put them on a self-feeder. One week later, turn in the boar and continue to flush during the three-week breeding period. Remove the gilts from the breeding pen when it is evident that they have been serviced.

HAND-FEEDING SOW AND GILTS DURING GESTATION

The feeding of brood sows and gilts during gestation offers a great potential for feed saving. Sows and gilts kept in a thin to medium condition farrow just as many or more pigs than sows permitted to become fat. They also have fewer problems at farrowing time. The amount of feed listed below should be used as a guide, but the actual day-by-day feeding will depend on the condition of the sows. The caretaker must make the necessary adjustments. Once-per-day feeding is just as good as twice-per-day feeding.

KIND AND AMOUNT OF FEED DURING GESTATION

	Ration	*On Pasture*	*In Dry Lot*
Gilts	MSU 12%	4 pounds	5 pounds
Sows	MSU 12%	3 pounds	4 pounds

Table 15. — Gestation Rations for Hand-Feeding Sows and Gilts.

Ingredient	MSU 12	Ration A	Ration B
Ground corn	1,710	1,592	1,292
Soybean meal	190	100	100
MSU supplement	100		
Ground oats			300
Alfalfa meal		200	200
Meat and bone meal		75	75
Dicalcium phosphate		7	7
Limestone		6	6
Trace mineral salt		10	10
MSU vitamin-trace mineral premix*		10	10
	2,000 lb.	2,000 lb.	2,000 lb.

*Listed on page 14.

Some farmers prefer to hand-feed corn and protein supplement, rather than feed a mixed ration. When this method of feeding is used, it is preferable to feed one ingredient at night and the other in the morning. If both ingredients are fed at the same time, the timid sows are often fought away from the supplement and consume mostly corn. Feeding stalls help to solve this problem.

Regulate the quantity of corn fed to keep the animals in a medium condition. Gilts should receive one pound of a 40-percent protein supplement daily, and sows two-thirds of a pound, to meet their protein requirement. A satisfactory protein supplement is listed on page 7.

Sows and gilts can be used to glean corn fields in the fall, but it is difficult to prevent them from becoming over-fat. It is usually wise to let finishing hogs clean up most of the corn before turning in the sow herd. When this is not possible, corn intake can be curtailed by allowing the sows access to the corn field every third day.

SELF-FEEDING DURING GESTATION

There are two ways of self-feeding during gestation. The most common method is to self-feed the sows a bulky ration. This method gives satisfactory sow performance, but grinding costs and excessive feed intake make it expensive. When justified because of a labor situation, the following ration can be fed:

Table 16. — Bulky Ration for Self-Feeding During Gestation.

Ingredient	Amount
Ground shelled corn	600 lb.
Ground oats	600 lb.
Ground alfalfa hay or alfalfa meal	600 lb.
Soybean meal (44%)	120 lb.
Meat and bone meal	60 lb.
Salt	10 lb.
MSU vitamin-trace mineral premix	10 lb.
	2,000 lb.

If sows have a tendency to become over-fat, substitute ground ear corn for the ground shelled corn.

A second method of self-feeding sows is to feed a high-energy ration (MSU 12), but limit the access to the self-feeder. Sows are simply shut away from the feeder for 2 days out of 3. This method has proven to be quite satisfactory in regulating feed intake, and the performance has been as good as hand feeding 4 pounds of feed every day.

SILAGE FEEDING DURING GESTATION

Corn silage is available on many dairy and beef farms and makes an excellent feed for brood sows. However, unless the sow herd is extremely large, it would not pay to construct a silo if there is no other silage-consuming livestock on the farm.

Silage serves as a substitute for pasture and alfalfa meal. It should be fed fresh daily in amounts the sows will clean up in 2 to 3 hours. Sows will usually eat 10 to 15 pounds, and gilts, 8 to 12 pounds. Some wastage can be expected. It is important that the silage be supplemented with 1.0 to 1.5 pounds of a good protein supplement per head daily. Feed additional corn, if necessary, to keep sows in proper condition. The following precautions should be noted:

1. Never feed silage alone or a poor pig crop will result.

2. Silage causes digestive upsets (diarrhea) in baby pigs. Do not feed it to lactating sows.

3. Avoid feeding moldy silage. It can cause sows to abort.

ANTIBIOTIC IN BROOD SOW RATIONS

Experimental results have been somewhat inconclusive regarding the value of antibiotics in the brood sow ration. In some tests Aureomycin or Terramycin fed during the breeding season have resulted in larger litters farrowed. In other tests, antibiotics had no effect.

On some farms where baby pig scours are a perennial problems, furazolidone (NF-180), fed at the rate of 150 grams per ton of complete feed for one week before and two weeks after farrowing, has improved the situation.

PASTURE FOR BROOD SOWS

Good legume pasture is an excellent feed for brood sows but it is not indispensable. The decision of whether to feed on pasture or in dry lot will depend on whether the land can be put to a more profitable alternative use.

Research data supports the conclusion that three pounds of feed per head daily on pasture provides a gain of sows and gilts during pregnancy equal to four pounds per head daily in dry lot. On this basis, it has been calculated that one-acre of alfalfa pasture has a feed replacement value of approximately 1000 pounds ($25 to $30) when stocked at the rate of 10 animals per acre.

Land not suitable for a continuous cropping program is often available on farms. Under these circumstances, a forage crop can be utilized to advantage by brood sows. The farrowing and weaning records are about the same for sows and gilts fed in drylot as compared to those fed during gestation on legume pasture.

ALFALFA MEAL FOR BROOD SOWS

The favorable results obtained from feeding a corn-soybean meal ration, properly fortified with vitamins and minerals, has caused researchers to question the importance of alfalfa meal in the gestation ration. Alfalfa meal will supply nutrients such as vitamins, protein, and calcium, but these can usually be purchased more cheaply from other sources. Until it has been definitely proven that alfalfa meal contains some unknown nutrient essential for improved reproductive performance, it is questionable whether it should be included in the ration.

Figure 9. — Profits start with the brood sow at farrowing time. Each pig lost is like throwing away a $5.00 bill.

Ground alfalfa hay is a good source of bulk in a self-feed gestation ration.

FEEDING SOWS AT FARROWING TIME

Move the sow to the farrowing house four or five days prior to farrowing. Hand-feed three to four pounds of the regular gestation ration, to which one to two pounds of wheat bran have been added. This makes the ration more bulky and has a laxative effect.

FEEDING SOWS AND LITTERS DURING SUCKLING PERIOD

Do not feed the sow the day she farrows. Starting the second day, feed three or four pounds per day of MSU 16 and gradually increase the amount until she is on full feed when the litter is 7 to 10 days old. A sow will eat about 12 pounds per day when on full feed. For maximum milk production, do not add bulky, high-fibrous feeds, such as alfalfa meal, to the lactation ration.

Table 17. — Recommended Lactation Rations for Sows and Gilts.

Ingredient	MSU 16	Ration A	Ration B
Ground corn	1,480	1,580	1,270
Ground oats			350
Soybean meal (44%)	420	290	250
MSU supplement	100		
Meat and bone meal		100	100
Limestone		10	10
Salt		10	10
MSU vitamin-trace mineral premix*		10	10
	2,000 lb.	2,000 lb.	2,000 lb.

*Listed on page 14.

CREEP FEEDING BABY PIGS

The money spent for pelleted commercial pig starters is usually money well spent. They contain the

vitamins and antibiotics necessary for getting the pigs off to a good start. Rarely will pigs eat any quantity of creep ration before they are three weeks old. This is especially true if the sow is a heavy milker. Pigs can be encouraged to eat by placing a small handful of pellets in a shallow pan or on the floor in the sleeping area. Replace with fresh pellets each morning until the pigs begin to eat. Floor feeding of sows will also help to teach pigs to eat. It should also be remembered that pigs will consume more creep ration and gain faster if they have free access to fresh water.

An economical creep ration which will also control anemia can be made by mixing 90 parts of MSU 16 ration and 10 parts of ferrous sulfate. It is important to place the mixture where it will be readily consumed by the pigs. This high-iron feed should not be fed after weaning because of potential toxicity problems. Another mixture which may be used is as follows:

Table 18. — Recommended Creep Ration.

Ingredient	Amount
Ground corn	1,044 lb.
Rolled dehulled oats	200 lb.
Soybean meal (50%)	300 lb.
Dried skim milk (or buttermilk)	300 lb.
Sugar	100 lb.
Limestone	18 lb.
Dicalcium phosphate	8 lb.
Salt	10 lb.
MSU Vitamin-trace mineral premix*	20 lb.
Antibiotic	40 gm.
	2,000 lb.

*Listed on page 14.

FEEDING FROM WEANING TO MARKET

FREE-CHOICE VS. MIXED RATIONS

In designing the feeding program, each producer must decide whether free-choice feeding or mixed rations best fit the size and intensity of his particular operation. From a nutritional standpoint, neither program has shown consistent advantage over the other. The same can be said of feed cost when all factors such as labor, grinding, and mixing are included. However, ground mixed rations do have the following advantages:

1. More uniform performance can be expected. There are fewer "tail-enders" at market time. Thus, the use of facilities can be kept on schedule.

2. Protein supplement consumption is easier to control. Under free-choice feeding, the supplement consumption is markedly influenced by the palatability. Pigs will over-eat on soybean meal when it is fed as a single protein ingredient. *Rule of Thumb:* If pigs eat *more* than ¾ to 1 pound of supplement per head per day from 40 pounds to market weight, they are eating more than is required to meet their protein needs.

3. When on pasture, hogs of all weights usually gain faster on a mixed ration. The advantage does not seem to be so great in drylot.

RESTRICTED FEEDING

Construction of swine housing having partial slotted floors and long, narrow pens has created an interest in restricted feeding. Feed is dropped directly on the floor at frequent time intervals. Unless the quantity of feed dropped is restricted to what the pigs will clean up in 15 to 20 minutes, considerable feed wastage is encountered. Restricted feeding should not be practiced until pigs weigh at least 100 pounds.

When hogs are fed by this method, as compared to self-feeding, the following results can be expected:

1. Restricting feed intake reduces daily gain on the average .15 to .20 pounds with each 10 percent restriction. This decreased growth rate results in an increased feeding time of 7 to 10 days to reach market weight with each 10 percent restriction.

2. The optimum level of feed restriction appears to be 75 to 80 percent of full feed. Restriction beyond this level increases the feed required per pound of gain.

3. Restricted feed intake improves carcass quality. The carcasses have less backfat and a higher yield of preferred lean cuts.

PREPARATION OF FEEDS

FINENESS OF GRIND

Fine to medium grinding of corn improves feed efficiency, as compared to coarsely ground or shelled corn. This is particularly true in the case of hogs over 100 pounds in weight. Fine grinding will cause some bridging in self feeders.

Feed grains with a considerable amount of hull, such as oats and barley, should be finely ground.

PELLETING FEEDS

Research data has not shown consistent advantages of pelleting complete feeds over meal form. Pelleted feeds are less dusty, easier to handle, and usually reduce feed wastage. From a feed cost standpoint, it appears questionable if pelleting is justified except in the case of high fiber rations.

SLOP FEEDING

Soaking or slop feeding will definitely cut down on feed wastage. In some cases it will increase feed con-

sumption and improve rate of gain. Labor costs are generally higher than self-feeding. When hogs are limit fed, there appears to be some advantage in wetting a complete ground mixed ration with equal weight of water at feeding time.

HIGH-MOISTURE CORN

In general, high-moisture shelled corn has not shown any advantage over regular dry corn for growing-finishing swine, whether the corn was stored in regular silos or in air-tight storage. Therefore, the decision to feed high-moisture corn must be based on whether this type of harvesting and storage fits best into the corn operation. A farmer is not justified in constructing a silo just to feed high-moisture corn.

Feeding high-moisture corn is somewhat of a problem. It is usually very palatable and when fed free-choice, pigs will often over-eat on corn and under-eat on protein supplement. When the two are metered together, separation is likely to occur. Some producers grind the quantity of corn needed each day in order to mix it with protein supplement. This adds labor and extra cost.

High-moisture corn should be fed fresh daily to prevent spoilage and caking in feeders. In winter months it will often freeze in outside feeders. One inch or more must be taken off the top of a silo to prevent spoilage in warm weather.

EFFECT OF HEATING ON FEEDING VALUE OF CORN

Some chemical changes do occur when grains heat in storage or are subjected to artificial heat in drying. However, the changes due to heat are usually relatively small and the energy value remains surprisingly good. Considerable loss in carotene content can be expected. In most instances, other factors such as molds and fungi cause more damage to the grain than heating.

Various experiments have been run to determine the effect of artificially drying at low and high temperatures. The nutritive value of corn was not affected.

RATIONS FOR GROWING-FINISHING HOGS

MSU 16 ration (listed on page 14) is designed for feeding pigs from 30 pounds to 125 pounds, and MSU 12 ration from 125 pounds to market weight. Other feed grains can be substituted for corn when price justifies. It should be remembered that fibrous feeds such as corn cobs, ground alfalfa hay, and hulls merely reduce rate of gain and increase the feed required per pound of gain.

Farmers desiring to prepare a home-mixed protein supplement to feed free-choice or to mix with home-grown grains can refer to Table **19.** Supplement A is designed for self-feeding pigs from weaning to 125 pounds and for hand-feeding sows and gilts during gestation. Supplement B can be self-fed satisfactorily to finishing hogs from 125 pounds to market weight.

Table 19. — Recommended Protein Supplements.

Ingredients	Supplement A	Supplement B
Soybean meal (44%)	1,300	1,200
Meat and bone meal	350	360
Alfalfa meal	200	300
Limestone	60	60
Dicalcium phosphate	40	30
Trace mineral salt (Hi Zinc)	50	50
	2,000 lb.	2,000 lb.
Crude protein, %	39.0	38.0
Calcium, %	3.77	3.74
Phosphorus, %	1.59	1.50
Recommended additions of vitamins and minerals to the above supplements.		
Vitamin A (I.U.) millions	13.5	12.0
Vitamin D (I.U.) millions	2.7	1.5
Riboflavin (gm.)	7.5	5.0
Pantothenic acid (gm.)	50.0	70.0
Nicotinic acid (gm.)	80.0	70.0
Choline (gm.)	500.0	400.0
Vitamin B_{12} (mg.)	70.0	70.0
Antibiotic (gm.)	100.0	70.0

Table 20. — Nutrient Content Percent of Commonly Used Feedstuffs.

Ingredient	Protein	Calcium	Phosphorus
Corn	9.0	0.02	0.26
Barley	11.5	0.08	0.38
Oats	12.0	0.09	0.39
Grain sorghum	10.5	0.03	0.30
Wheat	12.7	0.05	0.39
Dehulled oats	15.0	0.07	0.46
Soybean meal	44.0	0.30	0.64
Meat and bone meal	50.0	9.85	4.50
Fish meal (Menhaden)	61.0	5.00	3.30
Tankage	60.0	6.30	3.25
Alfalfa meal	17.0	1.55	0.25
Skim milk dried	34.0	1.27	1.00
Whey, dried	12.0	0.90	0.72
Bone meal (steamed)		26.00	14.00
Dicalcium phosphate		24.00	18.00
Limestone		38.00	

Table 21. — Estimated Amounts of Feed Required per Hog, by Periods.*

	Ave. daily feed intake	Per sow		Per pig raised		
		Grain	Suppl.	Grain	Suppl.	Creep
Gilts to breeding age	5.0	329	46	41	6	
Breeding season	7.0	172	24	22	3	
Gestation	5.0	456	114	57	14	
Lactation (5 week weaning)	12.0	336	84	42	11	14
Grower (30 to 125 pounds)	4.0			224	56	
Finisher (125 to 200 pounds)	7.0			275	40	
Boar (24 litters)	6.0			9	2	
		1,293	268	670	132	14

*Assumed 8 pigs raised under drylot conditions.

EFFECT OF SEX ON PERFORMANCE OF GROWING-FINISHING PIGS

When full-fed, boars consume less daily feed than barrows or gilts, but are 10 to 15 percent more efficient in feed conversion. Boars also gain faster than barrows or gilts. Barrows gain approximately .10 pounds faster per day than gilts, which reduces their age at slaughter by 10 days. Feed per pound of gain is similar for barrows and gilts. Gilts yield carcasses having .11 inch less backfat, .52 square inches larger loin eye area, and 1.8 percent more lean cuts than barrows. Dressing percentage usually favors barrows, which is consistent with their greater depth of backfat.

Partial List of Manufacturers and Suppliers of Feed Additives.*

Vitamins A and D

Merck & Co., Inc., Rahway, New Jersey
Nopco Chemical Co., Newark, New Jersey
Chas. Pfizer & Co., Brooklyn 6, New York
Dawes Laboratories, Inc., Chicago, Illinois
Bowman Feed Products, Holland. Michigan
Standard Brands, Inc., New York, N. Y.

Antibiotics and Arsenicals

American Cyanamid Co., New York 20, N. Y.
Merck & Co., Inc., Rahway, New Jersey
Chas. Pfizer & Co., Brooklyn 6, New York
Dawes Laboratories, Inc., Chicago, Illinois
Commercial Solvents, New York, N. Y.
Abbott Laboratories, North Chicago, Ill.
Dr. Salsbury's Laboratories, Charles City, Iowa

Vitamin - Antibiotic - Trace Mineral Premixes

Nopco Chemical Co., Newark, New Jersey
Chas. Pfizer & Co., Brooklyn 6, New York
Dawes Laboratories, Inc., Chicago, Illinois
Davis Enterprises, Dayton, Ohio
Ray Ewing Co., Pasadena, Calif.
Hoosier Mills, Inc., Marion, Indiana
Specifide, Inc., Indianapolis, Ind.
Holt Products Co., Milwaukee, Wisc.

B Vitamins

Merck & Co., Inc., Rahway, New Jersey
Chas. Pfizer & Co., Brooklyn 6, New York
Dawes Laboratories, Inc., Chicago, Illinois
Commercial Solvents, New York, N. Y.
U. S. Industrial Chem. Co., New York 16, N. Y.

*The above list is not complete; it is intended to indicate possible sources of certain feed additives. Some suppliers sell only to licensed feed manufacturers.

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