10. DIET PROCESSING AND DELIVERY

Processing and delivery of feed to pigs is obviously a critical part of pork production. Whether feeds are prepared at a commercial feed mill or mixed on the farm, proper processing and delivery are absolutely essential to achieving high quality, consistent feed mixtures for pig consumption. Poorly processed feeds result in impaired feed utilization, poor performance and in some instances, serious health problems. Understanding the nature of feed processing, the reasoning behind each procedure and the needs of the pig are important to all pork producers, whether they buy prepared feeds or manufacture their own diets on the farm.

There are several reasons for processing diets before feeding them to swine:

1. To alter the physical form or particle size. For example, grains are ground to reduce particle size and thus improve their compatibility with other ingredients in the diet.

2. To improve nutrient availability. All grains must be ground before being fed to swine if nutrient availability is to be maximized. Studies at the University of Alberta found that lysine is 12% more available to the pig from ground wheat as compared to rolled wheat. The average improvement in availability of all essential amino acids is more than 6%. Pelleting and extruding are also processes used to improve nutrient availability.

Photo 10-1.

A modern commercial feed plant.
Photo courtesy of Federated Co-operatives Ltd.

3. To isolate specific parts of an ingredient. For example, oat hulls can be separated from oats to produce oat groats for use in starter diets. The remaining oat hulls can be used in gestating sow or cattle diets.

4. To improve handling. The objective of feed processing is to create a feed mixture that flows freely and does not separate. In some cases producers may wish to increase bulk density to reduce storage and hauling costs. For example, pelleting has been found to increase the bulk density of wheat shorts by 80%. Bulkiness of the feedstuff can also reduce feed intake. By increasing the physical density of the diet, daily nutrient intake can be improved. For example, gut capacity often limits the quantity of feed consumed by the young pig. Therefore, physical density of the feed will influence the young pig's nutrient intake.

5. To improve palatability. Mixing unpalatable, but necessary ingredients with those that are more appealing to the pig, increases the intake of required nutrients over the amount that would be eaten if ingredients were offered individually.

6. To preserve. Drying or treating high moisture grains with organic acids improves the length of time they can be stored.

7. To detoxify. Cleaning removes undesirable weed seeds that may prove to be toxic to the pig. Researchers are currently looking at chemical detoxicants as a way to improve the feeding value of moldy grains.

8. To create a uniform final feed mixture. This is particularly critical in feeds for young pigs, who eat relatively small quantities of feed per day. However, a proper feed mixture is necessary for all classes of swine to ensure that they achieve maximum performance. Research has shown that pigs do not possess "nutritional wisdom" to the extent that they will consume a properly balanced diet. They will seek out certain nutrients such as salt if required, but they are incapable of balancing a complete diet. For this reason, a nutritionally balanced mixed feed must be offered to pigs. If the feed is not uniform, daily nutrient intake could fall below requirement and thus impair performance.

A large number of processing methods are available to the swine industry. They include mixing, grinding, rolling, cracking, popping, extruding, micronizing (pulverizing), roasting, dry pelleting, steam pelleting, steam rolling and reconstituting. In practice, only a few, including mixing, grinding, extruding and steam pelleting, are commonly used. The selection of one or more processes will depend on the ingredients employed, the age of the pig being fed and the cost/benefit relationship.

Grinding

Grinding is an essential first step in manufacturing diets for swine. Whole grains are poorly utilized by the pig and un-ground grains do not create a very uniform medium for delivering minerals, vitamins and protein in the mixed feed. It may surprise some that older pigs benefit more from ground feed than younger pigs because as pigs age, they grind their food less before swallowing (Figure 10-1).

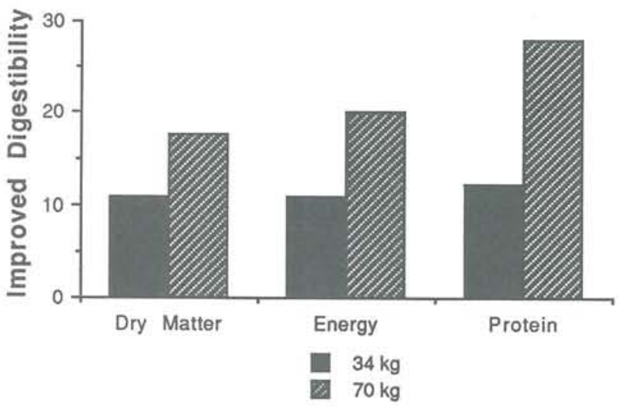


Figure 10-1. Improvement due to Grinding on the Digestibility of Nutrients for Two Sizes of Pigs

In general, it is suggested that barley should be ground using a 3.2 mm (1/8") screen. On the other hand, corn should be ground using a 4.6 mm (3/16") screen; there is ample evidence to show that a 4.6 mm screen reduces growth rate (5 - 8%) and feed conversion (5%) compared to the smaller size screen (4.6 mm). The data in Tables 10-1 and 10-2 illustrate the results of trials at Kansas State University using barley-based diets.

Table 10-1. Effect of Fineness of Grind on the Performance of Weanling Pigs Fed Barley-based Diets.

Screen size, mm	3.2	4.8	Difference
Particle size, µm	634	767	
Daily gain, g	386	367	+ 5.2%
Daily feed, g	653	653	nil
Feed:gain	1.70	1.79	+ 5.0%

Source: Adapted from Goodband et al., 1993.

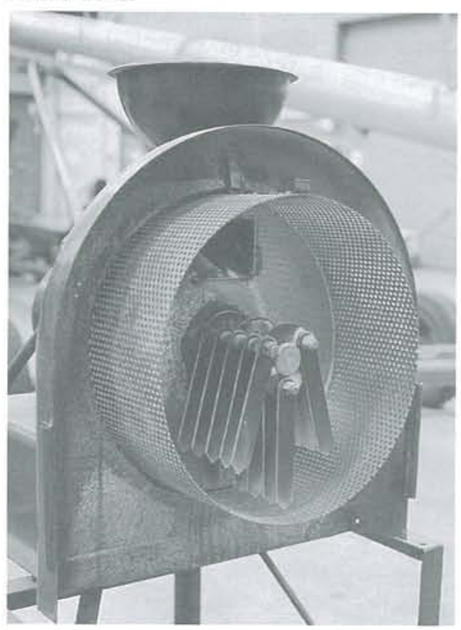
Table 10-2. Effect of Fineness of Grind on the Performance of Finishing Pigs Fed Barley-based Diets.

Screen size, mm	3.2	4.6	6.8
Particle size, µm	714	902	1146
Daily gain, g	890	820	810
Daily feed, g	2940	2820	2950
Feed:gain	3.32	3.58	3.65

Source: Adapted from Goodband et al., 1993.

Dietary particle size also affects sow performance (Table 10-3). While the smaller particle size improved productivity, the incidence of ulcers was also increased.

Photo 10-2.



Hammers and screens must be replaced regularly to ensure constant diet quality.

Table 10-3. Effect of Particle Size on the Performance of Lactating Sows Fed a Corn-based Diet.

	Particle size, μm			
	400	600	900	1200
Litter size, d21	8.9	9.4	9.0	9.0
Sow wt. loss, kg	8.0	6.8	8.5	3.7
Sow backfat loss, mm	3.3	3.8	4.6	4.1
Litter weight, kg	50.4	50.4	48.9	46.9
Feed intake, kg	4.4	4.3	4.2	4.2
Diet digestibility, %	88.6	86.7	85.4	84.4

Source: Adapted from Goodband et al., 1993.

In addition to the potential for increased ulcers, there are other down sides to seeking a more finely ground diet: mill output is reduced, the power demands per tonne of diet increase (Table 10-4), palatability may suffer and dustiness will increase. Another consideration is shrink, a factor often ignored when calculating the true cost of manufacturing feeds. It refers to material lost as dust and moisture and is believed to increase in parallel with fineness. Although shrink is difficult to quantify, most estimates range from one to three percent.

Table 10-4. Impact of Fineness of Grind on Mill Productivity and Energy Efficiency.

Particle size (μm)	Energy cost (Kwh/tonne)	Production Rates (tonnes/hr)
400	7.5	2.1
600	4.1	4.0
800	3.3	4.3
1000	2.7	4.3

Source: Adapted from Wondra et al., 1992, J. Anim. Sci. 70(Suppl. 1):239.

Many factors influence the efficiency of the grinding process. Screen size of the mill is important as well as the condition of the screen and the hammers. Normal wear and tear during grinding will result in uneven screen size, broken screens and worn hammers and will result in a poor job of grinding if they are not replaced. Based on a report by Pouteaux, 1988, screen wear is much more serious than hammer wear (Table 10-5).

Other factors may also play a role in the quality of grinding. These include the speed of the mill, the design of the hammers and screens, the ingredient transporting system and the physical characteristics of the grains, most important of which is moisture. Broad recommendations suggesting a specific screen size must be interpreted with care since a universal guide is not possible. This is graphically shown in Table 10-5. The same screen size and hammer speed were employed for both the hammer and screen studies. Only the brand of hammer mill differed. Nevertheless, mean particle diameter, particle surface area and particles per gram varied significantly, even with new equipment. The best alternative is to determine mean particle size on each diet and adjust mills accordingly. Mean particle size for market hogs and sows should be 650 to 750μm.

Photo 10-3.

Proportioner-type mills are very common in the swine industry. However, for best results, they must be carefully calibrated and regularly re-calibrated.

Table 10-5. Effect of Screen and Hammer Wear on Grinding Effectiveness

	Mean Particle	Surface Area Diameter (microns)	Particles/Gram (cm^2 per gram)
Peas			
New Screen	646	179	130,480
Worn Screen	344	355	1,132,500
(Difference)	(1.88x)	(1.98x)	(8.68x)
New Hammers	399	393	2,244,800
Worn Hammers	417	397	1,659,000
(Difference)	(1.05x)	(1.01x)	(1.35x)
Barley			
New Screen	692	229	118,200
Worn Screen	388	419	311,400
(Difference)	(1.78x)	(1.83x)	(2.46x)
New Hammers	633	274	180,700
Worn Hammers	627	250	124,100
(Difference)	(1.01x)	(1.10x)	(1.46x)
Wheat (HRS)			
New Screen	772	186	73,290
Worn Screen	358	427	938,200
(Difference)	(2.16x)	(2.30x)	(12.8x)
Wheat (Winter)			
New Hammers	443	390	2,319,500
Worn Hammers	433	392	1,841,900
(Difference)	(1.02x)	(--)	(1.26x)

x: The number of times the smaller value exceeds the larger value in a column.
All studies were conducted with a 7/64" (2.78mm) screen. Both the screen and hammer study employed a 100 HP tear-drop circular hammer mill operated at 3600 RPM. The mill used for the screen study though, was a different brand than that used for the hammer study.

Adapted from Pouteaux, 1988. Proc. Alberta Pork Congress. Red Deer, pp.20.

The most commonly recommended screen sizes for swine diets based on barley range from 3.0 to 3.5 mm. Often, producers should use these as guidelines only, considering them with the other variables involved in manufacturing swine diets such as moisture content, nature of the grain and the feed mill itself. Producers do not have access to analyses of particle size, therefore visual inspection of the ground feed remains important. In terms of final particle size, screen size is less important for barley than for wheat, as shown in Table 10-5.

As introduced previously, the incidence of gastric ulcers tends to increase with the use of finely ground feeds (Table 10-6 and 10-7).

Table 10-6. Effect of Fineness of Grind of Corn on Incidence of Ulcers and Other Stomach Lesions in Swine

	Hammermill Screen Size (mm)		
	1.6	6.4	12.7
Fineness of Grind			
Mean Particle Size (microns)	465	820	1,363
Surface Area (cm^2/gm)	110	72	52
Stomach Lesions (%)			
Normal Stomachs	0	50	63
Cornifications	25	38	38
Erosions	25	13	0
Slight Ulcers	38	0	0
Serious Ulcers	13	0	0

Adapted from Wu and Allee. 1984. Kansas State University Swine Day Progress Report pp. 83-88.

Table 10-7. Effect of Fineness of Grind of Barley on the Incidence of Ulcers and Other Stomach Lesions in Swine.

	Hammermill Screen Size, (mm)	
	3.2	6.4
Fineness of Grind		
Mean Particle Size (microns)	711	1159
Surface Area (cm^2/gm)	79	50
Stomach Lesions (%)		
Normal Stomachs	17	67
Cornifications	33	17
Erosions	0	17
Slight Ulcers	0	0
Serious Ulcers	0	0

Adapted from Goodband, 1986. Master's Thesis, Kansas State University, Manhattan, KS.

Mixing

Mixing is often taken for granted as a simple process that requires little attention to quality control. Unfortunately, nothing could be further from the truth! Mixer adjustment, mixing time and mixer design are all important variables in developing a proper protocol. Mixing efficiency is generally evaluated by taking 10 to 12 samples from within a single batch and analysing each sample individually for a single nutrient such as sodium, chloride, iron or lysine; sodium and chloride are the lowest cost assays. Tracer particles can be used as an alternative.

It should also be noted that as farms move to phase feeding, where nutrient supply is closely linked to nutrient requirements, the importance of diet uniformity will be much greater; this is due to the fact that single phase diets, for example, tend to provide nutrients in excess of requirement and thus provide some degree of protection from poor diet mixing.

In all cases, the variation of the nutrient within the batch is expressed as the coefficient of variation (C.V.). In general, the objective of most mixing systems is to reduce nutrient variability within a mix to a C.V. of less than 10% and certainly no greater than 15%. Excessive variability within a mix reduces growth rate and feed efficiency (Tables 10-8 and 10-9).

Table 10-8. Impact of Mixing Time on Diet Uniformity and Performance of Weanling Pigs.

	Mixing time, min.			
	0	0.5	2.0	4.0
Coefficient of variation	100+	28	16	12
Daily gain, g[1]	268	377	381	399
Daily feed, g[1]	599	712	703	721
Feed efficiency[1]	2.24	1.89	1.85	1.81

[1] Effect of mixing time significant, $P < 0.05$

Source: Adapted from Traylor et al., 1994.

While proper mix time is required to achieve adequate mixing, worn or poorly adjusted parts may also contribute to a poor mix. Operators must be careful not to exceed the recommended capacity of the mixer; otherwise poor mixing efficiency is almost a certainty.

There are two general types of mixers: horizontal and vertical. The following comments are generalities only; differences will exist among manufacturers due to variation in design. Typically, horizontal mixers are more expensive to purchase than vertical mixers, but have a lower maintenance cost, in part because they have a slower ribbon speed of rotation (30 to 40 rpm vs. 200 to 300 rpm). Also, horizontal mixers can generally handle higher quantities of added liquids than vertical mixers.

Horizontal mixers may employ either paddles or ribbons, or a combination of the two, circulating within the batch to achieve a uniform mix. Typical mixing times for horizontal mixers range from 3 to 6 minutes, while for vertical mixers, a somewhat longer period - 8 to 15 minutes - may be required to bring the coefficient of variation below the desired 10%. Portable grinder mixers are a version of the vertical mixer described above. Studies in which mixing efficiency has been properly evaluated suggest that for a mixer in good repair, mixing for 12-17 minutes after the addition of the last ingredient should suffice.

The proper order of addition of ingredients is also important. For best results, one-half to two-thirds of the major ingredient (eg. barley) should be added first. Intermediate ingredients, such as supplement, soybean meal or canola meal can then be added, followed by the minor ingredients such as premix or salt. Finally, the remainder of the major ingredient can be added.

Table 10-9. Impact of Mixing Time on Diet Uniformity and Performance of Finishing Swine.

	Mixing time, min			
	0	0.5	2.0	4.0
Coefficient of variation	53.8	14.8	12.5	9.6
Daily gain, g	776	808	794	785
Daily feed, g	2945	2904	2886	2881
Feed conversion	3.80	3.60	3.63	3.67

Source: Adapted from Traylor et al., 1994.

Pelleting

Swine diets are pelleted for handling reasons and to improve performance. The increased feed efficiency is believed to be due to reduced wastage and perhaps improved digestibility. A survey of 117 experiments showed an average increase in growth rate of 6.6% and an improvement in feed efficiency of 7.9% due to pelleting. The benefit depends on the nature of the ingredients used.

Generally, improvement in performance is greater with more fibrous feeds. Therefore greater benefits from pelleting would be expected from barley than from wheat or corn. One study found that the advantage to pelleting corn in terms of feed efficiency was approximately 11% while improvement in growth rate ranged from 4-9%, depending on the age of the pig; this was confirmed by a recent report from Kansas State University (Table 10-10).

A survey of 10 experiments using barley-based diets suggested that on average, pelleting improved growth rate and feed efficiency by 15%. On balance this appears to be high, but improvement in the range of 7-9% would not be unexpected. For example, Bell and Keith reported an average 4.7% improvement in growing pigs and an average 12.6% improvement in finishing pigs fed barley- or barley and wheat-based diets (Table 10-11).

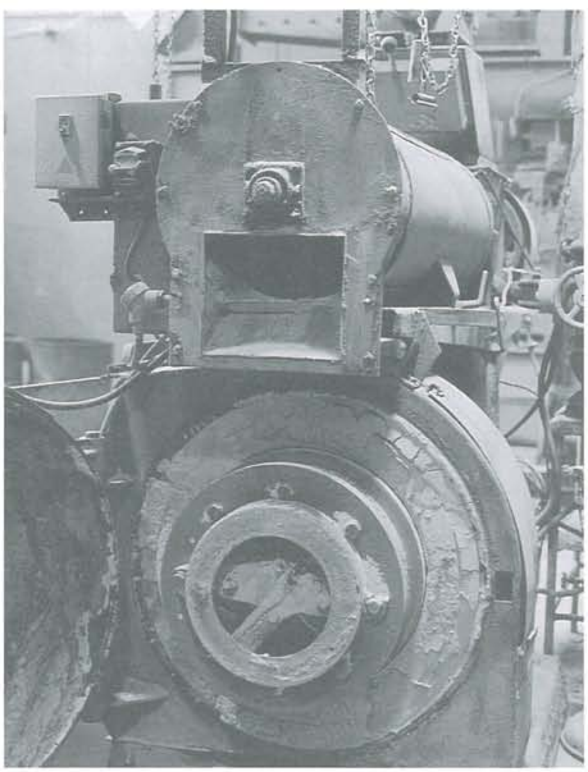
Table 10-10. Impact of Pelleting Corn-based Diets on Finishing Pig Performance, Nutrient Digestibility and the Incidence of Ulcers.

	Meal		Pellet	Difference, %
Pig performance				
Initial wt., kg		68		
Final wt., kg		119		
Ave. daily gain, kg	0.83		0.90	+8.8
Ave. daily feed, kg	3.02		3.11	+3.2
Feed conversion	3.65		3.46	+5.2
Apparent nutrient digestibility, %				
Dry matter	86.2		86.9	+0.8
Nitrogen	83.1		83.4	+0.4
Gross energy	87.0		87.3	+0.3
Stomach keratinization[1]	1.60		1.63	0.0
Stomach lesions[1]	0.32		0.97	+203

[1]Lesions and degree of keratinization in easophageal region of the stomach scored on a scale of 0 to 3, with 3 being the most severe.

Source: Adapted from Wondra et al., 1992a.

Photo 10-4.



Pelleting helps to increase nutrient digestibility and reduce ingredient separation in swine diets.
Photo courtesy of Federated Co-operatives Ltd.

There are a number of things that can be done if ulcers are a problem. In the short-term, hay or a similar material can be offered to the animals ad lib. This practice is most effective but may not be practical in barns using liquid manure pits. A second option is to include approximately 10% whole grain (eg. oats or barley) in the diet. Pellet quality may suffer somewhat, especially in diets based on corn, but it is an effective method for treating ulcers.

The preferred pellet size depends on the age of the animal being fed. The young pig prefers a smaller-sized feed, and therefore small or short-cut pellets or crumbles are best. Crumbled creep feeds tend to stimulate intake. As the pig gets older, larger pellets are quite acceptable.

Table 10-11. Effect of Pelleting Diets Based on Canola (seed and/or meal) and Cereal Grains (barley or barley plus wheat) on Pig Performance

	Mash	Pellets	Difference, %
Growing pigs (23-59 kg)			
Ave. daily gain, kg	0.67	0.72	+7.5%
Ave. daily feed, kg	1.89	1.83	-3.2%
Feed conversion	2.83	2.55	+9.9%
Finishing pigs (59-100kg)			
Ave. daily gain, kg	0.73	0.87	+19.2%
Ave. daily feed, kg	2.73	2.98	+9.2%
Feed conversion	3.78	3.43	+9.3%

Source: Adapted from Bell and Keith, 1991. Annual Report, Prairie Swine Centre, Saskatoon, SK. pp. 21-24.

Pellet quality is a subject that attracts a great deal of attention in feed manufacturing and probably receives more attention than is necessary if a producer's major concern is pig performance. Pellet durability is heavily influenced by diet composition. Wheat in particular is a good binding agent, while pellets made of corn do not hold together as well. When pigs have access to pellets and fines, they appear to prefer the pellets and let the fines collect in the corner of the feeder. This prompts concern on the part of the producer. Recent studies at Kansas State University reveal that the presence of fines has little effect on growth rate, but reduces feed efficiency (Tables 10-12 and 10-13).

Although many factors are believed to be involved, gastric ulcers tend to increase when pigs are fed pelleted diets. Part of the problem may be related to the fineness of grind used to prepare grains for pelleting. A finer grind results in better quality pellets; consequently, pellet-mill operators tend to use finely ground grains in an attempt to minimize customer complaints. With a coarser grind, pellet quality will suffer but the incidence of ulcers will be reduced. The heating process associated with pelleting results in gelatinization of the grain starches and has also been implicated as a cause of ulcers. In the example presented in Table 10-10, the grains used in both the meal and the pelleted diets were ground to the same particle size.

Table 10-12. Effect of Pellet Fines on Performance of Finishing Pigs Fed a Corned-based Diet (Initial wt. = 54kg).

	Meal	Screened pellets	Percentage fines		
			20	40	60
Ave. gain, kg/d	0.93	0.96	0.96	0.96	0.94
Ave. feed intake, kg/d	2.58	2.54	2.66	2.66	2.65
Feed conversion[1]	2.78	2.65	2.78	2.77	2.82

[1] Linear effect of fines significant, $P<0.10$

Source: Stark et al., 1993.

Table 10-13. Effect of Pelleting and Fines on Performance of Newly-weaned Pigs Fed Corn-based Diets (Initial wt.= 5.7 kg).

	Meal	Pellets	Pellets + 25% fines
d7 to d21			
Ave. gain, kg/d	0.32	0.36	0.34
Ave. feed intake, kg/d	0.56	0.52	0.54
Feed conversion[1,2]	1.73	1.44	1.55
d7 to d35			
Ave. gain, kg/d	0.47	0.49	0.49
Ave. feed intake, kg/d	0.78	0.73	0.76
Feed conversion[1,3]	1.67	1.50	1.54

[1] Effect of pelleting significant, $P<0.01$
[2] Effect of fines significant, $P<0.05$
[3] Effect of fines significant, $P<0.07$
Source: Stark et al., 1993.

Liquid Feeding

Liquid feeding was popular many years ago but fell into disfavour for a variety of reasons. Most of the reasons were related to problems with the mechanical equipment. New approaches have rekindled interest.

For example, one "version" of liquid feeding is the use of "wet-dry" feeders, a compromise between liquid and dry feeding. Feed is delivered to the self-feeder in dry form, but a nipple waterer located below the feeding platform allows the pig to drink water at the same time as it is eating. The pig can even mix the dry feed with water in the dish located below both the feeding platform and the waterer.

Field studies in Manitoba indicate that the wet-dry feeders are well received by the pigs, and the feed intake may be improved over conventional dry feeders. To maintain the cleanliness of the pens, the feeders should be placed within 2 feet of the slatted area, since some water spillage does occur. Wet-dry feeders have proven to be an effective way of incorporating liquid whey into the feeding program. Whey is delivered via the nipples and the composition of the dry feed is adjusted to complement the whey composition.

True liquid feeding systems are also appearing on the Canadian market. The new systems offer more precision in mixing and delivery and if they are linked to computer systems, they provide a much greater degree of control than was previously possible. It is too early to offer a definite evaluation of these newer units, but they do offer considerable advantages over previous liquid feeding systems. Small improvements in pig performance can be expected with such feeding systems. The main drawback is cost and the difficulty of adding antibiotics to certain diets without contaminating others.

Photo 10-5.

Computer controlled liquid feeding systems which supply exact amounts of feed to each pen at specified times are relatively new on the market, but gaining in popularity.

Liquid or paste feeding has shown some benefits for the young weanling pig. Liquid feeding refers to a feed with a high water content (2:1 water:feed ratio), while paste feeding is drier but still moist (1.3-1.5:1 water:feed ratio). Young pigs tend to eat wet feed more readily. The problem is maintaining feed freshness. Starter diets are high in milk products and tend to develop off-flavours very quickly. However, if suitable antioxidants are included in the diet and the feed delivery system is managed properly, these concerns can be largely overcome. The key to liquid or paste feeding systems is to provide fresh feed on a regular basis.

Drying Grains

Depending on cropping practices and weather conditions, grains may be dried to reduce moisture content and thus prevent spoilage during storage. An alternative to drying is to store the product as a high moisture grain. This method is discussed later in the chapter. Research has shown that corn can be dried to 12-15% moisture using temperatures of up to 110°C with no adverse affects on pig performance. Temperatures in excess of 150°C have been shown to affect the palatability of corn to the pig.

High Moisture Grains

High moisture storage and feeding of grain is popular in areas where grains are harvested wet and must then be dried before conventional storage. High moisture storage involves the use of either oxygen limiting structures or the addition of acidifying compounds. Both systems inhibit undesirable microbial deterioration, allowing the wet grain to be stored until fed. The systems add to the cost of storage but save on the cost of drying.

The use of high moisture grain can improve harvesting management, since a dryer tends to slow down the grain handling process. High moisture grains stored in silos should normally fall within the range of 22-28% moisture. This range limits the period of time for harvesting but provides ideal moisture to generate the desired level of fermentation.

Photo 10-6.

Grain dryers are used to reduce the moisture content of wet grains thus preventing spoilage.

Sealed, oxygen-limiting silos are the most convenient systems for storing high-moisture grains, but they are also the most expensive. Vertical concrete silos or horizontal silos can be used successfully, although the level of management required is greater than with the oxygen-limiting systems. Mechanization of feeding is also more difficult, especially in the case of the horizontal silos.

The grain should be ground and well packed in the silo to eliminate oxygen. All doors should be sealed; unsealed systems result in losses of 2-5% compared to oxygen limiting systems. Once a vertical silo is opened, a minimum of three inches must be removed per day to prevent spoilage. This may have to be increased during warm weather.

On a dry matter basis, there is very little difference in the feeding value of corn or barley of equal quality stored in an oxygen limiting unit compared to being conventionally dried. High moisture storage appears to increase the availability of phosphorous in the grain but it may also reduce the amounts of vitamins A and E. The main point to keep in mind is that rations must be adjusted to compensate for the extra moisture content of the grain.

Organic acids have been used extensively as preservatives for high moisture grains. The different types include propionic, acetic, isobutyric, formic and benzoic acids or their various combinations. These acids preserve the grain by preventing mold growth and by killing the grain germ. Organic acids can be corrosive to any metal they come in contact with such as transportation and storage equipment. If metal granaries are to be used, they must be lined with a protective covering to avoid premature rusting.

Acid preservation systems are more flexible than the use of oxygen limiting silos. The advantage is that continuous feeding is not necessary. The acid remains with the grain until feeding; therefore spoilage outside the granary is eliminated.

Pigs normally perform very well on high-moisture grain. Dustiness is reduced so the wet grain tends to be very palatable. It should not be used for the very young pig though, due to the high moisture content of the grain and the limited gut capacity of the small pig. Once high moisture grain is harvested and stored, there tends to be very little resale market available. The owner is generally committed to feeding it to livestock.

Mixing Feeds on the Farm

In Canada, a high but declining proportion of feeds are manufactured on the farm. There are many indications though, that many home-maufactured diets are not well mixed. The results of surveys in several provinces indicate that up to 75% of feeds submitted to feed testing laboratories for analysis fail to meet the nutrient requirements of the pigs being fed. The problem can occur at any number of the steps involved in feed manufacturing: diet formulation, feed mixing or feed delivery. A proper quality control program must be in place to ensure diet quality and consistency. A system for quality control was discussed in detail in Chapter 5. Ingredients grown on the farm should be analysed at least for crude protein and moisture.

If a proportioner-type mill is being used, the bushel weight should also be measured. Bushel weight should be checked on a regular basis because changes in bushel weight will alter mixing accuracy. Appendix II outlines the steps required to calibrate a typical proportioner-type mill, one of the common mixing systems.

It has been suggested that the moisture content of the ingredients will influence the rate of addition in proportioner-type mills. This is because moisture content affects bushel weight. However, moisture tests from a feed testing laboratory may not be completely accurate. This is because the moisture content of a sample of grain can change a great deal from the time it is sampled at the farm until it is finally measured in the lab. This problem is relatively minor for dry grains, but increases as actual moisture content increases. Researchers go to great pains to measure moisture accurately under laboratory conditions that would not be practical for farmers. Consequently, a good bushel weight is likely to be the best overall measurement on a grain sample, to determine if mill re-calibration is required.

For cereal grains, calcium and phosphorus analysis may not be required, as they are quite consistent from year to year and because they contribute relatively small proportions of the total

Photo 10-7.

To obtain best results, P.T.O. mixers should be operated for 12 to 17 minutes after adding the last ingredient.

quantities in the diet. Purchased ingredients should be analysed for protein, calcium, phosphorus and salt on a regular basis, perhaps every 2-3 months, to ensure that the assumed nutrient content is indeed correct.

Mixed diets should be sampled monthly and analysed as required. This step ensures that mixing and formulation steps have been completed correctly, and provides a final check on the quality of the feeds being offered to the pigs. Refer to Chapter 5 for a recommended feed sampling and analysis schedule.

Processing Problems

Achieving a proper mix on the farm is not easy, based on the results of surveys showing generally poor quality control. Surveys continually reveal that diets lack nutrient balance and often uniformity.

One major problem is separation. For example, Table 10-14 summarizes the results of a study conducted on a commercial farm in Saskatchewan using a typical proportioner-type mill. Feed was mixed in batches and stored in a hopper-bottomed (centre flow) steel bin. Feed samples were collected for analysis at the beginning, middle and end of the batch as it left the storage bin. Considerable separation was taking place, such that pigs were receiving diets of varied composition, depending on the location of the feed within the storage tank. Since this diet was formulated to be a pre-grower, the very high crude fibre and low protein level found in the latter part of the batch was a serious cause for concern.

Table 10-14. Separation of Feeds Following Mixing on the Farm.

	Portion of Storage Tank		
Nutrient	Start	Middle	End
		(%)	
Protein	17.60	17.40	15.70
Calcium	1.09	0.99	0.74
Phosphorus	0.95	0.85	0.65
Fibre	3.80	4.20	9.00
Salt	0.74	0.71	0.61
		(parts per million)	
Iron	310	200	200
Zinc	260	140	140
Manganese	50	40	40
Copper	23	20	20

A pre-grower diet was mixed using a proportioner-type mill and stored in a hopper-bottomed bin before feeding. Feed samples were collected at three stages of emptying: beginning, middle and end of the batch.

To improve uniformity, dispersion tubes should be placed inside feed bins to prevent segregation of ground feeds. Coarse grinding may also help, but losses in performance must be avoided. Pelleting of course would solve the problem, but is generally not available on most farms.

Dustiness is another problem. Recognition that dust in the barn poses a threat to the health of humans as well as pigs has focused greater attention on this subject. Adding 0.5-2% fat to the diet has proven beneficial in removing nuisance dust, but is very poor at controlling respirable dust - that which is small enough to enter the lungs and thus potentially contribute to respiratory problems. Including whole seed canola or soybeans in the formula is one way of accomplishing this objective and has the added benefit of increasing the energy content of the diet. Sprinkling oil directly in the barn is much more effective in reducing dust - by up to 80% - and at less cost than adding the oil to the diet.

Care must be taken to increase amino acid (protein) content of the diet when any fat source is used; otherwise, poor carcass grades may result. For every 1% vegetable fat added to the diet, the limiting amino acids should be increased by about 4%. For example, for every 1% of fat added to a finisher diet, lysine should rise by about 0.03 percentage units (eg. lysine increased from 0.75% to 0.78%). This can be accomplished most easily by increasing the amount of protein by 4% (i.e. crude protein increased from 16.5% to 17.2%). When whole seed canola or soybeans are used, they add protein as well as fat, so the increase in protein per 1% fat would be 1.5-2.0%.

Feeds Act and Regulation

Everyone manufacturing feeds, whether they are a commercial feed company or a private farmer mixing feed for his own use, should be familiar with three publications: the Feeds Act (1976), the Feeds Regulations (1983, revised) and the Compendium of Medicating Ingredient Brochures (CMIB). These are federal statutes and guides governing the manufacture and use of livestock feeds in Canada. Copies of all three can be obtained from the Federal Government. They detail the legal responsibilities associated with the production of feeds intended for use in livestock operations; contrary to common thinking, these rules apply equally to both commercial feed companies **and** farmers manufacturing their own feeds. However, the Feeds Act states that it does not apply to a feed:

"that is manufactured by a livestock producer if it is not offered for sale and has not had incorporated into it any drug or other substance that may adversely affect human health or the environment or that is sold by the individual grower thereof, if it is free from prescribed deleterious substances."

Simply stated, if the individual pork producer is mixing his own diets for his own use and is not adding anything to the feed that will be harmful to human health or the environment, then he or she is not bound by the legislation contained in the Act. However, if feed medications are used, such as antibiotic-type growth promotants, then the Feeds Act must be adhered to.

The following discussion summarizes general points of interest to livestock producers. It is not intended to be comprehensive; anyone interested in answers to specific questions should consult the Act or contact their nearest Agriculture Canada office.

Essentially, the objectives of the Feeds Act are to ensure that:

1. All animal feeds are efficacious in terms of the original purposes for which they were intended. For example, a sow lactation diet should support milk production in the sow.

2. When livestock diets are fed to animals, resulting human food products, such as meat or milk, do not pose any kind of health threat to persons consuming them. For example, the Act specifically forbids the use of in-feed drugs in such kind or quantity that would result in residue in the meat intended for human consumption.

3. Animal feeds do not pose a health threat to the animals consuming them.

4. Animal feeds do not pose a threat to the environment.

The Food Production and Inspection Branch administers the Feeds Act and Feeds Regulations. As a consequence of changes in the nature of the livestock feed industry, and in their view, to obtain the best results from a limited budget, they are focusing less attention on random visits to commercial feed mills, a major activity in the past, and spending more time following up on suspected abuses of in-feed drug usage at commercial mills or on livestock farms.

At the present time, all feeds imported, manufactured or sold in Canada must be registered with the Federal Government, unless they are specifically exempted by the Feeds Act; fortunately, since it takes considerable time and effort (and $95.00) to register a single feed, the majority of feeds are exempted. For example, a feed is exempted from registration if it does not contain any medicating ingredients and meets specified minimum requirements with respect to nutrient composition. These nutrient specifications are outlined in Table 4, Schedule 1 of the Feeds Regulations. Table 10-7 summarizes the information as it relates to swine. It must be recognized that Table 4 of the Regulations is continually being reviewed and adjusted; therefore, the reader is cautioned that changes to the Regulations may have occurred since this book was written and that Table 10-7 may not be completely up to date.

As indicated, registration requirements do not apply if the feeds are manufactured for a livestock producer's own use and do not contain medications; similarly, if the feed contains medications added at levels defined in the CMIB, the registration requirements are again waived. The CMIB defines which drugs are permitted to be used in swine diets, what levels may legally be added to the diet and identifies restrictions on their use, such as withdrawal times. Levels of drugs or combinations of drugs, not included in the CMIB cannot be used in swine diets unless the producer or feed manufacturer receives a veterinary prescription.

Agriculture Canada is primarily concerned with diets that contain medications or other substances that pose a potential hazard to animal or human health and if not used properly could result in carcass residue. They are also concerned about the use of other substances that may be harmful to the environment such as high levels of copper, which accumulate in manure and become concentrated on land where it is spread.

It is clear that the government wishes to be very careful about permitting the use of medications in livestock feeds. Anyone mixing diets which include medications may be required to submit to an on-farm inspection. The Act discusses such inspections of feed mixing facilities. They are intended to ensure that, if medications are going to be used, they are mixed adequately and safely. In this respect, the on-farm feed mixing facility is treated exactly the same as a large commercial feed mill. Such an inspection could include a listing of all medicating ingredients used and determine if such a premix is approved for use, a check of feed handling, delivery and mixing facilities to ensure they are in good repair and adequate for the job, and an evaluation of manufacturing practices such as those related to preventing inadvertent contamination of other, un-medicated feeds mixed at the same site.

Table 10-15. Nutrient Guarantees Required for Swine Diets that are Exempt from Registration Requirements.

Nutrient	Minimum	Maximum	Nutrient	Minimum	Maximum
Calcium, %	0.80(1)	2.00	Magnesium, %	0.04	0.30
	0.75(2,3)		Manganese, mg/kg	10	200
	0.5(4)				
Cobalt, mg/kg	NRS	5	Phosphorus, %	0.60(1)	2.00
					0.50(4)
Copper, mg/kg	6	125	Potassium, %	0.2	2.0
Iodine, mg/kg	0.2	10	Sodium, %	0.20(2)	0.80
Iron, mg/kg	150(5)	750			0.15(3)
	80(3)				0.10(4)
	40(4)				
			Selenium, mg/kg	NRS	0.30
Vitamin A, IU/kg	4,000(3)	20,000			added
	1,300(6)				
	2,000(4)		Sulphur, %	NRS	NRS
Vitamin D, IU/kg	125(4)	1,500			
	200(7)				
Zinc, mg/kg	100	500	Vitamin E, IU/kg	10	NRS

Minimum and maximum nutrient composition specified in the Feed Regulations for unregistered diets fed to various classes of swine:(1)1-10 kg bodyweight; (2)lactation; (3)breeding; (4)all classes not specified; (5)up to 20 kg bodyweight; (6)20 kg to market; (7)up to 60 kg; (NRS)No requirement specified. Diets offered for sale which fall within these ranges need not be registered. The limitations specified in this table do not apply to individual livestock producers who are exempt from these regulations (see above).

Clearly, the use of medications in livestock diets is considered a serious matter which must be carefully controlled to ensure that the pork industry produces a safe, wholesome product. It is the responsibility of each individual producer to ensure that proper procedures are followed.

Because they are in the business of selling feeds, the commercial feed manufacturer is expected to meet certain standards beyond those applying to the individual farmer. All feeds must be carefully labelled. Although the Regulations carefully define labelling requirements, the major objective is to provide the buyer with sufficient information to use the feed effectively and safely. Labels include feeding instructions, withdrawal times if medications are involved and cautions with respect to proper use. All diets manufactured for sale by feed companies that contain nutrients outside the bounds defined in Table 4 of the Feeds Regulations must be registered with the Federal Government. An exception is what the Regulations refer to as a customer formula feed. If the pork producer specifically asks for a feed that may contain levels above or below the standards outlined in Table 4 and provides a signed request form listing all the ingredients to be used, the feed manufacturer does not have to register the feed with the Federal government. Consequently, requests from farmers to commercial feed manufacturers should keep such restrictions in mind.

Agriculture Canada provides the 'Medicated Feed Information Guide'. Like any legal document, the Feeds Act is written in very precise legal language which is sometimes difficult to understand. This Guide is useful because it explains the Feeds Act and associated documents in simpler terms. Everyone mixing feeds on the farm would be well advised to read it, so they are familiar with their legal obligations. The Guide also provides useful tips on feed mixing and handling to help avoid potential problems.

Additional Reading and References

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