On Farm Feed Processing
Michigan State University
Cooperative Extension Service

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COOPERATIVE EXTENSION SERVICE • MICHIGAN STATE UNIVERSITY

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Storage and Handling of Ingredients

Swine rations consist of processed grain (usually ground), a protein source (usually soybean meal), macro-minerals (salt, calcium, phosphorus), and a vitamin, trace-mineral and antibiotic pre-mix. Other ingredients are sometimes added. A milk by-product is frequently included in starter rations. Lactation rations frequently include ground oats, wheat bran or other ingredients to provide bulk. Some producers like to include alfalfa meal in gestation and lactation rations.

Grain for swine rations can be ground, rolled, roasted, steam flaked, popped or processed by other methods. Whole soybeans can be roasted for swine rations. High moisture grain can be fed free-choice with complete supplements. Dry rations can be moistened for feeding as a paste or fed in the water. While all these methods have been used to some extent, the majority of swine rations involve dry, ground grain and soybean meal, thoroughly mixed with the other ingredients and fed in dry form in self-feeders.

All swine rations should be formulated by a competent swine nutritionist. The animal science department, extension swine specialist, or county extension agent of your state's land-grant university can provide suggested rations. Substitute ingredients only after checking with your nutritionist. Use feed additives only as directed, and observe withdrawal restrictions.

Complete Swine Rations

Five methods of obtaining complete swine rations can be outlined as follows (Fig. 1):

- Complete commercial rations can be delivered directly to bulk tanks or self feeders on the farm. The cost of this service includes mark-up on ingredients and charges for grinding, mixing and delivery.
- Farmers producing both grain and swine can deliver and/or store grain at a commercial elevator which has feed milling capabilities. Complete rations may be delivered back to the farm or hauled by the producer. Cost includes handling and storage charges, mark-up on ingredients and charges for grinding, mixing and delivery.
- Complete supplements can be purchased for mixing with ground grain on the farm. Two or three different supplements are usually required for farrow-to-finish systems. Supplements required in small quantities are purchased in bags. Larger volumes usually justify bulk handling. When bulk supplements are delivered to the farm, service costs include mark-up, mixing and delivery.
- Base mixes can be purchased in bags and mixed with soybean meal and ground grain on the farm. Two or three different base mixes may be used for farrow-to-finish systems. Base mixes, as defined in Figure 1, are sometimes called pre-mixes.
- Base mixes can be prepared on the farm. An appropriate size and design mixer is essential to insure adequate mixing. In general, horizontal mixers perform more satisfactorily than vertical mixers. Each base mix is then mixed with soybean meal and ground grain to produce the ration. Required bagged ingredients include: salt, calcium source, phosphorus source and vitamin, trace-mineral and antibiotic pre-mixes. The base mix method offers greater flexibility in ration formulation, lower ingredient costs, and is used by many producers with 60-sow or larger operations.

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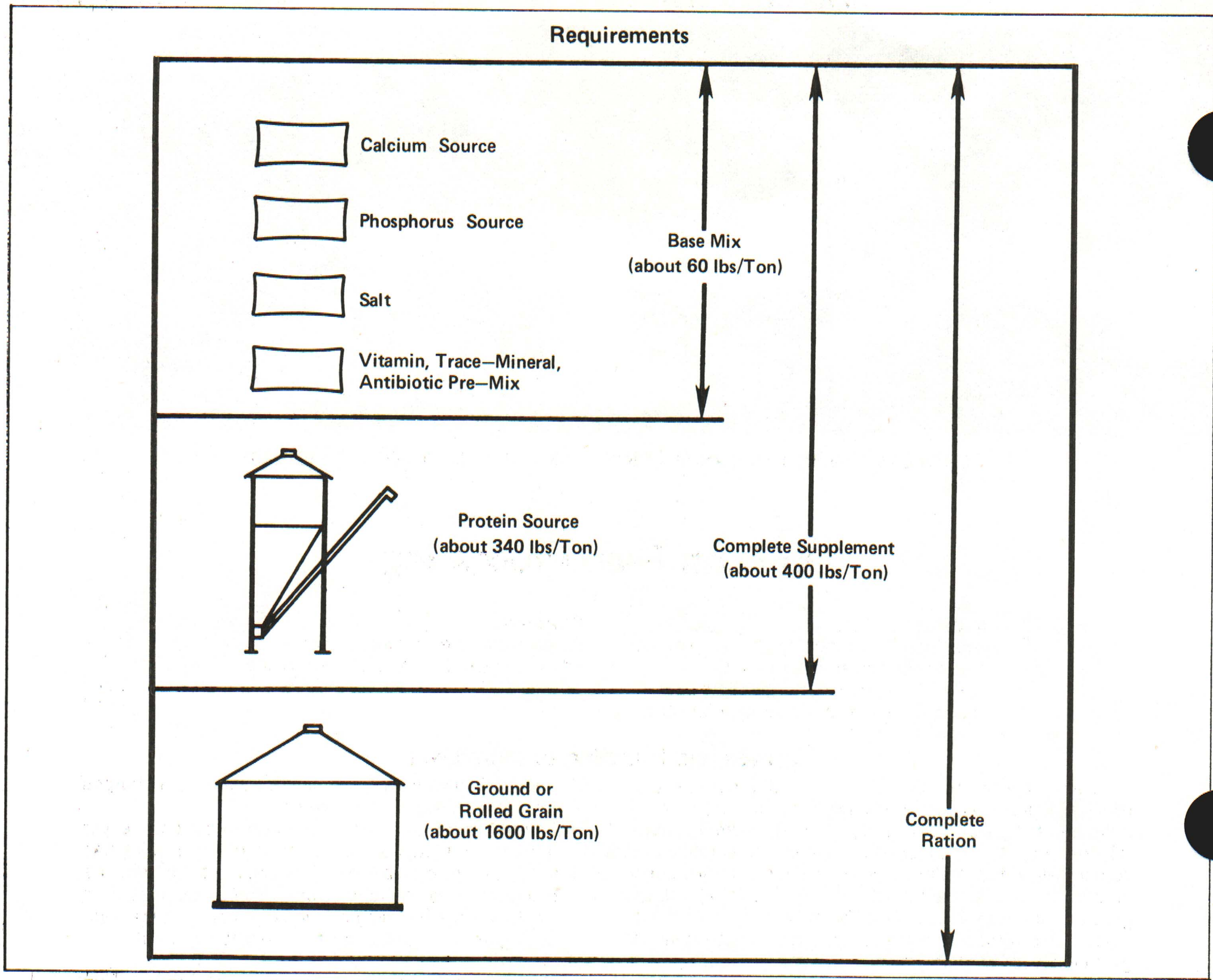

Figure 1. Requirements of complete swine rations.

Planning Ingredient Storage

When swine rations are processed on the farm, ingredient storage space should be available to carry the system for a reasonable period. Allowance should be made for bad weather, delayed deliveries, and rush seasons. A minimum two-week supply of ingredients should be maintained. Price advantages from timely, seasonal or volume purchases should be weighed against the cost of ingredient storage. Volume purchases of grain and soybean meal may reduce the number of adjustments required in rations since adjustments must be made when moisture, protein, energy, fiber or other contents of ingredients change appreciably.

Table 1, intended only as an aid in planning ingredient storage requirements, presents approximate ration compositions. Table 2 gives approximate ingredient needs for various production units and periods. The values of Table 2 may be multiplied by the appropriate number of production units to determine approximate needs of a specified system.

Types of Storage

Feed ingredients are stored or temporarily held in a variety of structures. The following are normally employed:

- Ground level, flat-bottom bins with unloading augers are normally used for storage of grain. These bins may be sized for a two-week to one-month supply (in systems where all grain is purchased). Or they may hold a one-year supply when the producer is feeding grain he produced. Ground-level, flat-bottom bins cost about $40 to $50 per ton capacity, on a turn-key basis.
- Ground-level, hopper-bottom bins are normally used for soybean meal, complete rations and/or grain, such as oats, required in relatively small amounts. These bins cost two to three times as much per ton capacity as flat-bottom bins.
- Overhead bins normally are used to provide gravity flow to processing or mixing equipment. Because these bins are expensive (about twice the cost per ton capacity as ground-level, hopper-bottom bins), their use must be justified by flexibility, efficiency and labor savings in feed preparation. In high volume systems, overhead bins are sometimes used to temporarily hold complete rations. Overhead bins are called working bins and are not intended for storage.
- Bagged ingredients are normally stored on pallets or a raised wooden platform. Small pallets can be moved by hand truck.

Table 1. Approximate ration composition.

Ingredient	Ration* Gestation	Lactation	Creep	Growing	Finishing
	(lb./ton)	(lb./ton)	(lb./ton)	(lb./ton)	(lb./ton)
Grain (corn, grain sorghum, wheat, oats, etc.)	1550	1450	1250	1550	1650
Protein meal (soybean, meat and bone, peanut, etc.)	300	300	550	400	300
Ingredients for bulk (wheat bran, alfalfa meal, etc.)	100	200	----	----	----
Macro-minerals (salt, calcium, phosphorus)	50	50	50	50	50
Milk by-products	----	----	150	----	----
Vitamin, trace-mineral, antibiotic premix	5-10	5-10	5-10	5-10	5-10

*This table **should not** be used to formulate rations.

Table 2. Approximate ingredient needs for various production units.

Ingredient	100 sow, farrow-to-finish continuous production, 200 litters, 1,600 hd/year			100 feeder pigs grown from 40 lb. to 220 lb. in 4 months			Producing 20 litters (160 hd) of feeder pigs
	1 week	1 month	Annual	1 week	1 month	4 months	Total
Grain	380 bu.	1,650 bu.	20,000 bu.	55 bu.	220 bu.	900 bu.	600 bu.
Soybean meal	2.2 ton	9.6 ton	115 ton	625 lb.	1.25 ton	5 ton	3.4 ton
Ingredients for bulk	550 lb.	1.2 ton	15 ton	----	----	----	1.5 ton
Macro-minerals	670 lb.	1.5 ton	17.5 ton	94 lb.	375 lb.	1,500 lb.	1,100 lb.
Milk by-product	30 lb.	120 lb.	1,400 lb.	----	----	----	140 lb.
Vitamin, trace-mineral, antibiotic pre-mix	70 to 140 lb.	300 to 600 lb.	1.8 to 3.6 ton	10 to 20 lb.	40 to 80 lb.	150 to 300 lb.	100 to 200 lb.
Totals	13.5 ton	58 ton	700 ton	1.9 ton	7.5 ton	30 ton	22 ton

More than one type of bin may be used for a single ingredient. As an example, large truckloads of soybean meal may be received in a ground-level, hopper-bottom bin. As needed for processing, the meal may then be transferred to an overhead, working bin.

Hopper-bottoms are probably most justified on those bins emptied and refilled many times and those for which complete clean-out is important. Complete clean-out is important in bins holding grain purchased in short intervals and in bins used for different ingredients at different times. Two bins, or a two-compartment bin, for a single ingredient will permit complete clean-out of one unit before using from the second, assuring no long carry-over of material in the bottom of a bin.

Hopper-bottoms must be steep enough to cause free flow of the material being held. Grains require a hopper slope of at least 45 degrees. Soybean meal is not a free-flowing material. Bins for soybean meal must be designed for the weight and flow characteristics of the material. Hoppers for bean meal must slope a minimum of 60 degrees unless a positive mechanical anti-bridge device is installed. Off-center hoppers (hoppered to one corner in rectangular bins or to the side in round bins) will also aid in controlling bridging. The best mechanical anti-bridge device, either commercial or home-made, consists of a rotating, vertical pipe with hanging chains. Vibrating devices have not proved effective in preventing bridging. Complete rations have somewhat better flow characteristics than soybean meal, but should also be held in 60 degree hoppers.

Soybean meal may be purchased either bagged or in bulk. The decision of which to use is based on the labor of handling bags, the cost of bulk storage and the higher cost of the bagged product. Processing feed for a 100-sow, farrow-to-finish system will require double handling of about 88, 50-lb. bags of soybean meal per week. Only about 26, 50-lb. bags of other ingredients will be used weekly.

Bin sizes, for ingredients received in bulk, are determined by the expected size of delivered lots. Common deliveries are 10-12-ton and 20-25-ton lots. Twenty to 40% carry-over capacity should be included in the bins.

Salt, calcium and phosphorus sources, milk by-products, and vitamin, trace-mineral pre-mixes are normally purchased and stored in bags. Enough bag storage space is needed for easy access to all ingredients.

In large systems, the labor and expense of handling bags will sometimes justify bulk purchase, handling and storage of truckload lots of all ingredients except vitamin, trace-mineral pre-mixes. Calcium, phosphorus and salt sources are corrosive and will draw moisture from surrounding materials. These minerals are commonly held in ground-level and overhead bins of wooden or steel construction. Corrosion in steel bins may be reduced by coating the inside with epoxy or other coating. Bins constructed of fiber glass or other non-corroding materials are available commercially.

Handling Ingredients and Feed

Auger conveyors commonly handle grain, soybean meal and mixed feed. Capacities vary, primarily according to auger diameter and operating speed. Four-inch diameter augers, operating at slow speed, can be matched to the capacity of PTO- or electric-powered mills. To save time and labor, at least 6-in., and preferably 8-in., diameter augers should be used for placing grain and soybean meal in storage and for load-out and delivery of finished feed.

For larger feed systems, and particularly those which include grain drying and storage, a bucket elevator should be considered. The original cost of a bucket elevator is higher than auger systems. But it has a lower power requirement and gives longer, more reliable service. A bucket elevator can replace several augers in a system.

Gravity spouts for dry grain must incline at least 37 degrees from horizontal (¾ ft. fall in 1 ft. run); spouts for wet grain must incline at least 45 degrees from horizontal. Gravity spouts for soybean meal must incline at least 60 degrees from horizontal (1¾ ft. fall in 1 ft. run).

Matching Flow Rates

Each component of the system must be able to handle the flow rate delivered to it. The full capacity of the limiting component will determine the system flow rate. A common example is a bin unloading auger supplying a PTO-powered portable mill. If exposure of auger to grain can be varied, then auger capacity can be matched to mill capacity. An alternate, although more costly approach, is to vary auger speed to match flow needs. Another solution is to construct a small surge hopper with a pressure switch to control the auger motor. An adjustable slide on the hopper is then set to match the mill capacity.

Bucket elevators with capacity of about 1,500 bu./hr. are well-matched to 6-in. downspouts and 6-in. bin unloading augers. Bucket elevators with 2,500-3,000 bu./hr. capacity are well matched to 8-in. downspouts and 8-in. bin unloading augers.

Weighing or Metering Ingredients

All ingredients must be combined in the proper proportions to produce the intended ration. Ingredients are weighed individually in systems which produce batches of feed and are metered together in the proper flow rates in systems which produce a continuous-flow of feed.

Portable grinder-mixers and portable mixers with built-in electronic scales are available. The scales are sufficiently accurate for weighing grain and soybean meal. They are not adequate for small quantities, such as minerals and pre-mixes.

A number of continuous weighing devices are available for attachment to augers for volumetric or weight determination of output. Most of these devices have a 2-chamber design that flip/flops or a trip weigher to measure small unit quantities continuously. These devices are usually sufficiently accurate for grain and soybean meal, but not for minor ingredients.

Metering devices must be calibrated. This simply means determining meter output with respect to its dial or lever setting. Output from the meter is collected for a short period, usually one minute, and then weighed. The longer the collection time, the greater the accuracy, but also the greater the quantity to be handled per check. Repeating this procedure over the range of possible settings yields a calibration table or curve. The desired output is then obtained by making the proper setting.

Automatic electric mills usually have four or more metering channels, all of which must be calibrated. The meters must then be set with respect to one another. Since swine rations are predominantly grain, the meter handling the grain should be set first. The remaining metering devices are then set to deliver a flow rate in the proper proportion to the set flow rate of grain.

After the mill is calibrated and settings are determined for each ration, they should be recorded. Rations can be duplicated simply by duplicating the meter settings.

Rations are formulated by weight. Metering devices meter by volume. If the bulk density (test weight) of an ingredient changes, the device must be recalibrated. If the moisture content of an ingredient changes appreciably, then the rations must be reformulated and the mill recalibrated. In addition, metering devices are sensitive to the flow characteristics of ingredients which may change from one delivered lot to the next.

Systems for Preparation and Distribution

Mechanization is the replacement of manual labor with machines. Automation is mechanization carried to the point that, with the proper control system, no operator or attendant is required. Automation means unattended operation.

While most modern farm chores are mechanized, only a relative few have been automated. Feed processing is one of those chores for which automation is both possible and practical.

Batch vs Continuous-Flow Processing

With batch processing of feed, individual ingredients are weighed, ground or rolled (in the case of grain) and mixed in batches. In some large commercial mills, batch processing is automated, even computer-controlled. Lack of volume prohibits complete automation of batch systems on most farms, although some steps can be automated. Pre-grinding grain to a holding bin and automatic delivery of batches of feed are examples of automated steps in a batch system.

With continuous-flow processing of feed, ingredients are metered into a mill and blended while the grain is ground. Automatic controls are built-in features of most continuous-flow mills. Pressure switches stop the mill when the supply of any ingredient is exhausted or when the bin to which feed is being delivered is full. Timers can also be used. Safety switches are built in to protect against mechanical failure.

Since continuous-flow processing is automated and does not require an operator, it can be low capacity. Many automatic electric mills operate 30 or more hours per week.

Alternative Systems

The swine producer who decides to process feed on the farm has a choice of several alternative systems (Fig. 2). Grains must be ground, all ingredients must be weighed or metered, then mixed and finally delivered to bulk tanks or feeders at point-of-use. Figure 2 illustrates basic systems, and Table 3 presents a summary of system features.

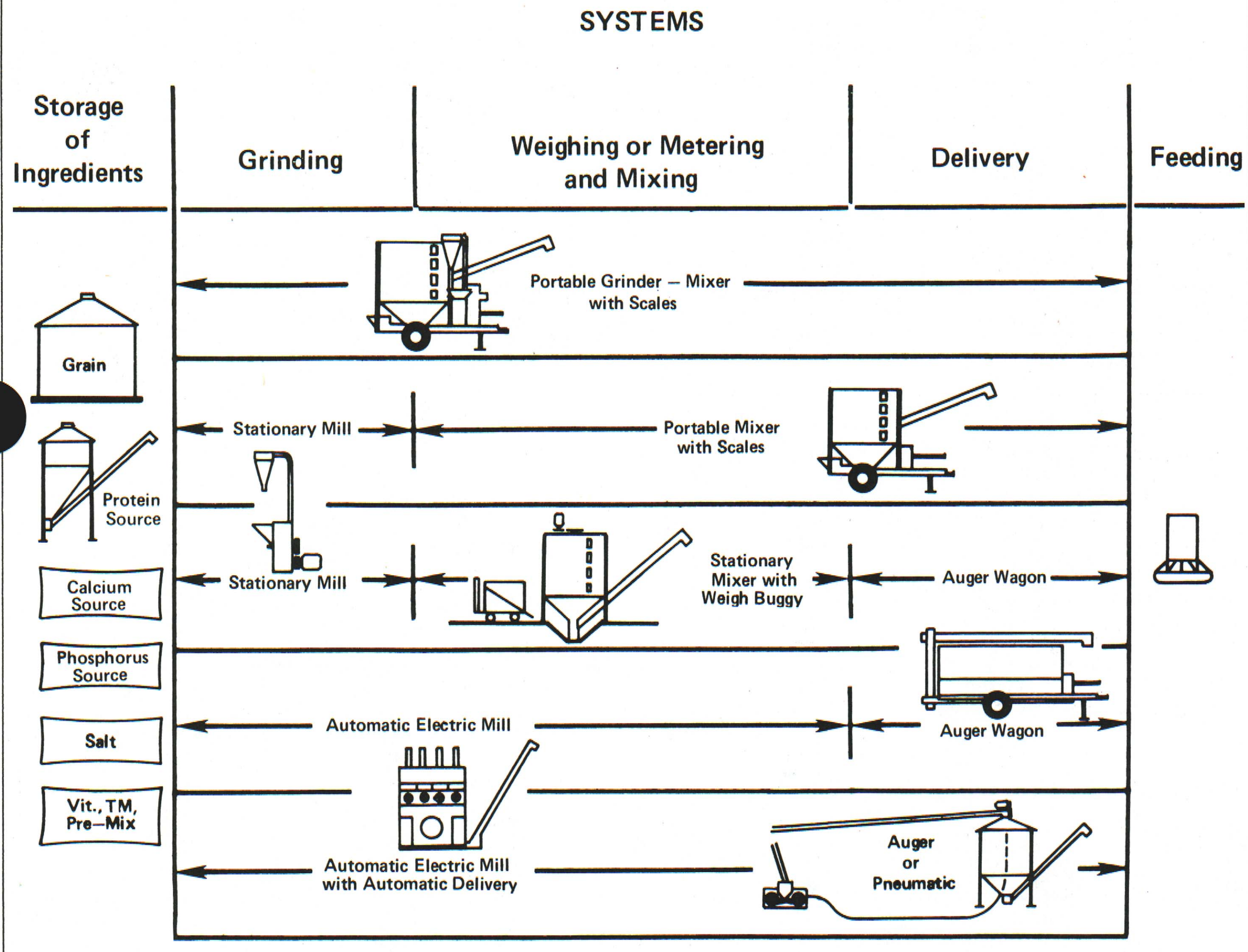

Figure 2. Alternative systems.

Table 3. Summary of basic systems.

Type of system	Usual break-even volume*	Advantages	Disadvantages	Comments
Portable grinder-mixer	200-400 tons/yr. (30-60 sows)	1. Portable-can pick up and deliver at existing facilities 2. Can grind hay	1. Highest labor 2. Highest operating cost 3. Requires a tractor	1. The most popular first system 2. Purchase of a used unit allows inexpensive start of on-farm processing
Mill with portable mixer	200-400 tons/yr. (30-60 sows)	1. Can pre-grind grain 2. Pick up and delivery at existing facilities	1. High labor 2. High operating cost 3. Requires tractor or truck	1. Mill may be stationary or portable 2. Mill can be located at grain storage
Stationary mill with stationary mixer	200-400 tons/yr. (30-60 sows)	1. Excellent control of ration composition 2. Can pre-grind grain 3. Can include automatic delivery	1. High labor 2. Components must be matched 3. May not be able to use existing facilities	1. Favored by producers who want direct control over ration composition
Automatic electric mill	200-400 tons/yr. (30-60 sows)	1. Lowest labor 2. Lowest operating cost 3. Long service life 4. Can include automatic delivery	1. Must be routinely calibrated 2. Will not handle hay 3. May not be able to use existing facilities	1. Planning is required to make best use of automatic features
Package feed center with automatic mill	800-1,200 tons/yr. (100-180 sows)	1. Pre-engineered for reliability 2. Quick installation 3. Bucket elevator can serve surrounding storage 4. Can include automatic delivery	1. High cost due to overhead bins 2. Few options in size of unit	1. Additional space for sacked ingredients and ground-level storage of grain and soybean meal is normally required
Batching plant-highly mechanized	2,000-4,000 tons/yr. (300-600 sows)	1. Best ration control for high volume systems 2. Calibration not required	1. First cost requires high volume 2. Must be custom built	1. Careful design is required for most efficient operation

*Actual break-even volume will depend on type and capacity of supporting equipment, storage, etc.

Portable Grinder-Mixer

Portable grinder-mixers are versatile. Portability is their major advantage. They can collect ingredients from a number of locations and process feed in batches. Grinding, mixing and delivery are provided in one machine. Portable grinder-mixers can be equipped to grind and handle hay.

Larger models usually have about 120 bu. (3 ton) capacity and require 60-100 hp. tractors as power units. About 20 minutes are required to grind grain for a 3-ton load. About one hour is required to collect ingredients, grind, mix and deliver a 3-ton load of finished feed.

Higher labor and operating costs are the major disadvantages of portable grinder-mixers. Both a tractor and an operator are required, and all ingredients must be weighed into the unit separately.

When shopping for a portable grinder-mixer, features that save time and labor, such as large, convenient hoppers and high grinding capacity, should be given priority. Augers driven by hydraulic motors improve reliability and electronic scales offer convenience.

Mill with Portable Mixer

A stationary or portable mill can be used to grind grain. A portable mixer is then needed to collect ingredients, mix the ration and deliver it to bulk tanks or feeders in batches.

Normally grain is ground as it is needed for individual batches. High grinding capacity is important to reduce the time required.

As an alternative, a low-capacity mill can be automated to pre-grind grain into a bulk tank. This can speed up mixing and delivery.

The portable mixer can collect ingredients from, and deliver rations to, several locations. Distances involved sometimes make a truck-mounted mixer more practical than tractor-drawn models. Portable mixers also can be equipped with electronic scales.

Stationary Mill with Stationary Mixer

A stationary mixer and a separate delivery wagon or truck can replace the portable mixer. For large swine systems, batches of feed can be delivered to bulk tanks by high capacity pneumatic system (conveying in an air stream) or by high capacity overhead conveyors. The stationary mixer can be mounted on scales to weigh ingredients. Or the ingredients may be weighed in a weigh buggy and then dumped into the mixer. Large capacity units increase time-use efficiency.

Automatic Electric Mills

Automatic electric mills are reliable and accurate if kept in calibration. They have low labor requirements and low operating costs, consuming about 3 kw-hr. of electricity per ton of feed.

These mills produce feed by metering ingredients together in the proper proportions. Mixing takes place in and beyond the grinding chamber. These mills will not handle hay. Capacities vary from 1 ton per hour for 3-hp. models to 8 tons per hour for 20-hp. models (roughly 600-800 lb. per hp.-hr.).

Automatic electric mills require a separate means of feed delivery. Grain and other ingredient storage must be convenient to the mill. Automatic electric mill use requires planning if full advantage of automatic operation is to be realized. While mill capacity is low, many automatic mills operate 30 or more hours per week producing complete rations for large swine systems with a minimum of operator time. However, automatic mills must be calibrated on a routine basis.

Package Feed Centers

Package feed centers are available in both batch and continuous-flow automatic types. Batch types consist of overhead bins, stationary grinding mill, stationary mixer, and required conveying equipment. Continuous-flow types consist of overhead bins feeding an automatic electric mill by gravity and a vertical, finished-feed auger. The area under the bins is enclosed to form a small building to house the mill. A bucket elevator and drive-over dump can be included in the package. Bucket elevators can serve surrounding grain bins as well as the overhead bins.

In package feed systems, pre-engineered for easy construction and reliable performance, all components are matched in capacity. However, they are usually more expensive than individually planned systems featuring all ground-level storage or utilizing existing space in buildings at hand. When quick construction is important or large annual feed volume will make use of the convenience features, package feed centers are justified.

Delivering Rations

Portable grinder-mixers, portable mixers and auger wagons or trucks can deliver feed to bulk tanks or directly to self-feeders. Feeders should be large to reduce both time involved and frequency of filling.

For most modern confinement buildings, feed is delivered to bulk tanks adjacent to the buildings, and conveyors move feed from the tanks to feeders inside the buildings. Additional labor can be saved by automatic delivery of feed to the bulk tanks.

With prior planning, feed can be automatically delivered from either a continuous-flow or a batch mill system. Overhead conveyors or a pneumatic system can be used.

With batching systems, overhead augers should be 6-in. diameter or larger and pneumatic systems should have 4-in. or larger lines. Small automatic mills can be served by 4-in. augers and 1½ or 2-in. pneumatic systems.

All buildings must be located close enough to the mill to make automatic delivery practical. Overhead conveyors can be cascaded over great distances. However, each separate conveyor involved reduces the reliability of the system. A practical limit for overhead conveyors appears to be in the 300-400 ft. range.

Pneumatic conveyors will deliver full volume for distances up to 600-800 ft. range. Beyond this distance, conveying capacity must be reduced or pneumatic systems must be staged. If all buildings in a swine system cannot be served by automatic delivery, plan first for the finishing building, where the greatest volume of feed is required.

A pneumatic system is preferred to overhead conveyors because it has a longer service life, is more reliable, and can be expanded simply by adding another line. Producers who have an automatic delivery system, particularly a pneumatic system, frequently refer to it as the "second half" of their feed system.

Cost Comparisons

Should a swine producer process feed on the farm or purchase commercial rations? If he processes feed on the farm, should he purchase complete supplements, base mixes and protein meal, or all ingredients separately? The answers to these questions lie in accurate cost comparisons.

Producers should determine the cost of all ingredients delivered, including their own time and expense if they do the hauling. Then they can figure the total ingredient cost for rations and compare them with the delivered cost of commercial rations. The result will be different for each producer, depending on hauling distance, source, and volume of each ingredient and distance to and the mark-up and service charge schedules of the commercial mill.

Costs of on-farm processing may be broken into two parts: fixed and operating. Fixed costs include depreciation, interest, property taxes and insurance. Operating costs include fuel, labor, electricity, repairs and maintenance.

Fixed costs per ton of feed decrease as feed tonnage increases. Operating costs per ton remain nearly constant regardless of volume. Consider both fixed and operating costs when comparing alternative systems.

Most producers find a cost advantage of $12-25 per ton when comparing the delivered cost of all ingredients with the delivered cost of complete rations. This cost advantage must be large enough to cover all fixed and operating costs, including labor, of the on-farm system. Obviously, higher annual tonnages of feed provide greater returns to on-farm processing. On-farm feed systems can require a great deal of labor and little capital or more capital and less labor, depending on the type of system chosen. Breakeven volumes for different systems normally range from 200 to 400 annual tons (roughly 30-60 sows, farrow-to-finish).

The decision to process feed on the farm also requires the owner be willing to devote management time to purchasing ingredients, staying up to date concerning use of additives, and maintaining quality control. If an employee will be responsible for feed processing, some training and continued supervision must be given, to avoid costly errors.

By purchasing one machine, a portable grinder-mixer, a swine producer can process his own feed. However, this alternative has the highest operating cost because both an operator and 60-100 hp. tractor are required.

For about the same first cost as a new portable grinder-mixer, an automatic electric mill can be set up for ground-level operation with a pre-mixer. And this alternative has the lowest operating cost.

If existing grain bins can be used by a portable grinder-mixer but not by an automatic mill, then total first cost will favor the portable mill. Package feed centers cost considerably more because of the high cost of overhead working bins.

The first cost of an auger wagon is comparable to the cost of a low volume pneumatic delivery system. But again, the feed center must be within about 600 ft. of the swine buildings to make automatic delivery practical.

Most swine producers gain their first experience with on-farm feed processing using a portable grinder-mixer. Later, as the enterprise enlarges and more time is required to process feed, many producers install centralized automatic electric mill systems. If possible, automatic delivery by pneumatic system is usually included. This means that planning for the automatic system should begin early—when the portable unit is placed in service. When high feed volumes are involved (more than 1,000 tons per year, 150 sows farrow-to-finish), the higher cost of package feed centers is usually considered justified because of greater convenience.

As swine systems continue to enlarge to 300-600 sows, farrow-to-finish (2,000-4,000 tons of feed per year), another set of circumstances frequently develops. Individual deliveries of ingredients are used up rapidly. Changes in moisture content, bulk density and flow characteristics necessitate frequent recalibration of automatic mills. Mill operation is frequently controlled by an employee who may not be sufficiently motivated or skilled to carry out accurate recalibration.

At these volumes, highly mechanized, high capacity batching systems become popular. Grains are usually pre-ground through an automated mill. Large mixers, with built-in scales, are supplied from overhead working bins and unload either to overhead load-out bins or to high capacity automatic delivery systems.

Other Economic Considerations

Before making a major investment in a feed system, the producer should consider the effects of investment credit, tax depreciation, interest charges and credit terms on his projected cash flow. This cash flow will help him determine if the investment will generate sufficient income to meet the short run repayment obligations of any required borrowed capital or if cash shortages will exist during the repayment period which will have to be met with other sources of income.

Other considerations, of course, exist. The farmer producing both grain and swine may simply wish to market some of his grain through livestock. Or a feed system may complement an existing or planned grain drying and storage complex.