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More and more ethanol co-products are available for livestock feed because of the rapid growth of the ethanol industry in South Dakota. The three main co-products are Distillers Grains, Solubles, and Distillers Grains with Solubles, and they can be either "wet" or "dried" depending on the manufacturing process.

Since, in the U.S., on-farm feed mixing and swine feeding systems are almost exclusively designed for dry feed, we deal here only with the dried products. All ethanol plants in South Dakota mainly produce Distillers Dried Grains with Solubles (DDGS), limiting our discussion further to only DDGS as a feed ingredient for swine.

DDGS

Corn is two thirds starch, and during the fermentation and distillation processes, the starch is converted to ethanol. One bushel of corn produces approximately 2.6 gallons of ethanol, 17 lbs of CO_2, and a wet spent-mash.

The wet mash goes through a series of centrifuges, evaporators, and presses to produce Solubles (liquid) and Distillers Grains (semi-dry). The Solubles and Distillers Grains are then blended and dried to produce 17 lbs of DDGS from the same bushel of corn.

DDGS is a co-product, and like all co-products (soybean meal, meat and bone meal, sunflower meal), it can vary greatly in nutrient concentrations. Ranges of nutrient concentrations and physical characteristics from nine DDGS samples are given here:

Dry matter	87 - 93%
Crude protein	23 - 29%
Crude fat	3 - 12%
Lysine	.59 - .89%
Color	light golden to dark brown
Smell	sweet to smoky or burnt

Growth trials conducted with the nine different DDGS sources demonstrated large differences in gain, feed intake, and feed efficiency, depending on the source of DDGS in the diet. Therefore, DDGS quality has a considerable—and variable—impact on livestock performance.

Why these differences in nutrient concentrations? There are several reasons.

First of all, nutrient variability of the corn used has a dramatic impact on the variability of DDGS. Since the starch in corn is converted to ethanol and removed, the remaining nutrients in corn are concentrated and roughly tripled in the resulting DDGS.

For example, if a load of corn contains .26% lysine, the resulting DDGS will likely contain .78 % lysine. However, if a lower lysine corn (.23% lysine) is used, the resulting DDGS will contain only .69% lysine. The same

rule applies for the concentrations of all the other nutrients (fat, fiber, protein, phosphorus, etc.)

The second factor to have a major impact on DDGS nutrient concentrations is processing methods. Type of yeast used, fermenting and distillation efficiency, drying temperature and time, and amount of solubles blended with the dry material all affect the nutrient concentrations in DDGS.

Recent research at the University of Minnesota also has shown that DDGS from the new-generation ethanol plants in South Dakota and Minnesota has higher nutrient concentrations than DDGS from traditional ethanol plants. Table 1 shows the nutrient composition of traditional and "new generation" DDGS.

Table 1. Nutrient composition of two sources of DDGS (as-fed basis).

Nutrient	*Traditional DDGS*	*SD/MN DDGS*
Crude Protein	27.7%	26.8%
Total lysine	.62%	.74%
Digestible lysine	.29%	.39
Crude fat	8.4%	9.7%
Crude fiber	9.1%	7.8%
Calcium	.20%	.05%
Total phosphorus	.77%	.79%
Digestible phosphorus	.59%	.71%
Metabolizable energy, kcal/lb	1282	1633

Table 1 shows large differences in nutrient concentrations for the processing methods, especially for two of the most critical nutrients: digestible lysine (34.5%) and digestible phosphorus (20.3%). The question then becomes "What values do I use when formulating swine rations?"

The best answer is to properly sample each load of DDGS you get and analyze for lysine and phosphorus. Then multiply those values by their digestibility coefficients (lysine = .53; phosphorus = .90) to get the amount digestible of each nutrient.

For example, if a sample of DDGS contained .80% total lysine and .78 total phosphorus, you'd multiply .80% times .53 to get a digestible lysine value of .42%. Then, multiply .78% by .90 to get a digestible phosphorus concentration of .702%. These are the values you need to use when balancing swine rations.

If analyzing each load of DDGS is not feasible, the next best thing to do is to visit the plant you purchased the DDGS from and find out the nutrient range of its product over the last 6 months. To avoid a potential nutrient deficiency, it is then best to select a value at the lower end of each range to use when formulating.

If that data is not available, consider changing suppliers or use the values for traditional DDGS.

Another method to reduce nutrient variation is to develop a DDGS specification sheet for nutrient levels and physical characteristics, and then only buy DDGS from plants that will guarantee meeting those specifications. However, you are responsible for periodic testing to ensure your specifications are being met. Table 2 is one example of such a sheet.

Table 2. Specifications for DDGS for swine diets.

Moisture	maximum 12%
Crude protein	minimum 26.5%
Crude fat	minimum 10%
Crude fiber	maximum 7.5%
Color	golden
Smell	fresh, fermented, pleasant cereal odor
Bulk density	34 – 37 lb/cubic foot
Particle size	coarse = 10% maximum on a 2000-mesh screen fine = 15% maximum on a 600-mesh screen and pan

Mycotoxins

Mycotoxins are produced by molds either in the field or during storage. They can severely impact pig and sow performance. While there are many different mycotoxins, zearalenone and vomitoxin (DON) are the main ones of concern for South Dakota pork producers.

Unfortunately, the fermentation process does not destroy mycotoxins. In fact, just as it does for lysine and other nutrients, it concentrates the mycotoxins threefold. If corn containing 1 ppm zearalenone is delivered to an ethanol plant, the resulting DDGS will contain 3 ppm zearalenone.

Since the maximum inclusion rate of both mycotoxins is 1 ppm in the total diet, it does not take a large amount of mycotoxins to cause problems, especially for sows.

This is more of a problem if the ethanol plant is purchasing damaged grains or if it has been a year in which there has been a mycotoxin problem in the corn in the field.

If you suspect a problem, send a DDGS sample to an analytical lab for a mycotoxin analysis.

Or you can purchase DDGS only from ethanol plants that do not buy damaged grains. Visit with each plant manager to learn the plant's policy on purchasing mycotoxin-contaminated grains. While damaged corn will not have much negative impact on ethanol production, it could have a great impact on the mycotoxin levels in the DDGS. Also, even in the best quality-control systems, some damaged corn can get in.

Therefore, it is strongly recommended to start conservatively when including DDGS in gestation and lactation diets.

Table 3. Recommended inclusion rates of DDGS in swine diets.

Phase	*Starting point*	*Maximum inclusion rate*
Nursery (>15 lbs)	5%	25%
Grow-finish	10%	20%
Gestating sows	20%	50%
Lactating sows	5%	20%
Boars	20%	50%

Incorporating DDGS into swine diets

Pigs require amino acids, not protein, so swine diets need to be balanced on a lysine or digestible lysine basis, not on crude protein. While DDGS is relatively high in protein, it is still low in lysine, the first limiting amino acid for swine in grain-based diets.

Due to its poor amino acid balance for pigs, corn is a poor quality protein source for pigs. When corn is processed into DDGS, the poor amino acid balance is concentrated, not improved in DDGS. Therefore, to properly incorporate DDGS in swine diets, the diets must be formulated on a lysine or digestible lysine basis. If the diets are balanced on crude protein, the diets will be grossly deficient in lysine and other essential amino acids, and pig performance will be substantially decreased.

Keep in mind that DDGS is not just another amino acid source. It is also an excellent source of digestible phosphorus. Therefore, when adding DDGS to a diet, you will be able to reduce the amount of dicalcium phosphate normally used.

As was mentioned before, source of DDGS is critical on pig performance. The recommendations in Table 3 are based on a high quality DDGS and on diets balanced on **digestible** lysine and phosphorus.

It is recommended to start at the lower inclusion level and then gradually work your way up to the maximum inclusion rate, especially for sows. University of Minnesota has shown that going immediately to the higher levels for sows resulted in an initial reduction in feed intake for about 1 week before they went back to full feed. Also, mycotoxins have the greatest effects on reproduction, so extra care must be taken when using DDGS in sow diets.

DDGS concentrations up to 30% of the diet have no effect on grow-finish pig performance. However, the 30% inclusion level does result in carcasses that have reduced belly firmness and more soft fat due to the high concentrations of polyunsaturated fatty acids in DDGS. Therefore, 20% is the maximum recommended amount in grow-finish diets.

Storage

DDGS contains approximately 10% fat, and a large portion of that fat is composed of polyunsaturated fatty acids.

Since polyunsaturated fatty acids are subject to rancidity, you will need to use DDGS as quickly as possible. It is recommended that you buy no more than a 3-month supply of DDGS in the winter and no more than a 1-month supply in the summer.

Due to its high fat content, DDGS "flowability" through bulk bins may be a potential problem. Use caution when selecting the facility to store DDGS in on-farm.

Health benefits

There have been reports by producers that 10-20% DDGS in grow-finish diets reduces the incidence/severity of ileitis and Hemorrhagic Bowel Syndrome (HBS). However, no controlled research trials have been conducted to demonstrate this effect. SDSU and the University of Minnesota are currently conducting such trials, but we have no data to offer at this point.

Therefore, use caution in applying any economic value to DDGS's health effects until the trials are completed.

Economics

DDGS provides lysine, phosphorus, and energy, and it replaces soybean meal, dicalcium phosphate, and corn. When considering the economics of using DDGS, all these factors must be included.

As a "rule of thumb", 200 lb of DDGS and 3 lb of limestone can replace 178 lb of corn, 19 lb of 46% protein soybean meal, and 6 lb of dicalcium phosphate in a ton of complete feed. However, by balancing on a digestible amino acid basis and making certain all ten essential amino acid requirements are being met, higher concentrations of DDGS can be used in swine diets.

Table 4. Determine the approximate worth of DDGS in your swine diets.

Ingredients	*$/lb*	*Lb*	*Total cost*
DDGS	_____	_____	_____
Limestone	_____	_____	_____
Corn	_____	_____	_____
SBM (46% CP)	_____	_____	_____
Dical Phos (18.5% P)	_____	_____	_____
Total cost, $	_____	_____	_____

If DDGS is $85/ton ($.043/lb), 46% SBM is $245/ton ($.123/lb), corn is $2.37/bu ($.042), limestone is $.013/lb, and dical phos is $.15/lb, you can calculate the worth of 200 lb of DDGS.

Table 5. The worth of 200 lb of DDGS.

Ingredients	*$/lb*	*Lb*	*DDGS cost*	*Current cost*
DDGS	.043	200	8.60	
Limestone	.013	3	.04	
Corn	.042	178		7.48
SBM (46% CP)	.123	19		2.34
Dical Phos (18.5% P)	.15	6		.90
Total cost, $			$8.64	$10.72

In this example, a 10% inclusion of DDGS (200 lb/ton) would save $2.08/ton of feed. Assuming that it takes three pigs to consume one ton of feed, using 10% DDGS would reduce diet cost by $.69/pig in this example.

For ease of calculation, there is an Excel spreadsheet available at your local county Educator's office and also on the Animal and Range Sciences Department homepage (http://ars.sdstate.edu/).

If you properly formulate diets so that the DDGS concentrations do not exceed the maximum recommended levels, the decision to use DDGS depends on which complete diet is less expensive—corn-SBM or corn-SBM-DDGS.

Summary

DDGS is a co-product from the ethanol industry and is a source of amino acids and phosphorus for swine. Producers must be aware of the wide range of nutrients and potential mycotoxin problems associated with DDGS. However, a proper analysis or screening program can alleviate those concerns.

DDGS can work well in swine rations at the proper inclusion level when the diets are balanced on digestible amino acids and phosphorus. Once that is done, the decision to use DDGS or not depends on economics.

For further information on DDGS, please contact your local county educator or Bob Thaler at 688-5011 (Robert_thaler@sdstate.edu).

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