THE VALUE OF DISTILLERS DRIED GRAINS WITH SOLUBLES IN PIG DIETS

G. C. Shurson, M. H. Whitney, M. J. Spiehs,
S. K. Baidoo, and A. Renteria
Department of Animal Science
University of Minnesota, St. Paul

Introduction

Distiller's Dried Grains with Solubles (DDGS) is a co-product of the distillery industries. Most (~98%) of the DDGS in North America comes from plants that produce ethanol for oxygenated fuels. The remaining 1 to 2% of DDGS is produced by the alcohol beverage industry.

Approximately 3.2 to 3.5 million metric tonnes of DDGS are produced annually in North America (Markham, 2000; personal communication). Ethanol plants in Minnesota, South Dakota and North Dakota produce approximately 25% of this amount (850,000 to 900,000 tonnes) annually (Markham, 2000; personal communication). Most of the ethanol plants in the Minnesota-Dakota (MNDAK) region are small, farmer owned, and relatively new (less than 5 years old). These plants are utilizing new technology (e.g. batch fermentation) and improved quality control procedures to produce a higher quality DDGS compared to older, larger, privately owned ethanol plants (Markham, 2000; personal communication). In recent years, some regions of the U.S. have required the use of oxygenated fuels (e.g. ethanol-gasoline blends) to reduce air pollution from automobile emissions. Because of the increased demand for ethanol, the production of DDGS is expected to double within the next few years, further increasing the quantity of DDGS available for use in livestock feeds.

Of the 3.2 million metric tonnes of DDGS produced annually in North America, about 700,000 metric tonnes are exported to countries in the European Union for use in livestock feeds. A very small amount of DDGS is exported to Mexico, leaving about 2.65 million metric tonnes available for domestic use in the U.S. and Canada (Markham, 2000; personal communication).

In North America, over 80% of DDGS are used in ruminant diets (Markham, 2000;personal communication). Minnesota is the only state in the U.S. where a significant amount of DDGS (40,000 to 50,000 tonnes annually) is fed to turkeys. Less than 1% of the total annual production is fed to swine. Traditionally, most of the DDGS in the U.S. has been fed to ruminants because of low protein quality, reduced amino acid digestibility, increased fiber, and lower DE and ME content compared to corn. Variability in nutrient content and cost competitiveness relative to corn and soybean meal have also limited the use of DDGS in swine diets in the Midwestern states of the U.S.. As a result, many swine nutritionists have considered DDGS to be a less desirable nutrient source compared to other energy and amino acid sources. However, due to the increasing quantities of DDGS being produced and the potential improvement in nutritional value resulting from using newer technology and quality control in the MNDAK plants, the application of DDGS in swine diets needs to be re-examined. The purpose of this chapter is to describe and compare the nutritional value of DDGS among published sources, provide new data on the nutritional value of DDGS produced in the Minnesota-Dakota region, and describe the application of DDGS in practical swine diets.

Production and Composition of Distiller's By-Products

Distiller's dried grains with solubles are the dried residue remaining after the starch fraction of corn is fermented with selected yeasts and enzymes to produce ethanol and carbon dioxide. After complete fermentation, the alcohol is removed by distillation and the remaining fermentation residues are dried.

Historically, three types of residual co-products were produced: distillers dried grains, distillers dried solubles, and distillers dried grains with solubles. Once the fermented mash was distilled, the soluble portion of the remaining residue was condensed by evaporation to produce Condensed Distiller's Solubles. The course material remaining in the fermentation residues was the Distillers Grains fraction. Both of these fractions were subsequently dried to produce either Distiller's Dried Solubles (DDS) or Distiller's Dried Grains (DDG).

Today, ethanol plants blend and dry these two residues to produce Distillers Dried Grains with Solubles, which is the only form available to the feed industry. A comparison of the nutrient profile of the three co-products is shown in Table 4.1. Note that the Distiller's Dried Solubles fraction has the highest concentration of nutrients compared to DDG and DDGS. It is a rich source of vitamins, and is the lowest in fiber and highest in fat, yielding a DE value that is approximately 91 % of that found in corn. Since DDGS is a blend of DDS and DDG, one would expect the nutrient composition of DDGS to be intermediate between DDS and DDG. As shown in Table 4.1, this is generally the case with the following exceptions: crude protein, arginine, histidine, lysine, methionine, cystine, tryptophan, magnesium, sodium, sulfur, selenium, vitamin B12, and folacin. These discrepancies suggest that more definitive nutrient values are needed for DDGS.

Table 4.1. Comparison of the Nutrient Composition (Dry Matter Basis) of DDG, DDS, DDGS, Corn, and Soybean Meal 44% (NRC, 1998).

	DDG	DDS	DDGS	SBM, 44 %	Corn
Dry Matter, %	94	92	93	89	89
Crude Protein, %	26.4	29.0	29.8	49.2	9.3
Crude Fat, %	8.4	9.9	9.0	1.7	4.4
ADF, %	18.6	8.2	17.5	10.6	3.1
NDF, %	43.0	27.0	37.2	14.9	10.8
DE, kcal/kg	3298	3614	3441	3921	3961
Arginine, %	0.96	0.96	1.22	3.63	0.42
Histidine, %	0.67	0.72	0.74	1.31	0.26
Isoleucine, %	1.01	1.32	1.11	2.23	0.31
Leucine, %	2.80	2.45	2.76	3.84	1.11
Lysine, %	0.79	0.89	0.67	3.18	0.29
Methionine, %	0.46	0.55	0.54	0.69	0.19
Cystine, %	0.30	0.50	0.56	0.79	0.21
Phenylalanine, %	1.05	1.50	1.44	2.45	0.44
Threonine, %	0.66	1.12	1.01	1.94	0.33
Tryptophan, %	0.21	0.25	0.27	0.69	0.07
Valine, %	1.32	1.63	1.40	2.31	0.44
Calcium, %	0.11	0.32	0.22	0.36	0.03
Chlorine, %	0.09	0.27	0.22	0.06	0.31
Magnesium, %	0.27	0.70	0.20	0.30	0.13
Phosphorus, %	0.43	1.17	0.83	0.73	0.31
Potassium, %	0.18	1.63	0.90	2.20	0.37
Sodium, %	0.10	0.28	0.27	0.01	0.02
Sulfur, %	0.46	0.40	0.32	0.48	0.15
Copper, mg/kg	48	90	61	22	3
Iron, mg/kg	234	609	276	227	33
Manganese, mg/kg	23	80	26	33	8
Selenium, mg/kg	0.43	0.36	0.42	0.36	0.08
Zinc, mg/kg	59	92	86	56	20
Vitamin E, mg/kg	13.7	-	-	2.6	9.3
Niacin, mg/kg	39.4	126	80.6	38.2	27.0*
Pantothenic acid, mg/kg	12.4	22.8	15.1	18.0	6.7
Riboflavin, mg/kg	5.5	18.5	9.2	3.3	1.3
Vitamin B12, mg/kg	0.0	3.3	0.0	0.0	0.0
Biotin, mg/kg	0.52	1.80	0.84	0.30	0.07
Choline, mg/kg	1255	5263	2835	3139	697
Folacin, mg/kg	0.96	1.20	0.97	1.54	0.17
Thiamin, mg/kg	1.8	7.5	3.1	5.1	3.9
Vitamin B6, mg/kg	4.7	9.6	8.6	6.7	5.6

*Niacin is totally unavailable. Niacin from most co-products originating from corn is probably also low.

Differences in Nutrient Content of DDGS Among Sources

Some ethanol plants also include milo, wheat, or barley in the fermentation process, depending on geographical location and time of the year (Markham, 2000; personal communication). As a result, use of multiple grains in DDGS contributes to some of the variability in nutrient content that has been of concern to swine nutritionists. Because of the near complete fermentation of starch, the remaining amino acids, fat, minerals and vitamins increase approximately three-fold in concentration compared to levels found in corn (Table 4.1). Despite the significant increase in crude protein, the amino acid balance of DDGS is inferior (as in corn) to soybean meal (Table 4.1).

Published feed ingredient tables used by nutritionists do not distinguish nutrient profiles among ingredient sources. In fact, one of the common reasons why more nutritionists do not use DDGS in swine diet formulations is because of product variability and lack of knowledge of DDGS nutrient values from specific sources. Cromwell et al. (1993) compared physical, chemical, and nutritional characteristics of DDGS from nine sources. They showed that there is tremendous variability in these characteristics among sources of DDGS available to the feed industry. In this study, color scores ranged from very light to very dark and odor scores ranged from normal to burnt or smoky. Nutrient concentrations for DDGS sources ranged from 23.4 to 28.7% crude protein, 0.43 to 0.89% lysine, 2.9 to 12.8% fat, 28.8 to 40.3% NDF, 10.3 to 18.1% ADF, and 3.4 to 7.3% ash.

There are three general types of ethanol plants that produce DDGS in North America. The oldest ethanol plants (OEP) are the largest and use fermentation and processing technology that is more than 40 years old. These plants have extremely large fermenters that are operated on a continuous basis, compared to a batch fermentation process used in modern plants. As a result, achieving satisfactory quality control is a challenge because many things can disrupt the quality and completeness of the fermentation process such as "hot spots" and infections from wild strains of yeast and bacteria. These plants also use different enzymes in the fermentation process compared to those used in new plants. Furthermore, there are differences in drying times and heating temperatures for manufacturing DDGS among plants. These differences in fermentation methods and heat processing ultimately affect the nutrient profiles and amino acid digestibility of the final product.

The second generation of ethanol plants is approximately 20 years old. These plants are using improved technology and have improved quality control and drying procedures to produce higher quality DDGS compared to OEP. Most of the nutrient values published in feed ingredient tables represent product originating from these plants. Nutrient profiles of DDGS produced by these plants are those commonly found in published feed ingredient nutrient tables (NRC, 1998; Feedstuffs Reference Issue, 1999; Heartland Lysine Inc., 1998) and represent the industry standard (ISP).

The newest plants in the ethanol industry are less than five years old and are using modern fermentation and processing technology. These plants are located in the MNDAK region of the U.S. and are farmer owned cooperatives. Corn delivered to these plants is from a smaller geographical region and may contribute to less variability in nutrient content of DDGS than that produced by older plants, where corn of variable quality is purchased from sources representing a broader geographical region.

The 1999 Feedstuffs Reference Issue lists nutrient values for both Distiller's Dried Grains with Solubles and Corn Distiller's Dried Grains with Solubles (Table 4.2). The distinguishing differences are between these two descriptions are unclear, other than to note that Corn DDGS is lower in crude protein and most of the essential amino acids (except leucine and methionine) than DDGS. The percentage availability values of amino acids are only presented for Corn DDGS in this reference (Feedstuffs, 1999), making it difficult to compare proportions of digestible amino acids between these two sources. Corn DDGS is lower in crude fat and higher in crude fiber than DDGS. However, the ME value of Corn DDGS is higher than DDGS, which appears contradictory, based upon the relationship of fat and fiber to ME. Mineral levels of both sources are similar, but significantly higher than that found in cereal grains. Phosphorus content is significantly higher and more readily available than that found in cereal grains. Both sources of DDGS contain relatively low levels of vitamins with the exception of choline. Although fairly high quantities of niacin are found in DDGS, most is assumed to be unavailable.

Table 4.2. Comparison of Nutrient Content (Dry Matter Basis) of Corn DDGS vs. DDGS (Feedstuffs, 1999).

	DDGS	Corn DDGS
Dry Matter, %	91	93
Crude Protein, %	31.9	29.0
Crude Fat, %	9.2	8.6
Crude Fiber, %	8.6	9.1
Ash, %	4.7	4.8
ME, kcal/kg	3593	3838
Arginine, %	1.23	1.08 (63)
Histidine, %	0.89	0.65 (75)
Isoleucine, %	2.12	1.08 (84)
Leucine, %	2.57	2.90 (89)
Lysine, %	0.89	0.65 (65)
Methionine, %	0.51	0.65 (84)
Cystine, %	0.57	0.43 (77)
Phenylalanine, %	2.12	1.29 (88)
Threonine, %	1.23	1.02 (72)
Tryptophan, %	0.22	0.22
Valine, %	2.01	1.43 (81)
Calcium, %	0.30	0.38
Chloride, %	0.20	0.18
Magnesium, %	0.37	0.38
Phosphorus, %	0.86 (0.38)	1.02 (0.43)
Potassium, %	0.95	1.08
Sodium, %	0.66	0.86
Sulfur, %	0.33	0.32
Copper, ppm	80	54
Iron, ppm	352	323
Manganese, ppm	44	32
Selenium, ppm	0.22	0.41
Zinc, ppm	77	91
Vitamin A, IU/g	-	6.7
Vitamin E, mg/kg	N/A	43
Thiamin, mg/kg	4.4	3.8
Riboflavin, mg/kg	10.5	9.7
Pantothenic acid, mg/kg	13.5	12.3
Biotin, mg/kg	0.4	0.3
Folacin, mg/kg	1.0	0.9
Choline, mg/kg	4401	3656
Vitamin B12, µg/kg	N/A	0.0
Niacin, mg/kg	89.3	85.9

Amino acid values in parentheses represent percentage available.
Phosphorus values in parentheses represent % available phosphorus.
N/A = data not available
- = does not contain a significant amount of that nutrient

For effective use of DDGS in swine diet formulation nutritionists must know the origin of DDGS. This is essential for evaluating quality, nutritional value and cost effectiveness in practical swine diets. Origin of DDGS is also important for use appropriate nutrient profiles in diet formulations, particularly amino acid digestibility values, so that precision can be used for minimizing excess nitrogen intake and excretion when formulating practical swine diets. Furthermore, fiber, fat, and DE and ME values need to be better defined to more precisely manage energy density of practical diets.

How Does the Nutrient Content of DDGS from New MNDAK Plants compare to DDGS from Older Ethanol Plants?

Our swine nutrition group at the University of Minnesota initiated a series of studies in 1998 to evaluate the nutritional value of DDGS originating from new ethanol plants in the Minnesota-Dakota region. In our first study (Whitney et al., 1999), a sample of DDGS from each of 10 ethanol plants was submitted every two months for a complete nutrient analysis (excluding vitamins). Thus, each ethanol plant submitted a total of 12 DDGS samples from 1997-1999. Amino acid analyses were conducted at the University of Missouri (Columbia, MO), and all other nutrients were analyzed at Iowa Testing Laboratories, Inc. (Eagle Grove, IA). Average nutrient values and coefficient of variation were calculated for each nutrient for each plant, as well as a composite mean and coefficient of variation for each nutrient. Composite means for each nutrient (on a dry matter basis) in DDGS produced by MNDAK ethanol plants are shown in Table 4.3. Coefficients of variation are shown in parentheses. These nutrient values were then compared to published values in three commonly used feed ingredient reference tables (NCR, 1998; Heartland Lysine Amino Acid Database, 1998; and Feedstuffs Reference Issue, 1999). We also compared the nutrient content of MNDAK DDGS with a sample of DDGS obtained from one of the oldest ethanol plants (OEP).

In general, coefficient of variation of nutrient levels among and within plants was low (0 – 5 %). This indicates good uniformity of DDGS produced by these plants, which is likely due to more consistent corn quality used in fermentation, as well as greater quality control of the fermentation process. Some of the variability that did exist is likely due to percentage of dried solubles added back to distillers dried grains, and completeness or duration of the fermentation process that may affect the degree of starch removal.

Average crude protein level of MNDAK DDGS is slightly higher than published book values, indicating that more complete starch removal may be occurring due to use of newer fermentation technology. However, due to the relatively low lysine level and poor amino acid balance, the high crude protein level in DDGS will result in increased nitrogen excretion and potentially, increased ammonia emissions from the slurry when DDGS is added to swine diets. Furthermore, increased energy is also required by the animal to excrete the excess nitrogen, leaving less energy available to the animal for production.

Crude fat and calculated DE and ME values for MNDAK DDGS are higher than published book values in NRC (1998). Also, ADF is slightly less, and NDF is slightly more than NRC (1998) levels. Since the difference between NDF and ADF is the amount of hemicellulose in the feed, the amount of hemicellulose in MNDAK DDGS appears to be higher than normally thought. Hemicellulose is slightly more digestible than the ADF fraction and may provide a slight advantage in DE and ME for MNDAK DDGS compared to published values.

We have conducted studies to determine the DE and ME value of MNDAK DDGS for grow-finish pigs. Although our estimates are quite variable (3380 kcal DE/kg to 5905 kcal DE/kg and 3315 kcal ME/kg to 5930 kcal ME/kg), we conservatively estimate the DE and ME content of MNDAK DDGS to be 3963 kcal DE/kg and 3917 kcal ME/kg. This DE value is similar to the calculated DE value, whereas the ME value is significantly higher than the calculated ME value. Both calculated and measured DE and ME values are significantly higher than those listed in NRC, 1998. The higher energy value of MNDAK DDGS is likely due to the higher level of crude fat compared to other sources. The values suggest that the energy value of MNDAK is equal to corn and should not be a factor limiting pig performance.

Table 4.3. Proximate Analysis Comparison of MNDAK DDGS with DDGS from Old Ethanol Plants (OEP) and Published Reference Values.

	MN-SD DDGS	OEP DDGS	NRC 1998	Heartland Lysine 1998	Feedstuffs Reference Issue 1999
Dry matter, %	89.1 (1.2)	89.5	93.0	90.8	93.0
Crude protein, %	30.5 (1.4)	29.0	29.8	28.5	29.0
Crude fat, %	10.7 (1.0)	9.7	9.0	-	8.6
Crude fiber, %	8.9 (0.6)	7.4	-	-	9.1
Ash, %	5.8 (0.7)	8.0	-	-	4.8
NFE, %	44.2 (2.2)	45.9	-	-	-
ADF, %	15.7 (2.1)	16.7	17.5	-	-
NDF, %	43.5 (3.0)	38.0	37.2	-	-
Calculated DE, kcal/kg	3953* (33.7)	3871*	3441	-	-
Calculated ME, kcal/kg	3580** (32.0)	3519**	3032	-	3838
DE, kcal/kg	3963	-	3441	-	-
ME, kcal/kg	3917	-	3032	-	3838

* Calculated DE = [(CP * 4) + (NFE * 4) + (Fat * 9)]

** Calculated ME = DE * [(0.96 - (0.2 * CP))/100]

Average lysine values for MNDAK DDGS are higher than those published by NRC (1998) and Feedstuffs Reference Issue (FRI) (1999), but similar to Heartland Lysine (HL) (1998) values (Table 4.4). Since lysine is generally considered to be the first limiting amino acid in swine diets, MNDAK DDGS would be a more valuable source than other DDGS sources because less amino acid supplementation is needed to meet the desired digestible lysine level in the diet. As shown in Table 4.4, our studies have shown that the higher level and digestibility coefficient of MNDAK DDGS, makes it a more valuable lysine source than other sources (e.g. OEP). However, the coefficient of variation (CV) for lysine level among the 10 MNDAK plants was the highest (17.3%) of all amino acid analyzed. Some MNDAK plants had a within plant CV for lysine level as low as 2.9%, whereas other plants had a within plant CV as high as 25.7% for lysine. Because of the need for predictability of lysine levels in DDGS for more precise diet formulation, we have determined CV's for each nutrient in each participating plant to aid nutritionists in using this co-product most effectively.

The total level of methionine in MNDAK DDGS is comparable to NRC (1998) but lower than published values from FRI (1999) and HL (1998). The digestibility coefficient for methionine is higher than for OEP DDGS but lower than other published levels. The variability of methionine among MNDAK plants (CV = 13.6%) was less than lysine, but more than threonine (CV = 6.4), and tryptophan (CV = 6.7). Average threonine values for MNDAK DDGS are higher than those published in NRC (1998) and FRI(1999), but similar to Heartland Lysine (HL) (1998) values (Table 4). Average tryptophan level is within the range of published values. Apparent digestible threonine and tryptophan levels were comparable to published values.

Table 4.4. Comparison of Total and Apparent Amino Acid Digestibility Between MNDAK and OEP DDGS Sources and with Published Values (Dry Matter Basis).

	MNDAK DDGS			OEP DDGS			NRC 1998			Heartland Lysine 1998			Feedstuffs Reference Issue 1999		
Amino Acid	**Total %**	**DC ***	**Dig %**	**Total %**	**DC ***	**Dig %**	**Total %**	**DC ***	**Dig %**	**Total %**	**DC ***	**Dig %**	**Total %**	**DC ***	**Dig %**
Lys, %	0.83	53	0.44	0.68	0	0.00	0.67	47	0.31	0.81	43	0.35	0.65	65	0.42
Met, %	0.55	59	0.32	0.49	48	0.24	0.54	72	0.39	0.63	71	0.45	0.65	84	0.55
Cys, %	0.58	51	0.27	0.56	40	0.22	0.56	57	0.32	0.64	59	0.38	0.43	77	0.33
Thr, %	1.13	55	0.62	0.99	36	0.36	1.01	55	0.56	1.11	54	0.60	1.02	72	0.73
Trp, %	0.24	64	0.15	0.22	68	0.15	0.27	50	0.14	0.20	50	0.10	0.22	n/a	n/a
Val, %	1.51	61	0.92	1.31	39	0.51	1.40	63	0.88	1.43	65	0.93	1.43	81	1.16
Ile, %	1.14	63	0.72	1.04	40	0.42	1.11	66	0.73	1.09	64	0.70	1.08	84	0.91
Leu, %	3.57	72	2.57	3.22	57	1.84	2.76	76	2.10	3.27	76	2.49	2.90	89	2.58
His, %	0.76	67	0.51	0.68	44	0.30	0.74	61	0.45	0.75	66	0.49	0.65	75	0.49
Phe, %	1.48	60	0.89	1.30	52	0.68	1.44	76	1.09	1.43	76	1.09	1.29	88	1.14
Arg, %	1.19	76	0.90	1.07	56	0.60	1.22	72	0.88	1.21	72	0.87	1.08	63	0.68

* DC = Digestibility coefficient

Levels of Ca, K, Mg, S, Na, Zn, Mn, Cu, and Fe in DDGS are of minor interest due to their low cost, and relatively low concentrations (Table 5). Phosphorus is generally considered to be the third most expensive nutrient (behind energy and amino acids) in swine diets, and averaged within the range of published values from NRC (1998), FRI (1999) and HL (1998). Ash values were lower for MNDAK DDGS compared to OEP DDGS (Table 4.3). Thus, the lower ash levels in MNDAK DDGS result in greater nutritional value compared to other sources.

Table 4.5. Comparison of Mineral Levels of MNDAK DDGS with OEP DDGS and Published Values (Dry Matter Basis).

	MNDAK DDGS	OEP DDGS	NRC 1998	Feedstuffs Reference Issue 1999
Calcium, %	0.06 (0.03)*	0.67	0.22	0.38
Phosphorus, %	0.89 (0.09)	0.98	0.83	1.02
Potassium, %	0.94 (0.11)	1.12	0.90	1.08
Magnesium, %	0.33 (0.03)	0.38	0.20	0.38
Sulfur, %	0.49 (0.15)	0.84	0.32	0.32
Sodium, %	0.25 (0.15)	0.55	0.27	0.86
Chlorine, %	-	-	0.22	0.18
Zinc, ppm	84 (53.0)	85	86	91
Manganese, ppm	15 (4.3)	46	26	32
Copper, ppm	6 (1.0)	8	61	54
Iron, ppm	121 (44.4)	263	276	323
Selenium, ppm	-	-	0.42	0.41

*Values in parentheses represent CV's among MNDAK plants.
- = no data available

Pig Performance

Distiller's Dried Grains with Solubles can provide significant amounts of energy, amino acids, and phosphorus to diets in all phases of production. Traditionally, it has been shown that because of the relatively high fiber content and lower DE and ME of DDGS compared to corn, it is best used in diets where maximizing energy consumption is not essential (e.g. gestation and finishing). However, our estimates of DE and ME for DDGS suggest that MNDAK can be effectively used in all diets as a partial replacement for corn and soybean meal without diluting the energy density of the diet.

The majority of performance studies evaluating the addition of DDGS in swine diets were conducted from 1939 (Robinson, 1939) to 1985 (Cromwell et al., 1985). Results from these studies have been summarized by Newland and Mahan (1990). However, these performance studies have used DDGS produced by older ethanol plants, and diets were formulated either on a crude protein or total lysine basis. Based on the performance results of these studies, Newland and Mahan (1990) suggested that DDGS can be included up to 5% in starter diets, 20% in grower diets, and 40% in gestation diets without compromising performance.

During the past 15 years, significant changes have occurred in methods of diet formulation and feeding as well as DDGS product quality. Development and use of new amino acid digestibility estimates for DDGS, along with synthetic amino acids supplementation, have improved the precision of formulating diets containing DDGS. Recent studies by Hansen et al. (1997;1998) have shown that DDGS use can be maximized in grow-finish diets, while supporting satisfactory performance, when synthetic amino acids are added to the diet to meet a digestible ideal protein ratio. Thus, knowledge of amino acid digestibility coefficients for DDGS from specific sources may result in greater amounts of DDGS to be included in the diet than previously shown. However, additional studies need to be conducted to evaluate DDGS produced by newer plants in order to re-define performance benefits of this feed ingredient.

The Value of DDGS in Reducing Manure Nutrients, Odor, and Gas Emissions

In recent years, the need for nutritionists to design eco-nutrition feeding programs has increased due to concerns about the impact of pork production on water, soil and air pollution. Most of the focus has centered on diet manipulation to minimize nutrient excretion (primarily nitrogen and phosphorus) as well as odor and gas emissions. Therefore, knowledge about eco-nutrition characteristics of feed ingredients is increasingly important.

Impact of MNDAK DDGS on nitrogen and phosphorus excretion

Due to the high crude protein level and relatively low lysine level and digestibility in DDGS compared to corn, nitrogen excretion in swine manure increases when pigs are fed DDGS diets. Our studies (Spiehs et al., 1999) have shown that adding 10 to 20% MNDAK DDGS to grower diets results in similar nitrogen retention compared to a corn-soybean meal control diet (69.8%, 68.8%, 68.5%, respectively), but the amount of nitrogen excreted increases. Nitrogen retention (63%) decreases and nitrogen excretion increases further when 30% DDGS is added to the grower diets. The same relationships were observed when feeding finisher diets, but the percentage of nitrogen retention for each diet was lower than that observed for grower diets. Therefore, adding up to 20% MNDAK to grow-finish diets will minimize nitrogen excretion while supporting nitrogen retention comparable to that found when feeding nutritionally adequate corn-soybean meal diets.

Distiller's dried grains with solubles have a higher concentration of more available phosphorus than corn, other cereal grains, and cereal co-products. Our studies (Spiehs et al., 1999) have shown that when formulating diets on a total phosphorus basis, the percentage of phosphorus retained tends to increase when 10 and 20% MNDAK DDGS is added to grower diets compared to a control corn-soybean meal diet (63.9%, 66.3%, and 59.1%, respectively). Similar results were also observed when feeding finisher diets containing up to 30% DDGS. These results suggest that phosphorus availability in DDGS is higher than in corn and soybean meal. As a result, adding up to 20% DDGS to grower and finisher diets will reduce the amount of supplemental inorganic phosphorus in the diet, and reduce phosphorus levels in the manure.

Impact of MNDAK DDGS on odor and gas emissions

Pork producers feeding grower-finisher diets containing DDGS have reported a "reduction" in odor in finishing barns compared to when feeding corn-soybean meal diets. As shown in Table 6, MNDAK DDGS is higher in crude fiber, intermediate in ADF and NDF content, lower in soluble fiber, and higher in insoluble fiber compared to corn and soybean meal. Feeding diets containing a higher proportion of complex carbohydrates such as cellulose, B-glucans and other non-starch polysaccharides shift nitrogen excretion toward feces and away form urine, which reduces ammonia emissions (Kreuzer and Machmuller, 1993; Mroz et al., 1993). Feeding a low carbohydrate, high fiber diet (alfalfa meal and rice bran) to pigs reduces excretion of fecal volatile acids compared to pigs fed a corn starch and glucose diet (Imoto and Namioka, 1978). However, Hawe et al. (1992) showed that feeding a diet containing increased fiber from beet pulp, increased the concentration of two odorous compounds, skatole and indole.

Table 4.6. Comparison of Crude Fiber, Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), Soluble Fiber, and Insoluble Fiber Content (As-fed Basis) of MN-SD DDGS with Various Feedstuffs.

Feedstuff	Crude Fiber %	NDF, %	ADF, %	Soluble Fiber, %	Insoluble Fiber, %
Corn	2.6	9.0	3.0	1.7	4.7
Soybean meal	7	13.3	9.4	1.6	13.2
Oat bran	-	19.2	-	7.2	14.6
Potato pulp	-	-	-	11.0	22.3
MNDAK DDGS	**9.9**	**44**	**18**	**0.7**	**42.2**
Alfalfa	26.2	45	35	4.3	52.4
Beet pulp	19.8	54	33	11.7	53.9
Wheat straw	41.6	85	54	0.5	71.0
Oat straw	40.5	70	47	2.2	74.4
Corn stalk	34.4	67	39	2.9	74.4
Soybean hulls	40.1	67	50	8.4	75.5

Based upon the fiber characteristics of MNDAK DDGS and the relationship between dietary level of non-starch polysaccharides and ammonia emissions, we conducted a study to determine the effects of adding 20% DDGS to corn-soybean meal grow-finish diets on odor and gas emissions. In this study, a three-phase grow-finish diet sequence was fed to grow finish pigs for a 10-week experiment. Manure was collected daily from eight pigs fed either the corn-soybean meal diet sequence or the corn-soybean meal 20% DDGS diet sequence, and added to one of 16 Deep Pit Simulation Models (DPSM). The DPSM's are constructed of 5 feet of PVC pipe and are 16 inches in diameter. The PVC pipe is upright in a plastic tub and the bottom filled with concrete to simulate the depth and characteristics of an anaerobic manure pit, a common method of manure storage in confinement finishing buildings. A total of 16 grow-finish pigs were provided ad libitum access to water and their respective diets for the 10-week experiment. Ammonia and hydrogen sulfide measurements were taken weekly. Odor measurements (olfactomenter) were taken during weeks 2, 5, and 8 of the experiment.

There was no effect of dietary treatment on odor ($p = 0.99$; Figure 4.1), hydrogen sulfide ($p = 0.39$; Figure 4.2), or ammonia levels ($p = 0.17$; Figure 4.3) during the 10-week trial. This is likely due to the large variation in measurements using the analytical technology available during the experiment. Although the results of this study suggest that adding 20% DDGS to the grow-finish diet does not alter the hydrogen sulfide, ammonia, or odor levels in the manure, the length of the experiment may have been too short to measure differences in gases and odor. Secondly, determining odor threshold with the olfactometer procedure is quantitative, not qualitative. These results suggest that adding 20% DDGS to corn-soybean meal diets has no effect on ammonia, hydrogen sulfide, or odor emissions compared to emissions from manure produced by pigs fed corn-soybean meal diets.

Figure 4.1. Odor detection threshold of air samples collected from deep pit simulators containing manure from pigs fed corn-soybean meal diets with and without 20% MNDAK DDGS.

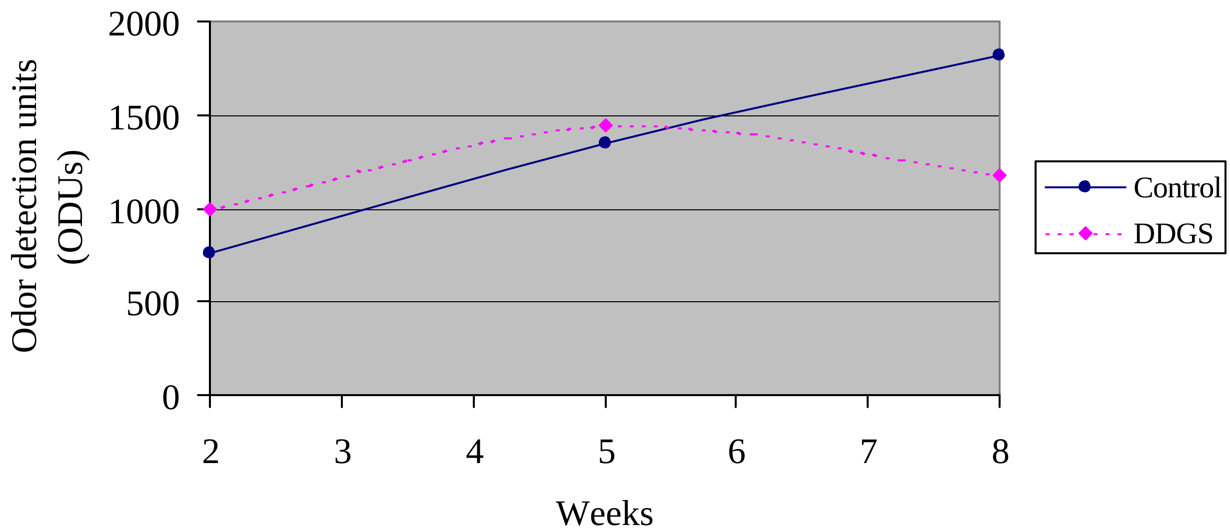


Figure 4.2. Hydrogen sulfide levels obtained from air space of deep pit simulators containing manure from pigs fed diets with and without 20% MNDAK DDGS.

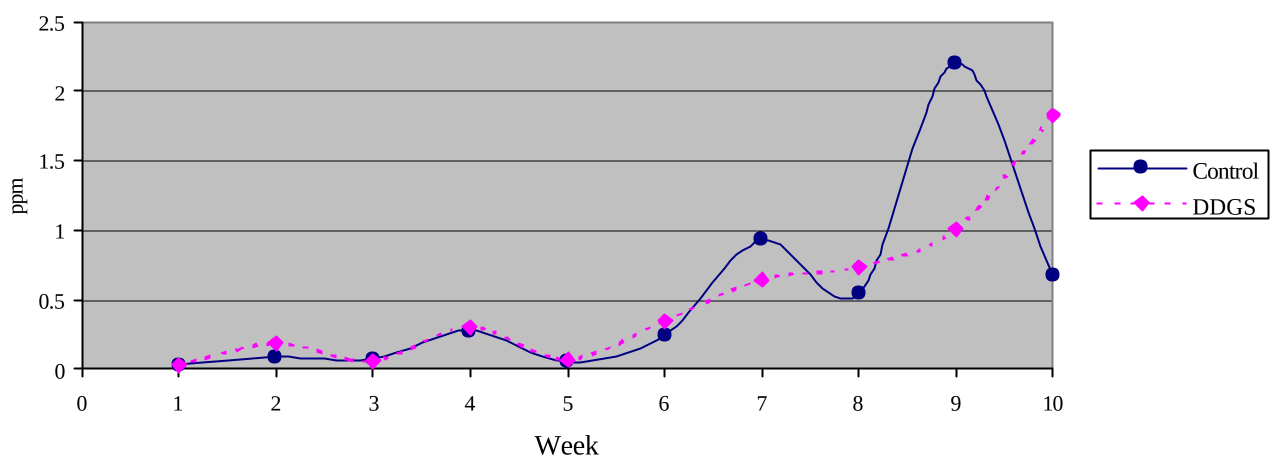
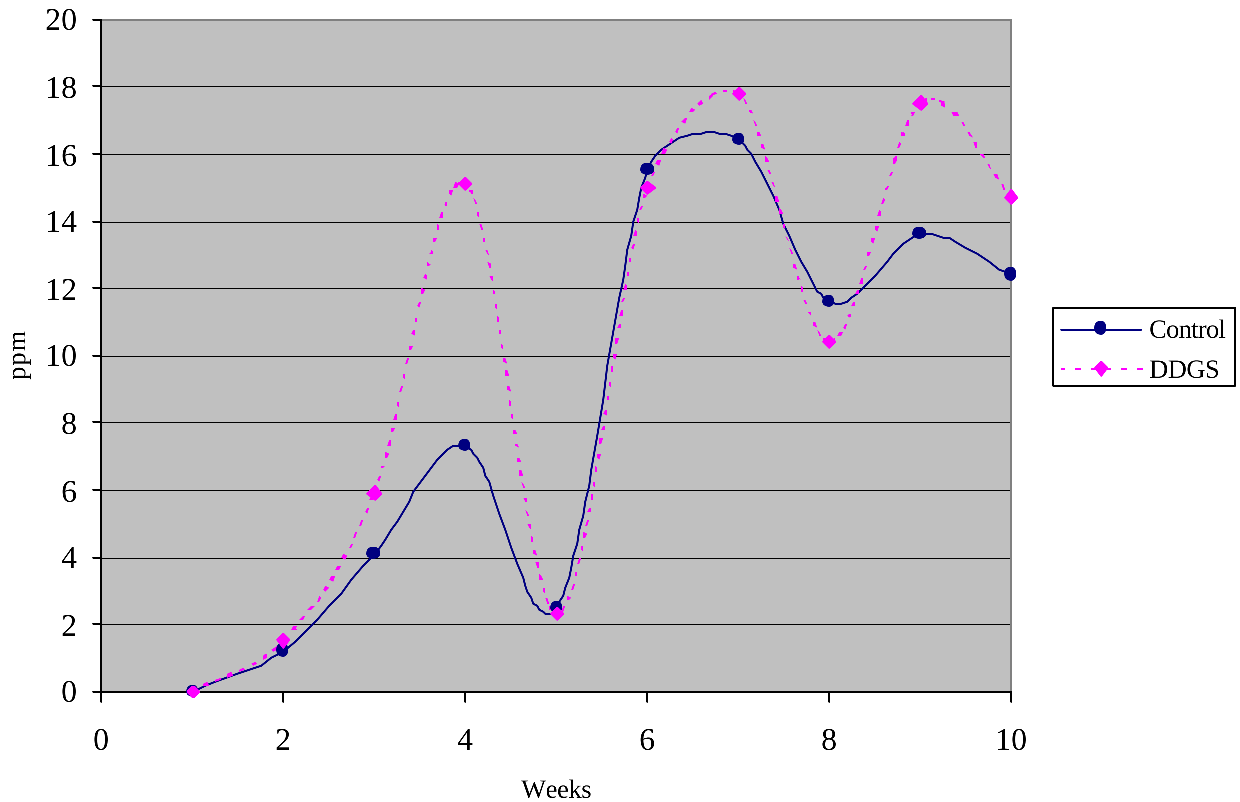


Figure 4.3. Ammonia concentration from air space of deep pit simulators containing manure from pigs fed diets with or without 20% MNDAK DDGS.



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