CANADIAN EXPERIENCE WITH FEEDING DDGS

Andrew Pharazyn
Nutreco Canada Agresearch
Suite 200, 150 Research Lane, Guelph, Ontario, N1G 4T2
E-mail: andrew.pharazyn@nutreco.ca

ABSTRACT

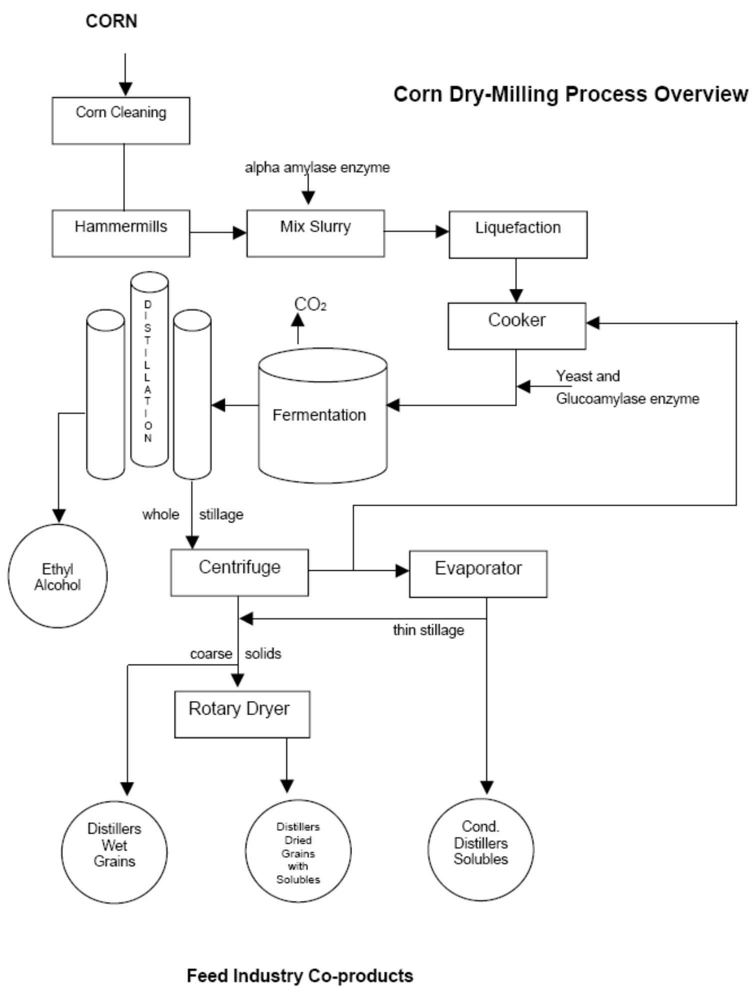
Corn Distillers Dried Grains with Soluble (CDDGS) is a byproduct of the ethanol industry. As commercial production of ethanol increases, the supply of corn distillers dried grains with solubles will increase. However, a number of risks must be addressed to efficiently utilize this feed ingredient in swine diets. Ingredient quality (energy, protein, amino acid availability, mycotoxin risk, etc.) must be monitored. Protein and fat content in batches of CDDGS can be highly variable between and within ethanol plants. The nutrient specifications used in the feed formulations need to reflect these changes in proximate analysis. Mycotoxins can be a risk depending on the mycotoxin content of the corn used in the ethanol facility. Beginning in the fall of 2006, the vomitoxin content of CDDGS was high (>8 ppm), which made it unacceptable for use in swine diets. Amino acid availability estimates of CDDGS showed a range in lysine availability from 64% to 84% which is consistent with estimates in the literature. Similar animal performance can be seen in GF pigs from 0 to 20% CDDGS in the diet provided that energy and amino acid levels are balanced. However, at higher dietary levels there is an increase in fat softness due to an increase in the polyunsaturated fat content of the carcass fat. In addition, there are production issues such as handling characteristics (flowability, bridging) and for pelleted diets, a decrease in mill throughput and increased fines can be seen when CDDGS exceeds 10% of the diet. Our experience has shown that CDDGS is a potential alternative ingredient for swine but a number of factors need to be addressed to use it properly.

INTRODUCTION

Corn Distillers Dried Grains with Soluble (CDDGS) is a byproduct of the ethanol industry. Government mandates have specified minimum levels of ethanol to be blended in gasoline. As cellulosic ethanol is not available in significant quantities, corn based ethanol production will be main source for the next several years. With the production of ethanol, corn distillers dried grains with soluble (CDDGS) is a co-product of the production process. As commercial production of ethanol increases, the supply of corn distillers dried grains with solubles will increase. The fermentation process removes the starch portion of the corn leaving a co-product with a higher protein, fat and fiber content. The technology used to produce ethanol has changed and continues to change. New technologies will change the type of ingredient that comes from the ethanol production facility. Part of the challenge facing the livestock feed industry is how to characterize the co-products coming from the ethanol industry. The future CDDGS "type" product will vary depending on the technology used in the ethanol industry.

We will need to re-think our definition of CDDGS, not so much as a single ingredient but as a group of ingredients.

GENERAL OVERVIEW OF ETHANOL PRODUCTION



In the production of ethanol, corn is cleaned of foreign material and then ground to a medium-coarse grind through a hammer mill. The corn is mixed with fresh and recycled water to form a slurry. The pH and temperature are adjusted and enzymes added to facilitate the breakdown of starch to dextrins or long chain sugars, in a process known as liquefaction. A second enzyme is added to take this down to simple sugars. A yeast, *Saccharomyces cerevisiae* is used to convert the simple sugars to ethanol and carbon dioxide. Fermentation is completed within 40 to 60 hours. The ethanol is then removed. The coarse solids are separated from the stillage. The thin stillage is recycled to the beginning of the process or concentrated as distillers solubles which is then added back to the coarse solids and the mixture dried to form the co-product Corn Distillers Dried Grains. The water content of the solubles added may vary and require a longer drying time and higher temperatures. This step is one of the key determinants in quality of CDDGS for swine.

To increase the efficiency of ethanol production, newer systems are pre-fractionating corn, removing the hull and germ, increasing the starch content of the material that is fermented prior to fermentation. As an example, the company QTI (Quality Technology International) uses a wet milling process to remove the germ and bran. They have a higher protein, lower fat type distillers grain that is markedly different in nutrient profile than “standard” CDDGS. In assessing CDDGS quality, the key first step is to understand the process used in producing the CDDGS.

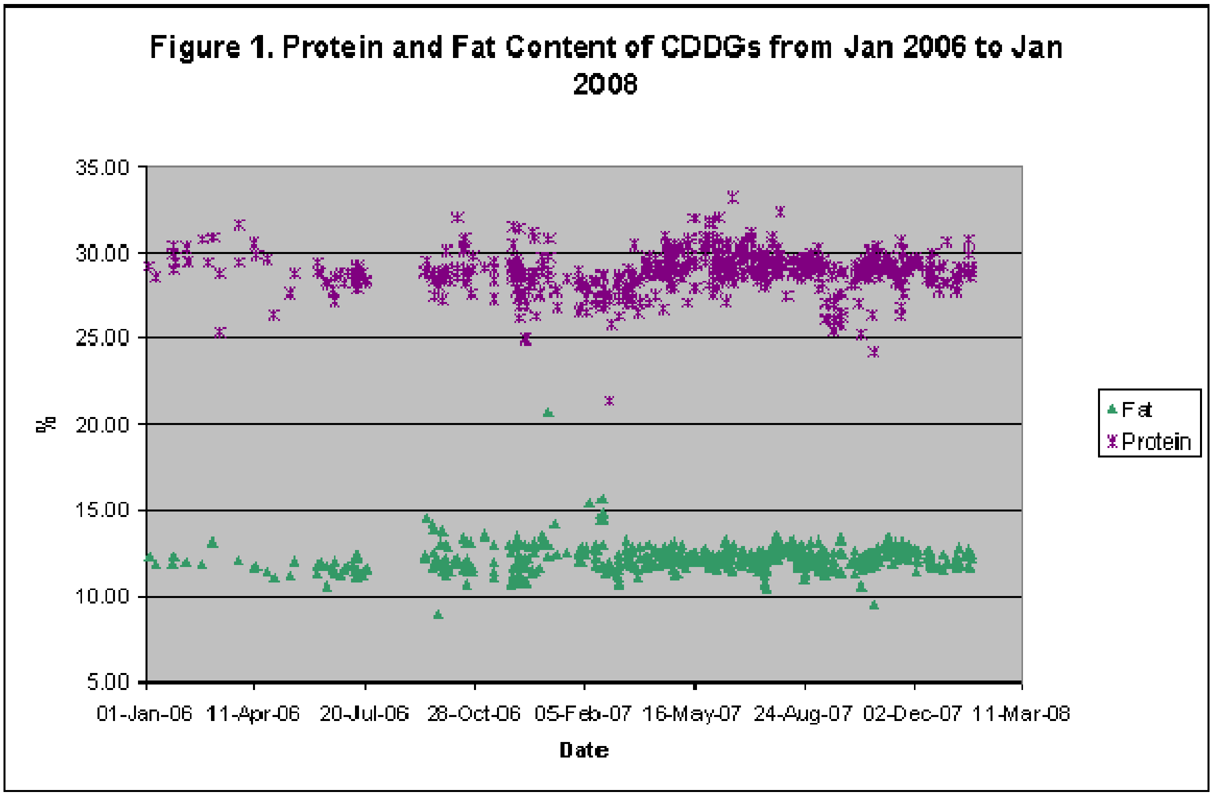
INGREDIENT QUALITY

The quality of Corn Distillers Dried Grains with Solubles depends on a number of factors. These are:

1. Corn quality – protein content, bushel weight, vomitoxin levels
2. Yeast used
3. Fermentation and distillation efficiency
4. Drying time and temperatures
5. Amount of solubles blended with dry material
6. Facility type – batch (modern) versus continuous (older)
7. Pre-fractionation prior to fermentation

Consistency in the process is the biggest driver in the variability in nutrient composition and availability.

The objective of a QA program is to assess quality of an ingredient that is to be used in the manufacture of a feed. When a co-product, such as CDDGS, is used the critical first step is to assess the quality of the material. This is more critical as the inclusion rate of the ingredient increases. CDDGS is a variable ingredient within and between ethanol plants (Figure 1).



Source: Nutreco Canada Agresearch

Utilizing constant energy and amino acid values for CDDGS would lead to inaccuracies in feed formulation. The use of a dynamic energy system allows a more accurate prediction of the energy and nutrient content of CDDGS used in swine diets. This is especially true given the variability that one sees in CDDGS coming out of ethanol facilities. Predicting the energy content based on proximate analysis (dry matter, protein, fat, etc.) gives a truer prediction of the ingredient value of CDDGS. The older literature estimates of energy content are based on the CDDGS with lower fat contents and higher fibre levels. The CDDGS from newer ethanol plants have higher fat content and higher energy content than normally specified for CDDGS.

The protein content of CDDGS is high (>27%). However, like corn, the amino acid balance is poor, being low in lysine and tryptophan in comparison to other protein sources such as soybean meal. The other concern is the variability in amino acid availability. Like all heat-processed products, the drying process used can reduce lysine availability, decreasing the quantity of this essential amino acid actually available to the pig.

Hans Stein at the University of Illinois determined the availability of amino acids from several newer ethanol plants (Table 1). Of the 10 samples collected, lysine availability ranged from 44% to 63%. Other amino acids showed a lower range in availability. Drying temperatures can vary from batch to batch. The amount of syrup added back to the grains can vary altering the drying time and temperatures required. Under high temperatures, lysine in the protein can form complexes with sugars (called a Maillard or "Browning" reaction), from the syrup. These Maillard products reduce the availability of lysine in the CDDGS. This is a similar process that occurs in corn that has been subjected to high drying temperatures. Heat damaged product is normally but not exclusively, a darker colour.

Table 1. Crude protein and total and digestible lysine from 10 ethanol plants in the Mid-West U.S. (Stein et al., 2006).

	DDGS Source												
Sample	1	2	3	4	5	6	7	8	9	10	Ave	Std Dev	% CV
Crude Protein, %	27.6	28.0	27.2	29.0	26.7	24.6	26.6	28.4	29.1	27.3			
Total Lysine	0.82	0.85	0.78	0.76	0.68	0.74	0.82	0.71	0.88	0.83	0.79	0.06	8.15
Lysine, as a % of Protein	2.97	3.04	2.86	2.62	2.54	3.01	3.08	2.50	3.03	3.04	2.87	0.23	7.89
Digestibility Co-efficient	59.3	56.8	63.0	57	43.9	59.4	59.4	48.6	61.3	59.6	56.83	5.96	10.49
SID Lysine, %	0.49	0.48	0.49	0.43	0.30	0.44	0.44	0.35	0.54	0.49	0.45	0.07	16.54

The colour of CDDGS can be an indicator of amino acid availability, although the relationship between colour and amino acid availability is not definite. Colour is dependent on the processing parameters of the ethanol plant with darker colour product associated with poorer quality and indicative of heat damage. The colour of CDDGS should be in the gold to yellow colour. When one gets into darker colour material, the amino acid availability, particularly that of lysine can be reduced dramatically.

There are a number of analyses that have been investigated to improve on amino acid assessment of CDDGS. These are listed in Table 2. These assays have different degrees of correlation with lysine availability. One of the more promising assays is the Immobilized

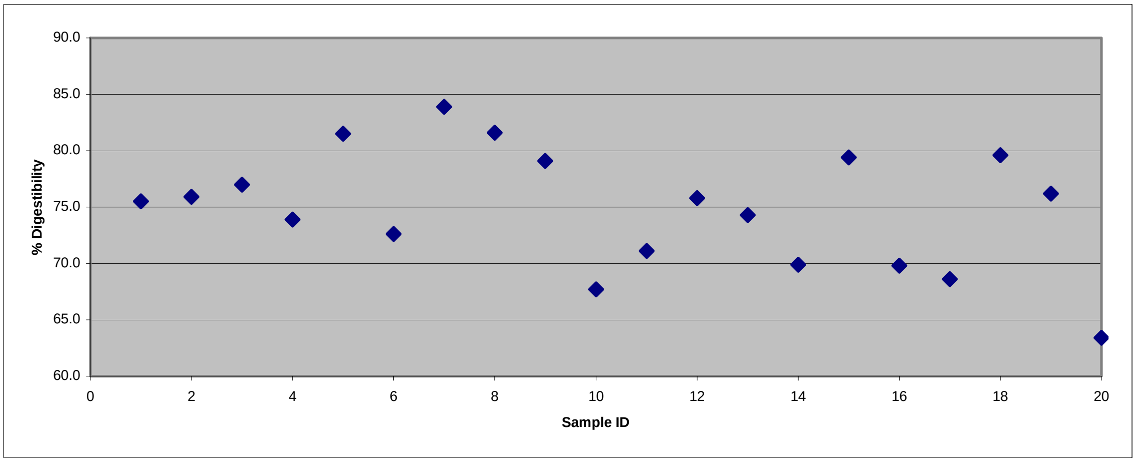
Digestive Enzyme Activity (IDEA) kit from Novus International. It relies on a direct measurement of amino acid availability and has a strong correlation with poultry amino acid digestibility estimates (Figure 2).

Table 2. List of methods and correlation to swine lysine digestibility estimate.

1. One-Step pepsin digest – R^2 = 0.52
2. Two-Step pepsin-pancreatin digest – R^2 = 0.79
3. Color – R^2 = 0.53-0.67
4. KOH Solubility – R^2 = 0.47
5. Furosine – R^2 =0.71
6. Reactive lysine – R^2 = 0.66
7. IDEA Value– R^2 = 0.88 (Novus) vs. True Lys Dig. (Poultry)

Source: Stein et al., 2005

Figure 2. Estimates of CDDGS lysine availability using IDEA kits from samples collected from across Canada.



Source: Nutreco Canada Agresearch

One of the major risk factors in using CDDGS is the presence of mycotoxins. Mycotoxin levels will be proportional to the level of mycotoxin in the corn used. The removal of starch through the fermentation process concentrates the remaining nutrients by a factor of 3. The level of vomitoxin in the CDDGS will reflect the corn used in the production of ethanol, increasing approximately threefold. In the 2006 corn crop, vomitoxin was a major concern in the crop. As the 2006 corn crop was used in the production of ethanol, the level of vomitoxin in CDDGS increased concurrently. Based on the risk of vomitoxin coming from CDDGS, the ingredient was excluded from swine diets. The 2007 corn crop was clean with low levels of vomitoxin in CDDGS and therefore greater opportunities to include CDDGS into swine diets. The Shur-Gain QC program requires monitoring of mycotoxin levels in CDDGS, ensuring that total mycotoxin levels are minimized in the diet.

ANIMAL PERFORMANCE AND CARCASS/MEAT QUALITY

When diets are properly balanced, CDDGS can be included up to 20% in grower-finisher diets with no significant difference in animal performance (Table 3). There was a significant decrease in cost per kg of gain. However, the cost savings is dependent on the relative costs of corn, SBM, fat and CDDGS. The decision whether CDDGS is a cost effect alternative should be done in consultation with a nutritionist.

Table 3. Swine grower-finisher performance in response to graded levels of corn distillers dried grains in diets of pigs fed from 25 to 115 kg.

	DDGS, %			Sign.
Treatment	0-0-0	5-10-10	10-20-20	DDGS
ADFI, kg/d	2.342a	2.293ab	2.230b	0.010
ADG, g/d	864	855	848	
Feed:Gain, g/g	2.71	2.68	2.63	
Cost/kg gain, $/kg	0.722a	0.706ab	0.683b	0.007
Feed Cost/pig, $	64.88a	63.51ab	61.93b	0.047

Source: Nutreco Canada Agresearch

Provided that the amino acid:energy levels are kept in balance, there was no effect of CDDGS on carcass characteristics. However, there was some alteration in meat quality as fat firmness showed a trend to lower firmness scores with increasing CDDGS. Other meat quality parameters were not significantly affected. The concern with CDDGS is the high content of polyunsaturated fat. The fatty acid profile of pork and backfat is reflective of the fatty acid composition of the diet. The high proportion of polyunsaturated fat can contribute to soft carcass fat. When CDDGS exceeds 10% of the diet, there is a tendency to have softer fat in the carcass (Table 4).

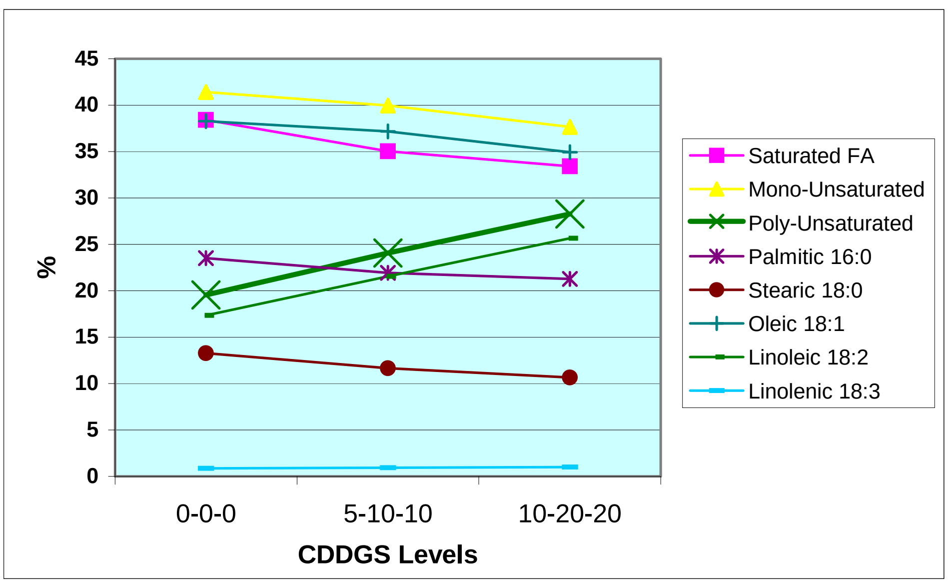
Increasing the level of CDDGS in the grow-finish diets elevated the level of linoleic acid and other polyunsaturated fatty acids by 45% compared to control diets (Figure 3). Similarly, the level of saturated fatty acid decreased in response to level of dietary CDDGS. The approach to reduce this would be to keep CDDGS to 10% or less in the finisher diets. With the higher polyunsaturated fat content, it may be advisable to increase the vitamin E content of the feed.

Table 4. **Swine carcass characteristics in response to graded levels of corn distillers dried grains in diets of pigs fed from 25 to 115 kg.**

	DDGS, %			
Treatment	0-0-0	5-10-10	10-20-20	P
Carcass weight, kg	89.09	89.06	89.78	
Backfat, mm	16.9	16.7	16.5	
Loin depth, mm	59.1	57.8	57.6	
Lean Yield, %	61.3	61.3	61.4	
Index	108	108	110	
Bending	2.1	1.9	1.8	
Fat Firmness	2.6a	2.1b	1.8c	0.09
Loin Firmness	2.9	3.1	2.7	
Fat Color Japan	1.8	1.8	1.9	
Loin Colour Japan	2.3	2.7	2.1	
Texture	2.0	2.1	1.7	

Source: Nutreco Canada Agresearch

Figure 3. **Change in backfat fatty acid profile in response to increasing levels of CDDGS in the diet.**



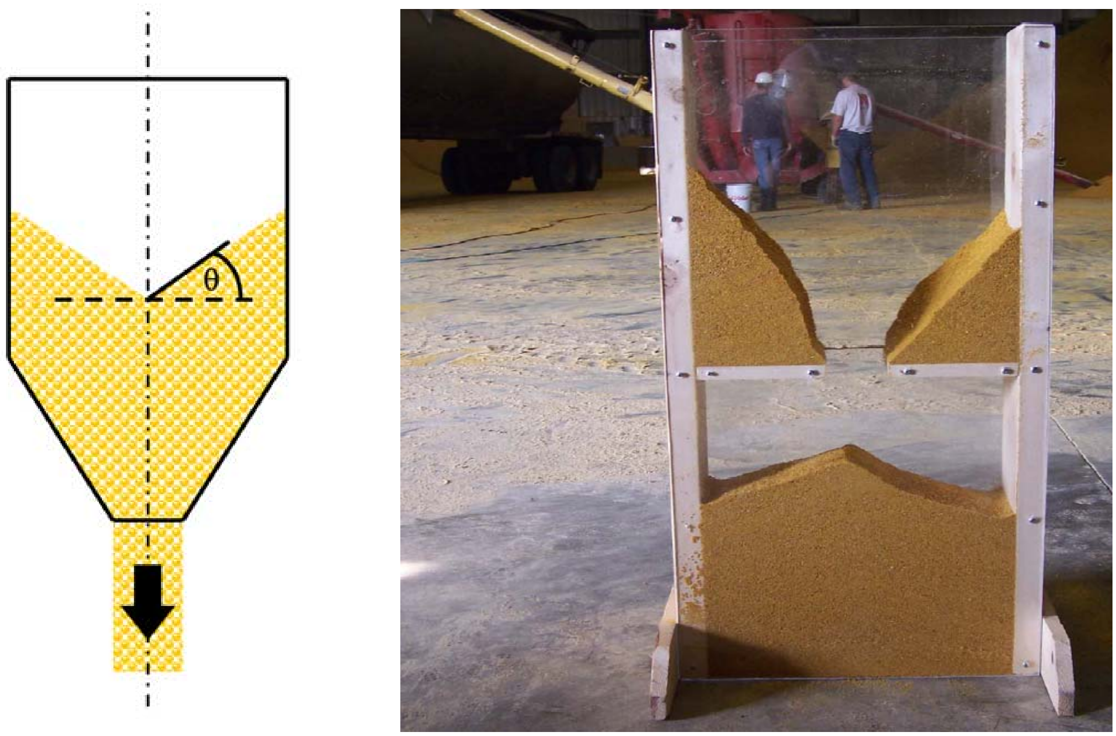
Source: Nutreco Canada Agresearch

PHYSICAL CHARACTERISTICS

Flowability

Flowability of CDDGS into and out of freight and storage facilities can be an issue given the nature of the product. The syrup portion has a high sugar content. The high sugar content can increase the stickiness of the product and reduce the flowability of the product. As the proportion of syrup added back to the CDDGS prior to drying increases, the stickiness or cohesiveness of the product increases, resulting in poorer flow characteristics. Flowability can be estimated by assessing the angle of repose. The Angle of Repose is the angle between a horizontal plane and the slope of a pile (at rest) formed by dropping from some elevation (Figure 4). The Angle of Repose is related to many of the flow properties of a material and is thus an indirect indication of flowability potential. Angle of Repose gives a reproducible numerical value for a given material, so it has been adopted as a standard measurement for general flowability behavior (Rosentrater, 2006). The optimum Angle of Repose falls within 25 to 35^{o}. Materials having an Angle of Repose falling within that range are considered free flowing. Materials with higher Angles of Repose may have problems with bridging.

Figure 4. Equipment for measuring Angle of Repose. (Shurson, 2007)



A study by Rosentrater (2006) measured a range of physical characteristics of CDDGS from several methanol plants in the U.S. (Table 5). The study indicated a range of flowability estimates in CDDGS samples measured. The addition of anti-caking agents such as limestone to increase flowability has been used with limited success. In our experience in the feed mill with our equipment, flowability has not been an issue. However, this is a characteristic that needs to be monitored.

Table 5. Angle of Repose and other physical characteristics of CDDGS (Rosentrater, 2006).

Physical properties of typical DDGS (n=48)				
Physical property	Minimum	Maximum	Mean	Standard Deviation
Moisture Content (%, d.b.)	13.21	15.01	14.37	0.42
Water Activity (-)	0.53	0.63	0.55	0.03
Bulk Density (kg/m^3)	389.28	496.40	479.97	28.29
Angle of Repose (°)	26.51	34.23	31.76	1.73
Color				
Hunter L (-)	39.99	49.82	43.05	1.96
Hunter a (-)	8.00	9.81	8.76	0.42
Hunter b (-)	18.22	23.50	19.44	1.14

Other Manufacturing Issues

There can be a variation in ingredient particle size which can negatively affect pellet quality. In addition, the “stickiness” of the ingredient, resulting from its hydroscopic characteristics, can cause some issues with balls of material during mixing. Adjustments to conditioning time and temperature will have to be made as increasing levels of CDDGS are included in the diet. Obviously, using CDDGS in mash diets alleviates some of these problems but not all.

CONCLUSIONS

As ethanol production from corn increases, the supply of CDDGS will increase. CDDGS can be used but a continuous assessment of the ingredient quality must be performed. Factors such as nutrient content (energy, protein, available amino acids, etc.), impact on carcass and meat quality, and mycotoxins must be considered when CDDGS are offered into swine diets to mitigate against the risk to overall animal performance and final pork quality when formulating with CDDGS.

LITERATURE CITED

Rosentrater, K. 2006. Understanding Flowability – Part 3: Some Physical Properties of DDGS - Distillers Grains Quarterly, Fourth Quarter 2006.

Shurson, G. 2007. Quality Issues Related to Corn Distillers. Ethanol Magazine.

Stein H.H., A.A. Pahm, and C. Pedersen. 2005. Methods to determine amino acid digestibility in corn byproducts. In: Proceedings of the 66th Minnesota Nutrition Conference. St. Paul. MN. USA. pp. 35-49.

Stein, H. H., M. L. Gibson, C. Pedersen, and M. G. Boersma. 2006. Amino acid and energy digestibility in ten samples of distillers dried grain with solubles fed to growing pigs. J. Anim. Sci. 84:853–860.