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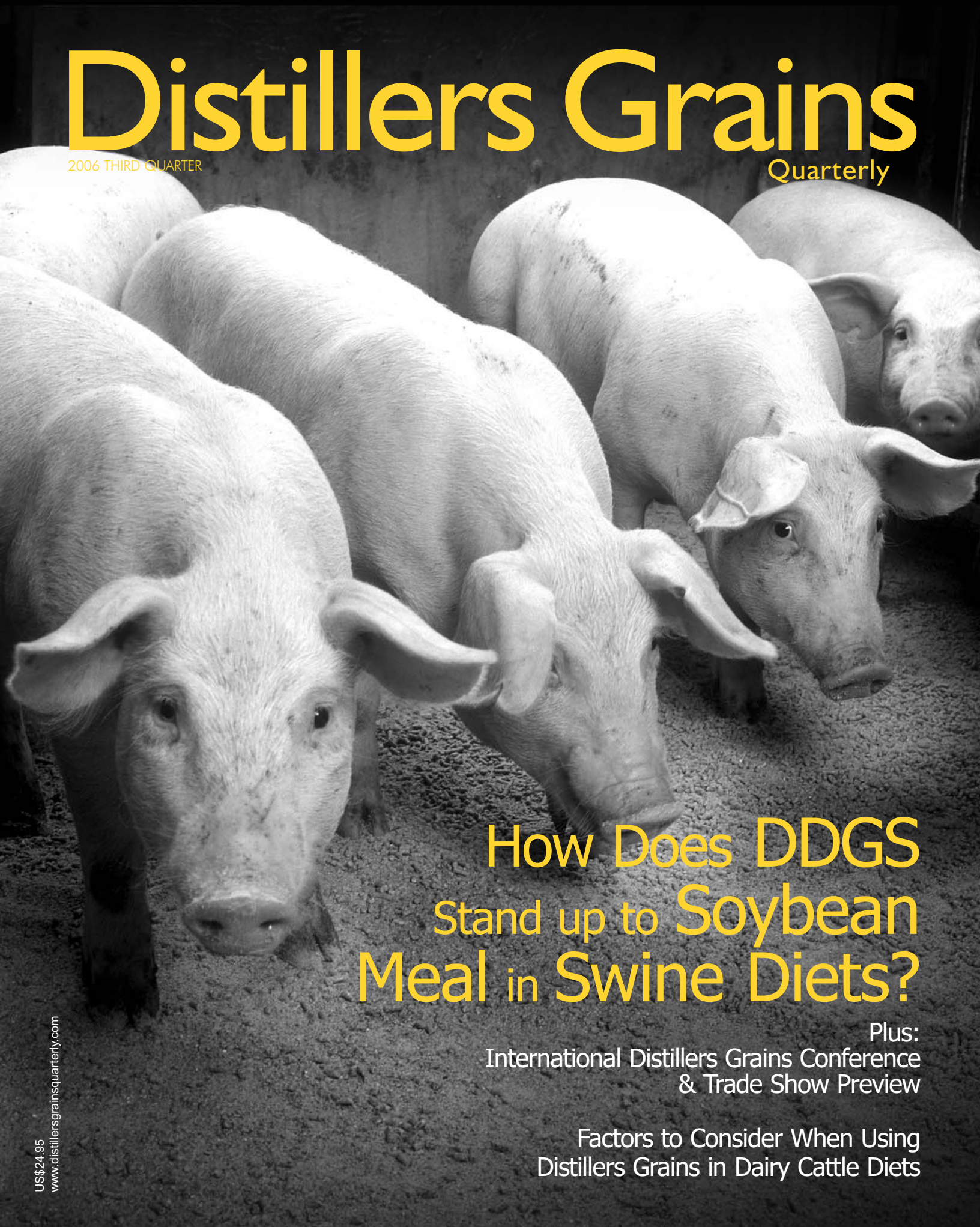

How Does DDGS Stand up to Soybean Meal in Swine Diets?

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How Does DDGS Compare to Soybean Meal in Swine Diets?

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Recently, one industry professional referred to DDGS as the "hottest ingredient to hit the feed industry since soybean meal." While that may be true—in terms of how fast the distillers grains market is growing—soybean meal has been, and will likely continue to be, the predominant protein supplement for livestock and poultry feeds in the United States. In addition to the fact that soybean meal is abundantly available, it's become America's protein supplement of choice because its amino acid profile complements the poor protein quality (i.e., the poor amino acid balance) of corn, it has a relatively consistent nutrient content among sources, and it is usually the lowest-cost protein source on the market. Therefore, one can think of soybean meal as the "gold standard" from which other protein sources should be compared.

Shurson

With that in mind, let's look at how DDGS stands up to this gold standard in the areas that matter most.

Key Nutrients

The three most expensive nutrients in a swine diet are energy, amino acids and phosphorus. Corn DDGS *partially* replaces some of the corn (a primary energy source), soybean meal (a primary amino acid source) and dicalcium phosphate (a primary phosphorus source) when it is added to commercial swine diets. In this regard, one can say that corn DDGS competes with these three ingredients to earn its place in practical swine diets. The most important criteria in determining how well DDGS competes with corn, soybean meal and dicalcium phosphate is price. That is, DDGS must be competitively priced relative to the value of energy, amino acids and phosphorus provided by competing ingredients.

The Crude Protein-Lysine Relationship

Soybean meal is generally available in two forms: "Hi-Pro" (product that is greater than 46 percent crude protein) and solvent-extracted soybean meal with hulls (approximately 44 percent crude protein). Corn DDGS is generally considered to be a "mid-protein" ingredient (generally ranging from 25 percent to 30 percent crude protein). However, for swine and poultry, it is the amino acid content and digestibility that is most important, not the protein content itself. The crude protein level of DDGS and soybean meal is a poor predictor of lysine content. An "r^2 value" is the proportion of the total variation of crude protein levels explained by lysine content. As shown in Figure 1, the r^2 values for the predictability of lysine from crude protein content are only 0.39 for soybean meal and 0.43 for DDGS.

Energy

Corn, DDGS and dehulled soybean meal are similar in their metabolizable energy content (see Table 1 on page 16). However, if soybean meal with hulls (at 44 percent crude protein) is used, it has only 93 percent of the energy value of corn. Therefore, from an energy point of view, DDGS competes favorably with corn and soybean meal in swine diets.

Amino Acids

The amino acids most likely to be limiting in a corn/soybean meal swine diet are lysine, methionine, threonine and tryptophan. Soybean meal is superior to corn and DDGS in lysine, methionine, threonine and tryptophan content. Because most DDGS is derived from corn, it inherits some of the less desirable nutritional properties of corn, most notably low lysine and poor amino acid balance relative to the pig's nutritional needs. Therefore, even though the high protein content of DDGS may initially be attractive to nutritionists, the lower lysine content and poor amino balance make it

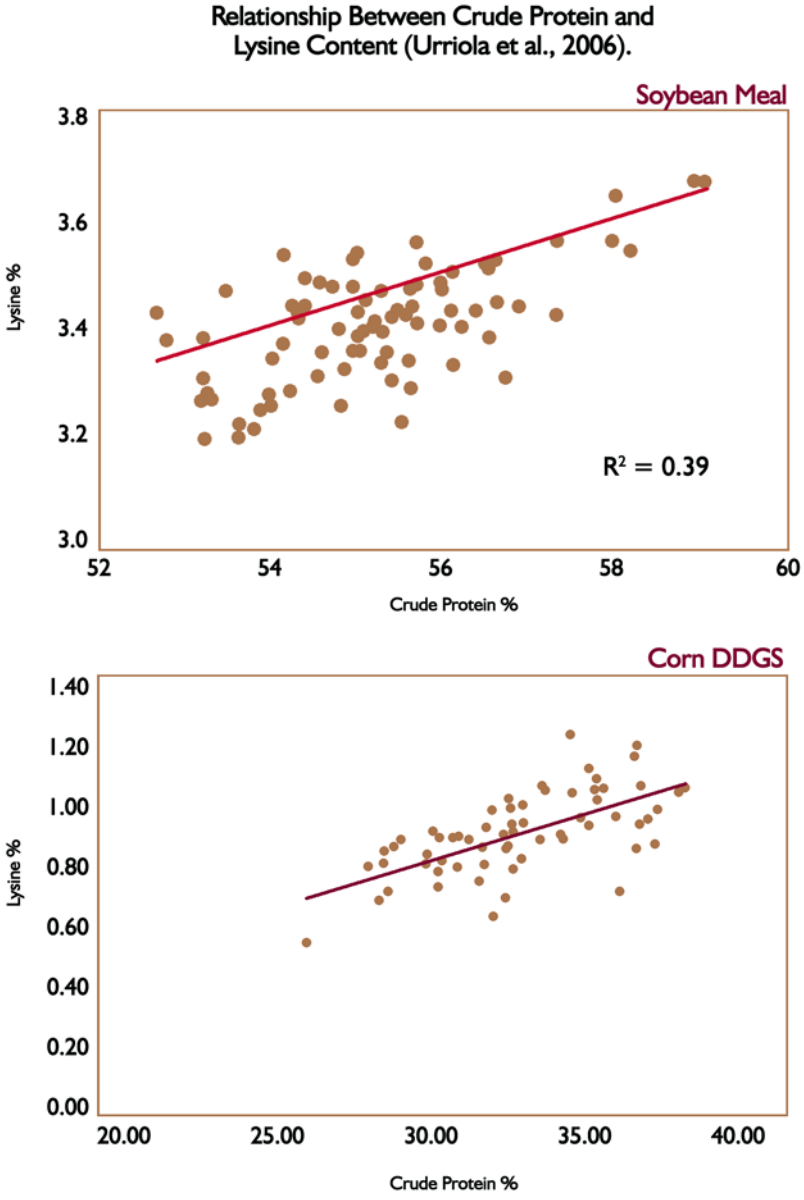

Figure 1.

less competitive as an amino acid supplement in swine diets compared to soybean meal. The relatively high cost of some synthetic amino acids limits the amount of DDGS that can be used to replace soybean meal in swine diets.

Furthermore, even though the amino acid content of DDGS is higher than corn, the average amino acid digestibility coefficients among DDGS sources are lower than those for both corn and soybean meal (see Table 1). In fact, results from a recent unpublished, collaborative study involving swine nutrition researchers at South Dakota State University (SDSU), the University of Minnesota and Degussa have shown that the lysine content ranged from 0.52 to 1.13, and the "standardized true ileal lysine digestibility" values ranged from 17.7 percent to 74.4 percent among 35 different corn DDGS sources.

In a recent study conducted at the University of Minnesota (Urriola et al., 2006) comparing variation in nutrient content of soybean meal samples among three upper Midwest plants and three southeast U.S. plants over a two year time period, the lysine content ranged from 2.82 percent to 3.23 percent, which is more consistent than the diversity of corn DDGS sources currently being produced by the U.S. ethanol industry. Although heat is used to produce both soybean meal and DDGS, the lysine digestibility coefficients among soybean meal sources would be expected to be much higher and more consistent than the values we have obtained from evaluating various DDGS sources. Because of the variation in amino acid digestibility among DDGS sources—and the need to know amino acid digestibility for swine among DDGS sources—research is underway at SDSU and the University of Minnesota to evaluate the accuracy of using several *in vitro* laboratory procedures to predict amino acid digestibility of DDGS sources before they are used to formulate and manufacture swine diets.

Phosphorus

Unlike the amino acid content and digestibility disadvantages that DDGS has in comparison to soybean meal, DDGS is superior to corn and about equal to soybean meal in total phosphorus content. Furthermore, the majority of the phosphorus in DDGS is in a chemical form that is easily digested and utilized by the pig compared to the indigestible form of phosphorus (phytic acid) found in corn and soybean meal. This nutritional advantage for DDGS allows nutritionists to significantly reduce the amount of inorganic phosphorus supplementation needed in the diet, reduce diet cost and reduce phosphorus concentration in manure, while supporting optimum pig performance.

Nutrient Variability

Nutritionists want consistency and predictability in the feed ingredients they

Table 1

Comparison of Metabolizable Energy, Selected Essential Amino Acids and Digestibility Coefficients, and Phosphorus Content and Availability Between Corn, Corn DDGS, Dehulled Soybean Meal and Soybean Meal with Hulls

Nutrient	Corn[1]	DDGS[2]	Dehulled soybean meal1	Soybean meal with hulls1
Metabolizable energy, kcal/kg	3420	3400	3380	3180
Lysine, %	0.26	0.81	3.02	2.83
True SID lysine digestibility, %	78	60	90	89
Methionine, %	0.17	0.57	0.67	0.61
True SID methionine digestibility, %	90	81	91	91
Threonine, %	0.29	1.02	1.85	1.73
True SID threonine digestibility, %	82	70	87	85
Tryptophan, %	0.06	0.21	0.65	0.61
True SID tryptophan digestibility, %	84	70	90	87
Phosphorus, %	0.28	0.69	0.69	0.65
Phosphorus bioavailability, %	14	90	23	31

[1] Values from Swine NRC (1998)
[2] Values from University of Minnesota trials

Table 2

Variability of Selected Nutrients Among 32 U.S. DDGS Sources vs. Six U.S. Soybean Meal Sources

Nutrient	DDGS	Soybean meal
Crude protein	4.5	2.3
Crude fat	17.1	30.9
Crude fiber	18.9	9.5
Ash	27.2	6.6
Lysine	12.1	3.0
Methionine	8.5	5.3
Threonine	5.8	4.2
Tryptophan	12.0	7.3
Calcium	117.5	25.8
Phosphorus	19.4	9.1

Coefficients of variation represented in percentages

purchase and use. Currently, soybean meal—as a commodity—is less variable in nutrient content among sources compared to the nutrient content among DDGS sources (see Table 2). Crude fat was the only nutrient that had a higher coefficient of variation in soybean meal compared to DDGS. This high variation in crude fat content of soybean meal was caused by three extreme values (3.27 percent, 3.55 percent and 3.86 percent) in the samples collected (Urriola et al., 2006); the fat content in soybean meal averages about 1.74 percent. With the growing diversity of distillers grains coming onto the feed ingredient market, DDGS is becoming less of a commodity compared to soybean meal. To manage the diversity among DDGS sources, some commercial feed manufacturers are beginning to require identity preservation of selected DDGS sources, and are limiting the number of DDGS sources on feed companies' preferred suppliers list.

Physical Characterisitcs

The physical characteristics of a particular feed ingredient, such as DDGS, also play an important role in the ingredients' acceptance and widespread use in the feed industry. Some of the

most important physical characteristics of feed ingredients include: particle size, bulk density, flowability and any effects an ingredient may have on pelleting of complete feeds. Particle size is important because it's one of the factors that affects flowability of an ingredient in storage bins and feeders, but it also affects mixing efficiency and ingredient segregation during handling, transit and storage.

Bulk density (weight per unit of volume) is important because it influences the transportation cost (per ton) and the amount of storage bin space required to handle an ingredient. Dr. Kurt Rosentrater, an agricultural and bioprocess engineer with the USDA-Agricultural Research Service's North Central Agricultural Research Laboratory, has provided an excellent review of the factors involved and the significance of DDGS flowability in previous issues of *Distillers Grains Quarterly*. Although most of the swine diets being manufactured and fed throughout much of the Midwest are in meal form, large swine integrators in the southeastern United States pellet their diets. When corn DDGS is added to diets that are pelleted, pellet quality is reduced and mill throughput is often reduced using conventional pellet mill equipment and procedures. A few researchers are beginning to evaluate potential solutions to deal with the challenge of pelleting DDGS and diets containing DDGS.

Particle Size

Our research group at the University of Minnesota has evaluated particle size and bulk density differences among U.S. soybean meal sources and U.S. DDGS sources (see Figures 2 and 3). For soybean meal, average particle size among the six sampled U.S. sources was 754 microns, with a range between 523 microns to 1,142 microns. Average particle size among DDGS sources was lower (665 microns) and more variable among sources (127 microns to 1,105 microns) compared to soybean meal samples. Feed manufacturers strive to achieve an average particle size of complete swine feeds in meal form to be between 700 microns and

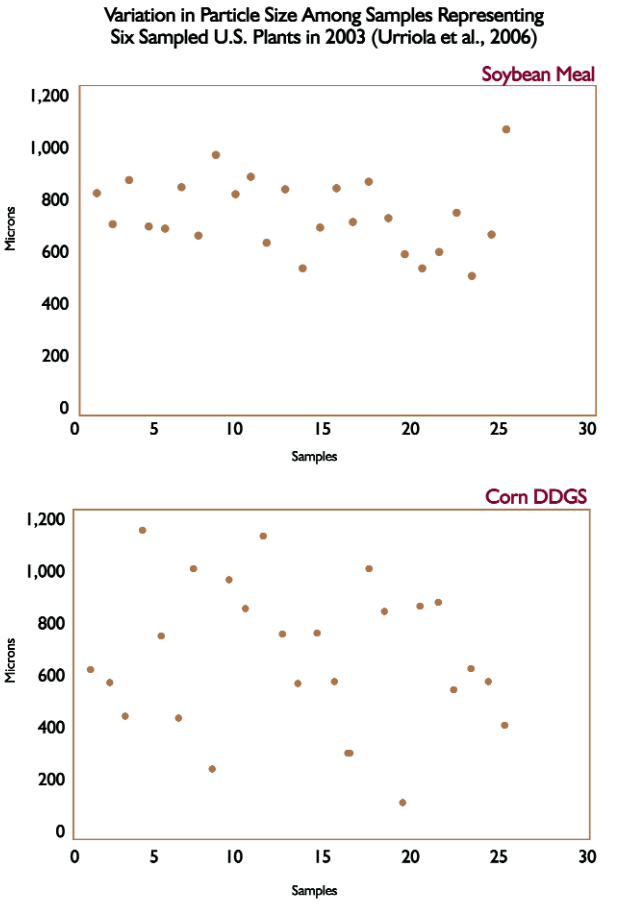

Figure 2.

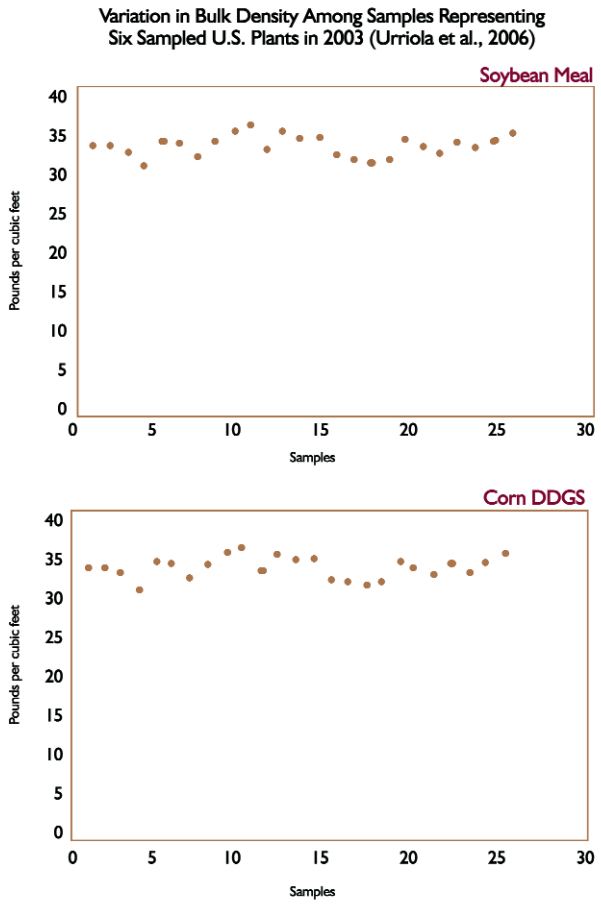

Figure 3.

800 microns. The average particle size of soybean meal samples fits well within this range. However, the many DDGS sources tested (see Figure 2) had an average particle size below 600 microns, which contributes to flowability problems and often reduces the acceptance of DDGS for use in swine feeds.

Bulk Density

Average bulk density is similar between soybean meal sources (32.2 pounds per cubic foot) and DDGS sources (30.8 pounds per cubic foot), but there is more variation among DDGS sources (25 to 35 pounds per cubic foot) than among soybean meal sources (31 to 35 pounds per cubic foot). Some of the increased variation in bulk density among DDGS sources may be due to differences in particle size and the amount of solubles blended with the grains fraction to make DDGS.

The Intangibles

Soybean meal is produced by heating soybean flakes after the oil is removed by solvent extractions. DDGS is a coproduct of corn fermentation involving yeast, which

appears to give it some unique properties. It has been estimated that DDGS contains about 4 percent yeast by weight. We know that there are components of yeast cell walls and yeast cell contents that have been shown to have immune system benefits in animals. There are several reports in the scientific literature suggesting that DDGS contains "unidentified growth factors." Less is known about the presence or impact of these potential "unidentified growth factors" in swine, but there is some evidence (Whitney et al., 2004) that DDGS is as effective as an approved antimicrobial treatment to reduce the length, severity and prevalence of intestinal lesions caused by *Lawsonia intracellularis*, the organism that causes ileitis, a common gut health problem in the swine industry.

Conclusion

Soybean meal will continue to be the primary protein source used in commercial swine diets in the United States because of its high levels of essential amino acids, complementary amino acid profile relative to that of corn and the pig's nutritional needs, high amino acid digestibility, and relatively good consistency in nutrient content and physical characteristics among sources compared to DDGS.

From a nutritional point of view, DDGS needs to be considered to be more of a diverse collection of ethanol coproducts that bring significant nutritional and economic value to swine diets—and less as a commodity. To reduce the risk of under- or over-valuing DDGS in swine diets, DDGS customers must select their sources based on available information addressing current and complete nutrient profiles. Ideally, they would set up rigorous DDGS quality assurance programs, as well as data bases of sample analyses over time to show how consistent the products being produced by a given ethanol plant are over long spans. If accurate, fast and inexpensive in vitro procedures can be identified and/or developed to estimate amino acid digestibility for swine among DDGS sources, the use of DDGS in swine diets would likely increase beyond the estimated 1.2 million tons used in 2005.

Depending on cost, it may be possible to add more synthetic amino acids to swine diets containing 20 percent to 30 percent DDGS to make up for the amino acid deficiencies inherent in DDGS, and thus displace more soybean meal in the diet. However, studies need to be conducted to demonstrate that this is an effective approach. Finally, it appears that DDGS may have some value-added properties that give it an advantage over soybean meal, particularly related to scientific evidence showing reduced gut health problems related to ileitis in growing pigs. DGQ

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