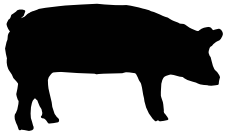
Distillers Grains
Feeding Recommendations

SWINE



Summary of Distillers Grains Feeding Recommendations for Swine

- "Based upon research studies we have conducted at the University of Minnesota, our current recommendations for maximum usage rate of DDGS in swine diets are as follows: nursery pigs (>15 lbs), 25%; grow-finish pigs, 20%; developing gilts, 20%; gestating sows, 50%; lactating sows, 20%; boars, 50%."
- "Nursery diets containing up to 25% DDGS will support growth performance equivalent to feeding pigs fed corn-soybean meal based diets…"

— Dr. Gerald Shurson and Mindy Spiehs, University of Minnesota, *Feeding Recommendations and Example Diets Containing Minnesota-South Dakota Produced DDGS for Swine*

- "(DDGS) is an excellent source of digestible phosphorous. Therefore, when adding DDGS to a diet, you will be able to reduce the amount of dicalcium phosphate normally used."
- "20% is the maximum recommended amount in grow-finish diets."
- SDSU recommends inclusion rates as outlined by Dr. Gerald Shurson from the University of Minnesota.

— Bob Thaler, Extension Swine Specialist, *Use of Distillers Dried Grains with Solubles (DDGS) in Swine Diets,* South Dakota State University Extension Service Extension Extra, ExEx 2035, August 2002

- "DDGS can be used in nursery, growing-finishing, gestation and lactation diets. The maximum recommended inclusion rate of DDGS in 35- to 250-pound pig diets is 20%. The more acceptable rate is 10% in grow-finish diets."

— Dr. Gilbert Hollis, Extension Swine Specialist, *Distillers Dried Grains with Solubles in Swine Diets,* University of Illinois, Illini PorkNet, 2002

The Advantages of Using Corn Distillers Dried Grains with Solubles in Swine Diets

- **Corn Distillers Dried Grains with Solubles is an Economical Addition to Swine Diets**

In one ton of complete feed, adding 200 lbs. of Corn Distillers Grains with Solubles (CCDGS) and 3 lbs. of limestone to a finisher diet will replace approximately:

177 lbs of corn
20 lbs of soybean meal 44%
6 lbs of dicalcium phosphate

Calculate the opportunity cost of using CDDGS in swine diets as follows:

Additions:

+ CDDGS	200 lbs. X price/lb	= $
+ Limestone	3 lbs. X price/lb	= $
	TOTAL A	= $

Subtractions:

- Corn	177 lbs. X price/lb	= $
- Soybean Meal 44%	20 lbs. X price/lb	= $
- Dicalcium Phosphate	6 lbs. X price/lb	= $
	TOTAL S	= $

Opportunity Cost:

Total S – Total A = Opportunity Cost of CDDGS/lb X 200 lbs/ton = Opportunity cost/ton of complete feed

- **"New Generation" Ethanol Plants Produce Higher Quality CDDGS**

CDDGS have more digestible energy, amino acids, and phosphorus than other DDGS sources produced in the ethanol industry. This makes CDDGS an excellent alternative ingredient for livestock rations.

- **CDDGS Can Be Effectively Used in Swine Diets With Maximum Dietary Inclusion Rates of:**

Nursery Pigs (>15 lbs.)	25%	Lactating Sows	10%
Grow-finish Pigs	20%	Gestating Sows	50%

- **Feeding High Levels of CDDGS to Sows Has Been Shown to Increase Litter Size Weaned**

Recent research results from the University of Minnesota have shown that feeding high levels of CDDGS in gestation and/or lactation in a previous reproductive cycle, increases litter size weaned in the subsequent reproductive cycle compared to sows fed typical corn-soybean meal diets.

- **Feeding Diets Containing CDDGS May Improve Gut Health of Pigs**

Studies are currently underway at the University of Minnesota to determine if adding CDDGS to diets for growing pigs reduces the incidence and severity of ileitis (Lawsonia intracellularis).

- **CDDGS Reduces Phosphorus Excretion in Manure and Does Not Adversely Affect Air Quality in Confinement Swine Facilities**

CDDGS contains 0.70% available phosphorus (P), which is 18 times more than the available P in corn (0.04%). This means that the natural P in CDDGS is better digested and absorbed by the pig than P in corn and soybean meal. The end result is less need for dietary P supplementation and a reduction in P excretion in manure.

University of Minnesota research has shown that ammonia, hydrogen sulfide, and odor emissions from swine manure from grow-finish pigs fed a diet containing CDDGS are the same as when conventional corn-soybean meal based diets are fed to swine.

- The Greatest Nutritional and Economic Value from Using DDGS in Swine Diets in Achieved when Diets are Formulated on a Digestible Amino Acid and an Available Phosphorus Basis.
- Nutrient Profiles and Digestibility Coefficients are Available for Each Ethanol Plant Producing CDDGS.

For additional information on feeding distillers grains to swine, contact:

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Feeding Recommendations and Example Diets Containing Minnesota-South Dakota Produced DDGS for Swine

Jerry Shurson and Mindy Spiehs
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University of Minnesota, St. Paul

Use Only High Quality DDGS in Swine Diets.

Historically, distiller's dried grains with solubles (DDGS) have not been used extensively in swine diets. The primary reasons for this limited use are variability in quality and nutrient content, poor amino acid digestibility from some sources, and cost competitiveness with corn, soybean meal and dicalcium phosphate. However, our research at the University of Minnesota has clearly shown that DDGS produced by small, and relatively new ethanol plants in Minnesota and South Dakota, is very high quality and is an excellent partial substitute for corn, soybean meal, and dicalcium phosphate in swine feeding programs. Distiller's dried grains with solubles from Minnesota and South Dakota plants is higher in digestible and metabolizable energy, higher in total and digestible amino acids, and higher in available phosphorus compared to other DDGS sources and values listed in NRC (1998). Use of low quality, dark colored DDGS has reduced feeding value and pig performance may be reduced if the lower levels of digestible nutrients are not considered in diet formulation.

What Are the Recommended Maximum Inclusion Rates of DDGS in Swine Diets?

Based upon research studies we have conducted at the University of Minnesota, our current recommendations for maximum usage rate of DDGS in swine diets are as follows:

Production Phase	Maximum % of Diet
Nursery pigs (>15 lbs)	25
Grow-finish pigs	20
Developing gilts	20
Gestating sows	50
Lactating sows	20
Boars	50

These recommendations assume that high quality DDGS is free of mycotoxins. Nursery diets containing up to 25% DDGS will support growth performance equivalent to feeding pigs fed corn-soybean meal based diets provided that diets are formulated on a digestible amino acid and available phosphorus basis. Similarly, grow-finish and gilt development diets containing levels up to 30% DDGS should provide equivalent growth performance compared to pigs fed corn-soybean meal diets if they are formulated on a digestible amino acid and available phosphorus basis. However, due to concerns of reduced belly firmness and soft pork fat at high levels of DDGS inclusion, we recommend no more than 20% DDGS be added to grow-finish diets. If the DDGS supplier has a quality control program that includes screening corn and/or DDGS for

mycotoxins, developing gilt diets can contain up to 20% DDGS in the diet. For sows, up to 50% DDGS can be successfully added to gestation diets, and 20% DDGS can be added to the lactation diet if DDGS is free of mycotoxins. If there are no assurances that DDGS is mycotoxin free, no more than 20% should be added to gestation diets and no more than 10% DDGS should be added to lactation diets to minimize the risk of mycotoxicosis. However, when switching sows from a corn-soybean meal diet to diets containing DDGS, formulate gestation diets to contain 20% DDGS and then increase DDGS inclusion level when each new batch of feed is made to allow the sows to adapt to the DDGS diets and avoid reduced feed intake. Similarly, when switching from a corn-soybean meal diet to a DDGS diet for lactating sows, begin feeding a 10% DDGS diet to allow the sows to adapt (approximately 5 to 7 days) before feeding the maximum recommended level to allow the sows to adapt to the DDGS diet and avoid potential reductions in feed intake.

How Should I Formulate Diets Containing DDGS to Obtain Optimal Performance and Value?

Our research results have shown that energy and amino acid digestibility, as well as phosphorus availability of DDGS produced in Minnesota and South Dakota ethanol plants, is higher than nearly all of the values reported in NRC (1998) "Nutrient Requirements of Swine" and values we obtained from evaluating low quality DDGS (Table 1). Our apparent digestible amino acid and available phosphorus nutrient values should be used to formulate practical diets for all phases of production to ensure that the maximum nutritional value of DDGS is obtained, and that optimal performance is achieved, particularly when adding more than 10% DDGS to any swine diet. Formulating diets using total amino acid and phosphorus values may provide acceptable performance at low inclusion rates (< 10%) of DDGS in swine diets, but will not capture the full nutritional value of DDGS.

Table 1. Comparison of Nutrient Content, Apparent Amino Acid Digestibility, and Phosphorus Availability of MN/SD DDGS, a Low Quality DDGS Source, and NRC (1988).

Nutrient*	MN/SD DDGS	Low Quality DDGS	NRC (1998)
Dry matter, %	88.9	88.3	93.0
Crude protein, %	30.2	28.1	29.8
Crude fat, %	10.9	8.2	9.0
Crude fiber, %	8.8	7.1	4.8
Calcium, %	0.06	0.44	0.22
Phosphorus, %	0.89	0.90	0.83
Available phosphorus, %	0.80	?	0.64
Digestible energy, kcal/kg	3,965	3,874	3,441
Metabolizable energy, kcal/kg	3,592	3,521	3,032
Lysine, %	0.83	0.68	0.67
App. digestible lysine, %	0.44	0.00	0.31
Methionine, %	0.55	0.49	0.54
App. digestible methionine, %	0.32	0.24	0.39
Threonine, %	1.13	0.99	1.01
App. dig. threonine, %	0.62	0.36	0.56
Tryptophan, %	0.24	0.22	0.27
App. dig. tryptophan, %	0.15	0.15	0.13

* Values expressed on a 100% dry matter basis.

Are There Any Concerns in Feeding DDGS to Swine?

Quality

Historically, grain co-products like DDGS have been treated as commodities in the market place. However, like all co-products, there is large variation in the quality of DDGS available for livestock feeds. Cromwell et al. (1993) conducted a study to compare physical, chemical, and nutritional characteristics of nine different sources of DDGS for chicks and pigs. The color of these sources ranged from very light to very dark, and odor ranged from a sweet smell to smoky or burnt smell. There was also a wide range in nutrient concentration among DDGS sources. Ranges in nutrient concentration of selected nutrients were:

Dry matter – 87 to 93%
Crude protein – 23 to 29%
Crude fat – 3 to 12%
Ash – 3 to 6%
Lysine – 0.59 to 0.89%

Lysine concentration tended to be highest in light-colored DDGS and lowest in the darkest-colored DDGS sources. When the four darkest, burnt smelling sources were fed to chicks, growth rate, feed intake, and feed conversion were reduced 18 %, 13%, and 6 %, respectively,

compared to chicks fed the lightest-colored DDGS. Results from this study suggest that DDGS that is dark in colored and/or has a burnt smell should not be used in swine or poultry diets.

Source: Cromwell, G.L., K.L. Herkleman, and T.S. Stahly. 1993. Physical, chemical, and nutritional characteristics of distiller's dried grains with solubles for chicks and pigs. J. Anim. Sci. 71:679-686.

In order to differentiate DDGS sources that are suitable for swine and poultry diets from other nutritionally inferior sources, the Minnesota and South Dakota ethanol plants have established nutrient specifications and recommended physical characteristics when selecting DDGS sources for swine and poultry diets.

Minnesota-South Dakota Nutrient Specifications and Physical Characteristics for DDGS in Swine and Poultry Diets

Nutrient specifications

Moisture – maximum 12%
Crude protein – minimum 26.5%
Crude fat – minimum 10%
Crude fiber – maximum 7.5%

Physical characteristics

Bulk density – 34 to 37 lb/cubic foot
Particle size:
maximum coarse particles - 10% on 2000 screen
maximum fine particles - 15% on 600 screen & in pan
Smell – fresh, fermented
Color – goldenrod

Pork fat quality

Our studies have shown that when feeding DDGS to grow-finish pigs (50-250 lbs), the oil present in DDGS will make pork carcass fat softer and more oily with increasing levels of DDGS in the diet. Similar effects have been shown when adding any high oil grain or grain co-product to swine grow-finish diets. Although softer fat and reduced belly firmness are a concern for packers and meat processors, there currently are no price penalties for pork producers for marketing pigs with reduced pork fat quality. Results from our studies show that feeding up to 20% DDGS in grow-finish diets has no effect on belly thickness or belly firmness score compared to carcasses from grow-finish pigs fed conventional corn-soybean meal diets.

Mycotoxins

The incidence of documented cases of mycotoxicosis from feeding DDGS to swine is extremely low. However, corn is susceptible to molds that can produce mycotoxins prior to harvest, as well as during storage. The primary mycotoxins of concern to swine are zearalenone, vomitoxin

(deoxynivalenol), T-2 toxin, fumonisin, and aflatoxins. In the Midwestern U.S., zearalenone and vomitoxin are the greatest risks.

If corn containing mycotoxins is delivered to an ethanol plant for ethanol production, these mycotoxins are not destroyed or inactivated during the fermentation process and will be present in DDGS produced from this corn source. In fact, the concentration of mycotoxins in DDGS will be 2 to 3 times higher than the initial concentration in the grain because the removal of starch during the fermentation process concentrates all of the unfermentable residual portions of the grain that remain after fermentation.

Ethanol plants are encouraged to monitor incoming corn for mycotoxins and reject loads that are contaminated to prevent mycotoxins in DDGS. Buyers of DDGS are encouraged to work with their suppliers to establish a quality control protocol for the production of DDGS that should include screening tests and procedures for mycotoxins.

Feed intake

Our studies have shown that feeding nursery and grow-finish pigs diets containing up to 25-30% DDGS from a high quality source has no detrimental effect on feed consumption. However, abruptly switching gestating sows that are being fed 4 to 5 lbs per day of corn-soybean meal based diet to a diet containing 50% DDGS can cause sows to not consume all of the feed offered for a period of 5 to 7 days. After sows have adapted to the 50% DDGS diet, feed consumption and weight gains are equivalent to sows fed a conventional corn-soybean meal diet. We have observed a similar response when feeding lactating sows a diet containing 20% DDGS. Although our preliminary results suggest no negative effects on reproductive performance from this slight reduction in feed intake during this diet adaptation period, it can be avoided by feeding lower levels of DDGS initially and then gradually increasing the inclusion rate of DDGS to a higher, desired level for the duration of the production phase.

Calculating the Value of "New Generation" DDGS in Swine Diets Using Soybean Meal 46%

Additions/1000 kg diet

+ 100 kg DDGS	x	cost/kg	= $
+ 1.5 kg limestone	x	cost/kg	= $
TOTAL ADDITIONS (A)			**= $**

Subtractions /1000 kg diet

– 89 kg corn	x	cost/kg	= $
– 9.5 kg SBM (46%)	x	cost/kg	= $
– 3 kg dicalcium phosphate	x	cost/kg	= $
TOTAL SUBTRACTIONS (S)			**= $**

S – A = Opportunity cost for DDGS/100 kg

Calculating the Value of "New Generation" DDGS in Swine Diets Using Soybean Meal 44%

Additions/1000 kg diet

+ 100 kg DDGS	x	cost/kg	= $
+ 1.5 kg limestone	x	cost/kg	= $
TOTAL ADDITIONS (A)			**= $**

Subtractions /1000 kg diet

– 88.5 kg corn	x	cost/kg	= $
– 10 kg SBM (44%)	x	cost/kg	= $
– 3 kg dicalcium phosphate	x	cost/kg	= $
TOTAL SUBTRACTIONS (S)			**= $**

S – A = Opportunity cost for DDGS/100 kg

Nursery Diets

Phase II (15-25 lbs)

Diet	**0% DDGS**	**5% DDGS**	**10% DDGS**	**15% DDGS**	**20% DDGS**	**25% DDGS**
DDGS	0.00	5.00	10.00	15.00	20.00	25.00
Corn	50.43	45.72	41.00	36.29	31.58	26.86
SBM, 47%	23.43	23.24	23.06	22.87	22.69	22.50
Whey, dried	15.00	15.00	15.00	15.00	15.00	15.00
IPC 790 fish meal	6.00	6.00	6.00	6.00	6.00	6.00
Choice white grease	2.20	2.16	2.12	2.08	2.04	2.00
Dicalcium phosphate	1.18	1.03	0.87	0.72	0.56	0.41
Limestone	0.35	0.45	0.56	0.66	0.77	0.87
Vitamin premix	0.30	0.30	0.30	0.30	0.30	0.30
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15
Mecadox-10	0.13	0.13	0.13	0.13	0.13	0.13
Zinc oxide	0.28	0.28	0.28	0.28	0.28	0.28
Salt	0.30	0.30	0.30	0.30	0.30	0.30
L-lysine	0.15	0.15	0.15	0.15	0.15	0.15
DL-methionine	0.10	0.09	0.08	0.07	0.06	0.05
Total	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***
Nutrient Composition						
ME (kcal/kg)	3340	3340	3340	3340	3340	3340
Crude protein, %	22.39	23.29	24.19	25.09	25.99	26.89
Crude fat, %	5.42	5.71	6.00	6.29	6.58	6.87
Crude fiber, %	1.20	1.50	1.80	2.11	2.41	2.71
Calcium, %	0.95	0.95	0.95	0.95	0.95	0.95
Phosphorus, %	0.80	0.80	0.80	0.80	0.80	0.80
Avail. phosphorus, %						
App. dig. lysine, %	1.35	1.35	1.35	1.35	1.35	1.35
App. dig. met+cys, %	0.80	0.80	0.80	0.80	0.80	0.80
App. dig. threonine, %	0.79	0.80	0.82	0.83	0.85	0.86
App. dig. tryptophan, %	0.24	0.24	0.25	0.25	0.26	0.26

Phase III (25-50 lbs)

Diet	0% DDGS	5% DDGS	10% DDGS	15% DDGS	20% DDGS	25% DDGS
DDGS	0.00	5.00	10.00	15.00	20.00	25.00
Corn	61.68	57.20	52.72	48.23	43.75	39.27
SBM, 47%	32.62	32.20	31.77	31.35	30.92	30.50
Choice white grease	2.20	2.16	2.12	2.08	2.04	2.00
Dicalcium phosphate	1.67	1.52	1.37	1.22	1.07	0.92
Limestone	0.56	0.66	0.77	0.87	0.98	1.08
Vitamin premix	0.30	0.30	0.30	0.30	0.30	0.30
TM premix	0.15	0.15	0.15	0.15	0.15	0.15
Mecadox-10	0.13	0.13	0.13	0.13	0.13	0.13
Copper sulfate	0.10	0.10	0.10	0.10	0.10	0.10
Salt	0.40	0.40	0.40	0.40	0.40	0.40
L-lysine	0.15	0.15	0.15	0.15	0.15	0.15
DL-methionine	0.04	0.03	0.02	0.02	0.01	0.00
Total	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***
Nutrient Composition						
ME (kcal/kg)	3390	3390	3390	3390	3390	3390
Crude protein, %	20.94	21.75	22.55	23.36	24.16	24.97
Crude fat, %	5.41	5.70	6.00	6.29	6.59	6.88
Crude fiber, %	1.42	1.73	2.04	2.34	2.65	2.96
Calcium, %	0.80	0.80	0.80	0.80	0.80	0.80
Phosphorus, %	0.70	0.70	0.70	0.70	0.70	0.70
Avail. phosphorus, %						
App. dig. lysine, %	1.15	1.15	1.15	1.15	1.15	1.15
App. dig. met+cys, %	0.65	0.65	0.65	0.65	0.65	0.65
App. dig. threonine, %	0.69	0.70	0.71	0.72	0.73	0.74
App. dig. tryptophan, %	0.24	0.24	0.24	0.24	0.24	0.24

Grow-Finish Diets (50-250 lbs)

Gilt Diets **Diet**	**Grower 1 (45-80 lbs) 10% DDGS**	**Grower 2 (80-130 lbs) 10% DDGS**	**Finisher 1 (130-190 lbs) 10% DDGS**	**Finisher 2 (190-250 lbs) 10% DDGS**
DDGS	10.00	10.00	10.00	10.00
Corn	63.69	66.89	72.88	79.18
SBM, 47%	10.00	17.18	14.97	8.83
Choice white grease	4.00	3.50	0.00	0.00
Dicalcium phosphate	1.14	0.91	0.63	0.49
Limestone	0.67	0.72	0.82	0.83
Vitamin premix	0.20	0.20	0.15	0.15
Trace mineral premix	0.15	0.15	0.10	0.10
Salt	0.30	0.30	0.30	0.30
L-lysine	0.15	0.15	0.15	0.12
Total	***100.00***	***100.00***	***100.00***	***100.00***
Nutrient Composition				
ME (kcal/kg)	3470	3456	3320	3320
Crude protein, %	17.26	16.33	15.79	13.36
Crude fat, %	7.23	6.75	4.02	4.08
Crude fiber, %	2.76	2.75	2.83	2.77
Calcium, %	0.70	0.65	0.60	0.55
Phosphorus, %	0.60	0.55	0.50	0.45
Avail. Phosphorus, %	0.39	0.36	0.24	0.20
App. dig. lysine, %	0.77	0.71	0.67	0.50
App. dig. met+cys, %	0.47	0.45	0.44	0.39
App. dig. threonine, %	0.48	0.44	0.42	0.34
App. dig tryptophan, %	0.14	0.13	0.12	0.09

Gilt Diets **Diet**	**Grower 1 (45-80 lbs)** **20% DDGS**	**Grower 2 (80-130 lbs)** **20% DDGS**	**Finisher 1 (130-190 lbs)** **20% DDGS**	**Finisher 2 (190-250 lbs)** **20% DDGS**
DDGS	20.00	20.00	20.00	20.00
Corn	54.75	57.98	63.39	71.27
SBM, 47%	18.80	16.25	14.63	6.85
Choice white grease	4.00	3.50	0.00	0.00
Dicalcium phosphate	0.88	0.65	0.35	0.25
Limestone	0.77	0.82	0.92	0.92
Vitamin premix	0.20	0.20	0.15	0.15
Trace mineral premix	0.15	0.15	0.10	0.10
Salt	0.30	0.30	0.30	0.30
L-lysine	0.15	0.15	0.16	0.16
Total	***100.00***	***100.00***	***100.00***	***100.00***
Nutrient Composition				
ME (kcal/kg)	3451	3437	3300	3300
Crude protein, %	18.58	17.64	17.32	14.28
Crude fat, %	7.66	7.18	4.36	4.43
Crude fiber, %	3.15	3.14	3.20	3.15
Calcium, %	0.70	0.65	0.60	0.55
Phosphorus, %	0.60	0.55	0.50	0.45
Avail. phosphorus, %	0.38	0.36	0.26	0.23
App. dig. lysine, %	0.77	0.71	0.68	0.50
App. dig. met+cys, %	0.48	0.46	0.45	0.39
App. dig. threonine, %	0.49	0.46	0.44	0.35
App. dig. tryptophan, %	0.15	0.14	0.13	0.09

Barrow Diets **Diet**	**Grower 1 (45-80 lbs) 10% DDGS**	**Grower 2 (80-130 lbs) 10% DDGS**	**Finisher 1 (130-190 lbs) 10% DDGS**	**Finisher 2 (190-250 lbs) 10% DDGS**
DDGS	10.00	10.00	10.00	10.00
Corn	63.69	68.56	77.07	81.20
SBM, 47%	19.69	15.48	10.73	6.78
Choice white grease	4.00	3.00	0.00	0.00
Dicalcium phosphate	1.14	0.95	0.73	0.54
Limestone	0.67	0.71	0.79	0.82
Vitamin premix	0.20	0.20	0.15	0.15
Trace mineral premix	0.15	0.15	0.10	0.10
Salt	0.30	0.30	0.30	0.30
L-lysine	0.15	0.15	0.13	0.11
Total	***100.00***	***100.00***	***100.00***	***100.00***
Nutrient Composition				
ME (kcal/kg)	3470	3456	3318	3320
Crude protein, %	17.26	15.66	14.10	12.55
Crude fat, %	7.23	6.75	3.36	4.10
Crude fiber, %	2.76	2.73	2.77	2.74
Calcium, %	0.70	0.65	0.60	0.55
Phosphorus, %	0.60	0.55	0.50	0.45
Avail. phosphorus, %	0.39	0.36	0.33	0.21
App. dig. lysine, %	0.77	0.67	0.55	0.44
App. dig. met+cys, %	0.46	0.43	0.40	0.37
App. dig. threonine, %	0.47	0.42	0.36	0.32
App. dig. tryptophan, %	0.14	0.12	0.10	0.08

Barrow Diets **Diet**	**Grower 1 (45-80 lbs)** **20% DDGS**	**Grower 2 (80-130 lbs)** **20% DDGS**	**Finisher 1 (130-190 lbs)** **20% DDGS**	**Finisher 2 (190-250 lbs)** **20% DDGS**
DDGS	20.00	20.00	20.00	20.00
Corn	54.75	61.33	68.05	73.30
SBM, 47%	18.80	13.26	9.93	4.81
Choice white grease	4.00	3.00	0.00	0.00
Dicalcium phosphate	0.88	0.71	0.46	0.30
Limestone	0.77	0.80	0.88	0.90
Vitamin premix	0.20	0.20	0.15	0.15
Trace mineral premix	0.15	0.15	0.10	0.10
Salt	0.30	0.30	0.30	0.30
L-lysine	0.15	0.15	0.13	0.14
Total	***100.00***	***100.00***	***100.00***	***100.00***
Nutrient Composition				
ME (kcal/kg)	3451	3414	3300	3300
Crude protein, %	18.58	16.53	15.45	13.46
Crude fat, %	7.66	7.24	4.40	4.45
Crude fiber, %	3.15	3.13	3.17	3.12
Calcium, %	0.70	0.65	0.60	0.55
Phosphorus, %	0.60	0.55	0.50	0.45
Avail. phosphorus, %	0.38	0.32	0.27	0.23
App. dig. lysine, %	0.77	0.67	0.55	0.44
App. dig. met+cys, %	0.48	0.44	0.42	0.38
App. dig. threonine, %	0.49	0.43	0.39	0.33
App. dig. tryptophan, %	0.15	0.12	0.11	0.08

Example Grower Diet Containing 20% DDGS and 100 FTU Phytase/kg

Ingredient	**%**
Corn	60.70
DDGS	20.00
Soybean meal, 46%	17.65
Dicalcium phosphate	0.05
Limestone	0.95
Salt	0.30
Vitamin-trace mineral premix	0.15
L-lysine HCl	0.15
Phytase - 1000	0.05
Total	**100.00**
Nutrient Composition	
ME, kcal/kg	3,330
Crude protein, %	19.10
Calcium, %	0.44
Phosphorus, %	0.43
Avail. phosphorus, %	0.20
App. dig. lysine, %	0.74
App. dig. met+cys, %	0.51
App. dig. threonine, %	0.48
App. dig. tryptophan, %	0.15

Gestation and Lactation Diets

	Gestation 20% DDGS	Gestation 50% DDGS	Lactation * 10% DDGS	Lactation * 20% DDGS	Lactation ** 10% DDGS	Lactation ** 20% DDGS
DDGS	20.00	50.00	10.00	20.00	10.00	20.00
Corn	67.75	36.97	64.40	56.68	57.44	50.64
SBM, 44%	8.83	8.68	18.88	16.74	25.93	22.86
Choice white grease	0.00	0.00	3.00	3.00	3.00	3.00
Dicalcium phosphate	2.19	0.82	2.31	2.08	2.17	1.9
Limestone	0.48	2.58	0.41	0.50	0.46	0.55
Breeder vitamin premix	0.30	0.30	0.30	0.30	0.30	0.30
Breeder trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15
Salt	0.50	0.50	0.50	0.50	0.50	0.50
L-lysine	0.00	0.00	0.15	0.15	0.15	0.15
Total	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***	***100.00***
Nutrient Composition						
ME (kcal/kg)	3235	3254	3352	3336	3340	3325
Crude protein, %	14.47	20.94	16.14	17.07	18.62	19.24
Calcium, %	0.90	1.28	0.90	0.90	0.90	0.90
Phosphorus, %	0.80	0.73	0.80	0.80	0.80	0.80
Available P, %	0.59	0.57	0.55	0.57	0.54	0.56
App. dig. lysine, %	0.45	0.47	0.64	0.64	0.77	0.77
App. dig. met, %	0.41	0.49	0.45	0.45	0.50	0.50
App. dig. threonine, %	0.40	0.48	0.44	0.45	0.52	0.52
App. dig. tryptophan, %	0.11	0.13	0.13	0.13	0.16	0.16

* ADFI = 10.5 lbs/d, 21-d litter wt. < 120 lbs
** ADFI = 12.0 lbs/d, 21-d litter wt. > 120 lbs

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Use of Distillers Dried Grains With Solubles (DDGS) in Swine Diets

Bob Thaler, Extension swine specialist

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).

This publication and others can be accessed electronically from the SDSU College of Agriculture & Biological Sciences publications page at http://agbiopubs.sdstate.edu/articles/ExEx2035.pdf or the Extension Service Drought Information Website at http://sdces.sdstate.edu/drought/

COOPERATIVE EXTENSION SERVICE SDSU

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Distillers Dried Grains with Solubles in Swine Diets

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Distillers grains are by-products of when grains are fermented into alcohol. The spent grains are dried and sold as feed. Solubles left over from fermentation usually are added to the distillers grains (DDG) before drying, resulting in a product called distillers dried grains with solubles (DDGS), the most common commercial product. Distillers grains are identified by the type of grain from which they are made, i.e. corn distillers, milo distillers, or other grains (wheat or rye). Distillers Dried Grains with solubles (DDGS) is the product obtained by condensing and drying the stillage that remains after fermenting the starch in corn or milo in the production of ethyl alcohol.

There is renewed interest in feeding DDGS to swine because the rapid growth of the ethanol industry in the Midwest has increased the quantity and local supply. Historically, DDGS has not been used in swine diets because of the low protein quality (poor amino acid balance), low amino acid digestibility, high fiber content and the nutrient variability among sources. This left an image of an inferior ingredient for swine diets. Today, according to University of Minnesota research the new ethanol plants are producing DDGS with higher nutrient content and digestibility than that listed in the 1998 National Research Council publication on Nutrient Requirements of Swine.

Nutrient Profile

When compared to corn, the typical energy source used in Midwestern swine diets, the nutrient profile of DDGS varies slightly. Distillers' grains has higher protein (25 to 30 %), fat (8 to 10 %), and fiber (4 to 12 %) content than corn due to the fermentation process removing the starch component. Distillers' by-products do have several features that limit their use in swine diets. The high fiber content may cause diarrhea in young pigs. Distillers' grains will have a lower metabolizable energy content due to less starch. The crude protein content is relatively high, but the amino acid profile is not well balanced. For example, distillers' grains are quite low in lysine content (0.6 to 0.9 %). Therefore, swine diets containing distillers' dried grain with solubles (DDGS) need to be formulated on a digestible lysine and energy basis. Formulating the diet on a crude protein basis will result in a lysine deficiency and possible a deficiency of other amino acids, such as tryptophan, methionine or threonine, which will reduce growth performance.

Growth Performance

DDGS can be used in nursery, growing-finishing (G-F), gestation and lactation diets. Several research studies have reported favorable results in growth and feed efficiency of pig when fed 2.5 to 5% of DDGS. The maximum recommended inclusion rate of DDGS in 35 to 250 pound pig diets is 20%. The more acceptable inclusion rate is 10% in G-F diets. When the

20% inclusion rate is used then synthetic lysine and tryptophan should be added to maintain an amino acid balanced diet with adequate growth performance.

Recommended Maximum Inclusion Rates of DDGS in Swine Diets

Based upon research studies conducted at the University of Minnesota over the last three years, the recommended maximum usage rate of DDGS in swine diets are as follows (Assuming that high quality DDGS is free of mycotoxins):

Production Phase	Maximum % of Diet
Nursery pigs (> 15 lbs)	5
Growing pigs (35-125 lbs)	10
Finishing pigs (125-260 lbs)	20
Developing Gilts	20
Gestating sows	50
Lactating sows	20
Boars	50

Table 1 gives a comparison of nutrient content, apparent amino acid digestibility, and phosphorus availability of MN/SD DDGS, a low quality DDGS source, and NRC (1998).

Table 1. Comparison of Nutrient Content, Apparent Amino Acid Digestibility, and Phosphorus Availability of MN/SD DDGS, a Low Quality DDGS Source, and NRC (1998).[a]

Nutrient*	MN/SD DDGS	Low Quality DDGS	NRC (1998)
Dry matter, %	88.9	88.3	93.0
Crude protein, %	30.2	28.1	27.7
Crude fat, %	10.9	8.2	8.4
Crude fiber, %	8.8	7.1	(4.8-1988 NRC)
Calcium, %	0.06	0.44	0.20
Phosphorus, %	0.89	0.90	0.77
Available phosphorus, %	0.80	?	0.57
Digestible energy, kcal/kg	3,965	3,874	3,200
Metabolizable energy, kcal/kg	3,592	3,521	2,820
Net energy, kcal/kg			2,065
Lysine, %	0.83	0.68	0.62
App. digestible lysine, %	0.44	0.00	0.29
Methionine, %	0.55	0.49	0.50
App. digestible methionine, %	0.32	0.24	0.36
Threonine, %	1.13	0.99	0.94
App. digestible threonine, %	0.62	0.36	0.52
Tryptophan, %	0.24	0.22	0.25
App. digestible tryptophan, %	0.15	0.15	0.13

[a]Source: Feeding recommendations and Example Diets Containing MN/SD Produced DDGS for Swine. Jerry Shurson and Mindy Speihs, Department of Animal Science, University of Minnesota

Cautions in Feeding DDGS to Swine

1. Quality
    a. There is a large variation in the quality of DDGS available for swine feeds. Golden color DDGS is much better suited for swine diets than darker colored DDGS due to higher amino acid digestibility.
    b. Odor ranges form sweet to smoky to burnt
    c. According to research at the University of Minnesota, DDGS produced by new Midwestern plants is higher in nutrient content and digestibility (Table 1) than DDGS from older plants.
    d. Quality considerations for selecting DDGS sources;

        Nutrient Specifications

        - Moisture – maximum 12%
        - Protein – minimum 26.5%
        - Fat – minimum 10%
        - Fiber – maximum 7.5%

2. Nutrient variability of Midwestern DDGS sources
    a. Dry matter – 87 to 93%
    b. Crude protein 23 to 29%
    c. Crude fat 3 to 12%
    d. Ash – 3 to 6%
    e. Lysine – 0.59 to 0.89%

3. Pork fat quality

    University of Minnesota studies have shown that when feeding DDGS to G-F pigs (50-250 lbs), the oil present in DDGS will make pork carcass fat softer and more oily with increasing levels of DDGS in the diet. These same studies showed that feeding up to 20% DDGS in G-F pig diets had no effect on belly thickness or belly firmness score compared to carcasses from G-F pigs fed conventional corn-soybean meal diets.

4. Mycotoxins

    Corn is susceptible to molds that can produce mycotoxins prior to harvest, as well as during storage. The primary mycotoxins of concern to swine are zearalenone, vomitoxin (deoxynivalenol), T-2 toxin, fumonisin, and aflatoxins. In the Midwestern U.S., zearalenone and vomitoxin are the greatest risk.

5. Amino acid digestibility is reduced in dark colored DDGS.

6. High fiber limits its use in pre-starter diets (< 15 lb livewight)

7. Because of the high fiber content, sows will take twice as long to eat their daily feed allotment than sows fed a corn-soybean meal diet.

Maximizing the Value of DDGS in Swine Diets

1. Excess nitrogen can be minimized by using synthetic amino acids.

2. Dietary inclusion rates should be gradually increased in gestation (up to 40%) and lactation (up to 20%) diets to allow sows to adapt.

3. Formulate diets using digestible amino acid values.

4. High available phosphorus reduces the level of dietary phosphorus supplementation.

Feeding Recommendations

For feeding recommendations and example diets containing DDGS for all classes of swine contact Dr. Gilbert Hollis, 1207 West Gregory Drive, Urbana, IL 61801; E-mail: g-hollis@uiuc.edu or see the following University of Minnesota web site: http://www.ddgs.umn.edu/diets-swine.htm