Improving the Nutrient Yield from a Feed

Feces are partially produced because feed is not 100% digestible. For example, amino acids in typical feedstuffs have a digestibility ranging between 60% and 90%, while P digestibility ranges from 20% to 70% (Table 10-2a). For minerals such as copper and zinc, digestibility typically ranges from 5% to 45% (Table 10-2b). It is thus important to take the digestibility of nutrients in consideration when formulating diets, and the 1998 NRC recommends using true ileal digestibility figures for amino acids and availability for P.

When selecting feed ingredients, it is thus crucial to select ingredients that have high digestibility. Formulating diets with least-cost formulating software that uses digestible nutrients in formulation will help in selecting those ingredients that have a high digestibility within the range of what is economically attractive.

For each 1% improvement in digestibility, N waste produced per kg of meat produced decreases by 1.4%.

New sources of highly digestible feedstuffs are being developed by crop breeders, either using classical breeding techniques or through genetic modification of crops. Examples of such products are low-phytate corn and low-stachyose soy. Low-phytate corn has been shown to substantially reduce P excretion when diets are formulated on an available P basis (Table 10-3).

One method of reducing the waste produced is to improve the digestibility of feeds, for example, through technological treatments of the feeds or through the addition of enzymes to the feed. For each 1% improvement in digestibility, N waste produced per kg of meat produced decreases by 1.4%.

Examples of technological treatments include particle size reduction (grinding, roller milling), pelleting, and expanding. Wondra et al. (1995) demonstrated that a uniform particle size of approximately 400 microns leads to a better nutrient digestibility than coarsely ground material (although ulcers may increase with fine particle size). For practical purposes, Kansas State University recommends a particle size of 700 microns (Kansas Swine Nutrition Guide 1999).

Vanschoubroek et al. (1971) calculated the effect of pelleting on performance based on a literature review; not only did animals prefer pelleted feed over mash feed, but feed efficiency was improved by 8.5% (for a large portion due to a reduction in feed waste), and protein digestibility improved by 3.7%. Expanders and extruders are used mainly to provide flexibility in ingredient selection and to improve pellet quality rather than to improve nutrient digestion. Due to the high temperature in these machines, their effect on digestibility depends strongly on the composition of the feed (and digestibility can actually decrease in some cases).

Feed enzymes that are commonly used to improve nutrient digestibility are phytase, xylanase, and beta-glucanase. Xylanases and beta-glucanases are enzymes that are used to degrade nonstarch polysaccharides (a soluble dietary fiber fraction) present in cereals such as wheat and barley. The pig does not secrete these enzymes and, therefore, does not have the capability to digest and use nonstarch polysaccharides, resulting in a loss of usable energy from the diet. Because these nonstarch polysaccharides can trap other nutrients, such as protein and minerals, they also increase mineral excretion. The addition of xylanase and/or beta-glucanase to cereal-containing diets can improve digestibility and feed efficiency. Graham and Inborr (1993) reported a 9% improvement in the ileal digestibility of protein

Table 10-2a. Digestibility for swine and typical content of protein and P in commonly used feed ingredients.

Feed Ingredient	Protein		Phosphorus	
	Digestibility %	Content %	Digestibility %	Content %
Corn	85	8.5	14	0.28
Soybean meal 48	87	49.0	23	0.69
Soybean meal 44	84	45.6	31	0.65
Wheat	89	13.3	50	0.37
Wheat bran	75	15.7	29	1.20
Barley	85	10.6	30	0.36
Sorghum	83	9.2	20	0.29
Meat & bone meal	84	49.1	95	4.98
Poultry byproducts	77	57.7	95	2.41
Fish meal	88	62.9	95	2.20
Dicalcium phosph.	—	—	100	18.50

Adapted from NRC 1998 and the Rhone-Poulenc Nutrition Guide 1993.

Table 10-2b. Digestion and retention of N, P, Cu, and Zn by different classes of pigs.

Mineral	Nursery	Finishing	Gestating	Lactating
Nitrogen				
Digested, %	75-88	75-88	88	—
Retained, %	40-50	30-50	20-30	20-40
Phosphorus				
Digested, %	20-70	20-50	30-45	10-35
Retained, %	20-60	20-45	20-45	20
Zinc				
Digested, %	20-45	10-20	—	—
Copper				
Digested, %	18-25	10-20	—	—

Based on C-SBM diets.
Source: Kornegay and Harper 1997.

Table 10-3. Phosphorus in normal and low-phytate corn.

P, %	Normal Corn	Low-phytate Corn
Total	**0.25**	**0.28**
Phytate	0.20	0.10
Bio-available	0.05	0.21

Source: Pierce et al. 1998. The bio-available P was estimated.

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Based on the fact that most odors are the fermentation products of remnants of the digestive process, we can expect that improving digestibility reduces odor emission.

in a wheat/rye diet due to enzyme addition.

Proteases, as the name implies, are used to degrade proteins. The use of proteases in animal feeds is not yet widespread. Caine et al. (1997) tested the effects of proteases on the ileal digestibility of soybean meal, and their results were disappointing. Beal et al. (1998) used proteases on raw soybeans and observed a significant improvement in daily gain (+14.8%). Feed efficiency, however, was only numerically improved (+ 4.3%). Dierick and Decuypere (1994), when using proteases in combination with amylases and beta-glucanases, saw a substantial improvement in feed efficiency (and larger than what was observed with each enzyme individually).

With the advancements in enzyme-producing technology as well as a better understanding of the role of enzymes in animal nutrition, proteases, as well as other enzymes (e.g., pentosanases, cellulases, and hemicellulases as tested by Dierick 1989) are likely to find a place in swine nutrition. In particular, **the potential role of enzyme supplementation on odor emission has not been evaluated.**

Phosphorus in commonly used feed ingredients such as corn, wheat, and soybean meal is predominantly present in the form of phytate. Phytate is a molecule containing P, but pigs are unable to use this P because they cannot break down the phytate molecule. In corn, 90% of the P is present as phytate, while in soybean meal, 75% of the P is present as phytate. Since this phytate complex is digested poorly in swine, most of the P contained in the feedstuffs will end up in the manure. To meet the animal's P requirement, inorganic P such as dicalcium phosphate is traditionally added to the diet because this P is highly available.

Phytase has initiated a new era in the battle to reduce nutrient excretion. It breaks down most of the phytate complex, releasing the P in it as well as other nutrients (such as zinc and amino acids) bound by it. Mroz et al. (1994) showed that phytase improves P digestibility in a typical swine diet from 30% to 50%. Under practical conditions, van der Peet-Schwering (1993) demonstrated that the use of phytase resulted in a reduction in P excretion by 32% in nursery pigs.

The impact of improving the digestibility of feeds on odor emission has not been extensively studied. Based on the fact that most odors are the fermentation products of remnants of the digestive process, we can expect that improving digestibility reduces odor emission.

To improve the nutrient yield of feeds,

- Formulate feeds based on digestible nutrients rather than totals.
- Select feed ingredients that have high digestibility.
- Grind coarse feed ingredients to a uniformly fine particle size.
- Treat feeds thermally (e.g., through pelleting).
- Add phytase and fiber-degrading enzymes to the feed.