Excellent performance with DDGS diets

Distillers dried grains with solubles may be used at 20% for young and growing pigs and lactating sows and 40% in gestating diets says HANS STEIN*.

Distillers dried grains with solubles (DDGS) is produced from the fuel ethanol industry and is available for inclusion in diets fed to swine. During recent years, several research projects have been completed to investigate the feeding value of DDGS in diets fed to swine. Crude nutrient concentrations, energy and nutrient digestibility values, and effects of including DDGS in diets fed to different categories of swine has been investigated.

The concentration of energy in DDGS is greater than in corn, but because of a lower digestibility of energy in DDGS than in corn, there is no difference in the concentration of digestible and metabolizable energy between DDGS and corn. The apparent and standardized ileal digestibility of amino acids in DDGS does vary among sources but, with the exception of lysine, the variability is no greater than what has been reported for other feed ingredients.

Lysine in DDGS may be damaged if excessive heating is used during the drying process, which in turn leads to a low digestibility of lysine. To exclude heat damaged products from swine feeding, it is recommended that producers calculate the Lysine to crude protein ratio and only use DDGS if this ratio is greater than 2.80 %. The digestibility of phosphorus in DDGS is approximately 59%. This value is greater than in corn. Therefore, if DDGS is included in the diet, less inorganic phosphorus is needed and less phosphorus will be excreted in the manure.

Diets formulated to contain DDGS should be formulated on the basis of digestible amino acids and digestible phosphorus. DDGS can be included in diets fed to nursery pigs, growing finishing pigs, and sows in amounts of 20% and in diets for gestating sows at 40%. At these inclusion rates, excellent performance of pigs has been reported.

Table 1: Concentration of energy in corn and 10 samples of distillers dried grains with solubles (DDGS) fed to growing pigs [1].

Ingredient:	Corn	DDGS			
Item		Average	Standard deviation	Lowest value	Highest value
Gross energy, kcal/kg DM	4496	5434	292	5272	5592
Apparent total tract digestibility, %	90.4	76.8	2.73	73.9	82.8
Digestible energy, kcal/kg DM	4088	4140	205	3947	4593
Metabolizable energy, kcal/kg DM	3989	3897	210	3674	4336

[1] Data from Pedersen *et al.*, 2007.

Table 2: Concentration of carbohydrates in 46 samples of distillers dried grains with solubles [1].

Item	Average	Low	High	SD
Starch, total, %	7.3	3.8	11.4	1.4
Starch, soluble, %	2.6	0.5	5.0	1.2
Starch, insoluble, %	4.7	2.0	7.6	1.5
ADF, %	9.9	7.2	17.3	1.2
NDF, %	25.3	20.1	32.9	4.8

[1] Unpublished data from the University of Illinois.

Table 3: Concentration and digestibility of phosphorus (P) in 10 sources of distillers dried grains with solubles fed to growing pigs [1].

Item	Average	Low	High	SD
Total P, %	0.61	0.51	0.74	0.09
Total P, % DM	0.70	0.57	0.85	0.10
Apparent total tract digestibility, %	59	50	68	5.17
Digestible P, %	0.36	0.28	0.47	0.06

[1] Data from Pedersen *et al.*, 2007.

Table 4: Concentration and digestibility of crude protein and amino acids in 36 samples of distillers dried grains with solubles (DDGS) fed to growing pigs [1,2].

	Concentration in DDGS, %				Standardized ileal digestibility, %			
Item	Average	Low	High	SD	Average	Low	High	SD
CP	27.5	24.1	30.9	1.8	72.8	63.5	84.3	5.33
Indispensable AA								
Arg	1.16	0.95	1.41	0.10	81.1	74.1	92.0	5.18
His	0.72	0.56	0.84	0.07	77.4	70.0	85.0	4.58
Ile	1.01	0.87	1.31	0.09	75.2	66.5	82.6	4.77
Leu	3.17	2.76	4.02	0.32	83.4	75.1	90.5	3.85
Lys	0.78	0.54	0.99	0.09	62.3	43.9	77.9	7.61
Met	0.55	0.46	0.71	0.08	81.9	73.7	89.2	4.12
Phe	1.34	1.19	1.62	0.11	80.9	73.5	87.5	3.94
Thr	1.06	0.89	1.71	0.20	70.7	61.9	82.5	5.26
Trp	0.21	0.12	0.34	0.04	69.9	54.2	80.1	6.98
Val	1.35	1.15	1.59	0.11	74.5	65.8	81.9	4.72
Dispensable AA								
Ala	1.94	1.58	2.79	0.21	77.9	59.7	85.0	4.46
Asp	1.83	1.56	2.13	0.14	68.6	59.4	75.9	4.75
Cys	0.53	0.37	0.75	0.11	73.6	65.6	80.7	4.64
Glu	4.37	3.05	6.08	0.68	80.4	67.4	88.3	5.48
Gly	1.02	0.88	1.20	0.06	63.5	46.8	87.0	10.97
Pro	2.09	1.74	2.50	0.16	74.4	32.0	125.9	22.12
Ser	1.18	0.94	1.45	0.13	75.6	59.6	82.8	5.14
Tyr	1.01	0.83	1.31	0.16	80.9	74.6	88.9	3.79

[1] Data from Stein *et al.*, 2005; Pahm *et al.*, 2006. [1+2] Stein *et al.*, 2006; Urriola *et al.*, 2007.

Concentration and digestibility of energy and nutrients

In the United States, most ethanol is produced from corn. Analysed concentrations of energy and nutrients in a large number of DDGS samples are presented in Tables 1, 2, 3, and 4 along with measured contents of digestible energy, digestible phosphorus, and digestible amino acids.

The measured concentration of digestible (DE) and metabolizable (ME) energy in DDGS is 4140 and 3897 kcal per kg DM, respectively. These values are not different from the DE and ME in corn (Table 1).

Because starch is converted to ethanol during the fermentation process, only small amounts of starch is present in DDGS (Table 2). However, the fiber in corn is not converted to ethanol so the concentration of fiber (i.e., ADF and NDF) is relatively high in DDGS (Table 2).

The phosphorus concentration in DDGS is approximately 0.60%. The apparent total tract digestibility of phosphorus in DDGS is approximately 59% (Table 3). The corresponding value for corn is 21.5%, which is significantly lower than in DDGS. The reason for the greater digestibility of phosphorus in DDGS than in corn may be that some of the bonds that bind phosphorus to the phytate complex in corn have been hydrolyzed during the fermentation process in the ethanol plants, which makes more phosphorus available for absorption. As a consequence, if DDGS is included in diets fed to swine, the utilisation of organic phosphorus will increase and the need for supplemental inorganic phosphorus (i.e., dicalcium phosphate or monocalcium

phosphate) will be reduced.

The concentration and standardized ileal digestibility of amino acids were determined in 36 samples of DDGS originating from 35 different ethanol plants in the Midwest (Table 4). The results showed that some variation exist for amino acid digestibility among different samples of DDGS. This is true in particular for lysine that is more variable than all other indispensable amino acids in terms of digestibility.

The reason for this variation is believed to be that lysine may have been heat-damaged in some of the samples of DDGS, which has lowered the digestibility of lysine in these samples. Most amino acids in DDGS have a medium digestibility and, except for lysine, the variability among different samples is within the normal range of variation found in other feed ingredients. To reduce the risk of utilising sources of DDGS that have a low digestibility of Lysine because of heat damage, the lysine to crude protein ratio can be calculated (Table 5).

Table 5: Concentration, standardized ileal digestibility (SID), and ratio of crude protein and lysine in distillers dried grains with solubles [1,2].

Item	Av.	Low	High
Crude protein, %	27.5	24.1	30.9
Lysine, %	0.78	0.54	0.99
SID Lysine, %	62.3	43.9	77.9
SID Lysine, g/kg	0.50	0.27	0.70
Lysine:CP, %	2.86	2.18	3.54

[1] Data calculated from Stein *et al.*, 2005; Pahm *et al.*, 2006. [1+2] ; Stein *et al.*, 2006; Urriola *et al.*, 2007.
[2] Data are based on *in vivo* measurement of standardized ileal digestibility of lysine and other amino acids in 36 samples of DDGS.

The low digestibility of lysine is often associated with a low analysed concentration of lysine in the sample, which is the reason why the lysine to crude protein ratio gives an estimate of the quality of the lysine in the sample. If the lysine to crude protein ratio is 2.80% or greater, then the DDGS has an average or above average quality, but if the ratio is lower than 2.80, then the product has a reduced quality. DDGS samples with a lysine to crude protein ratio that is less than 2.80 should not be used.

Considerations when buying DDGS

Because there is some variability among sources of DDGS, it is recommended that producers examine concentrations of nutrients in the product before buying DDGS. To confirm that the product is a true DDGS product that has not been diluted with soy hulls or reduced in fat concentration, it is recommended that guaranties for nutrient concentrations are obtained from the supplier. The crude protein concentration should be at least 27% and total fat and total phosphorus concentrations should be at least 9 and 0.55%, respectively. Concentrations of ADF and NDF should not exceed 12 and 40%, respectively. To avoid sources of DDGS that have been heat damaged, the lysine to crude protein ratio should be at least 2.80%. It is also recommended that producers seek assurances for the

Table 6: Effects of including up to 20% distillers dried grains with solubles (DDGS) in diets fed to growing-finishing pigs [1].

Item	Diet:	Control	DDGS		SEM	P-Value	
			10%	20%		Linear	Quadratic
Initial wt, lb		48.6	48.0	48.5	0.48	0.82	0.40
Final wt, lb		273.0	281.0	274.8	2.77	0.77	0.23
Average daily gain, lb		1.96	2.05	1.98	0.02	0.76	0.22
Average daily feed intake, lb		5.65	6.05	5.72	0.08	0.78	0.11
Feed conversion ratio, lb/lb		2.86	2.94	2.86	0.01	0.94	0.32
Hot carcase wt, lb		194.3	201.8	195.1	2.54	0.91	0.25
Dressing, %		71.1	71.8	71.0	0.48	0.85	0.23
Lean meat, %		51.30	50.15	51.17	1.20	0.92	0.31
Longissimus muscle area, inches^2		7.22	6.97	6.92	2.48	0.51	0.79
Longissimus muscle depth, inches		2.39	2.33	2.27	0.24	0.25	0.94
10th rib backfat, inches		0.98	1.02	0.94	0.21	0.70	0.46
Longissimus muscle marbling		2.17	2.13	2.29	0.40	0.68	0.69
Longissimus muscle color score		3.38	3.17	3.25	0.24	0.65	0.54
Longissimus muscle, 24h pH		5.35	5.37	5.43	0.06	0.09	0.65
48h drip loss, %		4.04	4.28	3.89	0.51	0.84	0.61
7d purge loss, %		3.22	3.29	3.23	0.44	0.99	0.88
Belly thickness, inches		53.69	52.28	47.19	4.50	0.01	0.18
Adjusted belly firmness score, degrees		4.77	4.77	4.72	0.46	0.82	0.90
Iodine value of belly fat		69.77	69.82	72.04	1.25	0.22	0.49

[1] Data from Widmer *et al.*, 2007 (unpublished).

Table 7: Recommended and maximum inclusion rates of distillers dried grains with solubles (DDGS) in diets fed to different categories of swine.

Category	Rec. [1]	Max. [2]
Gestation	40	50
Lactation	20	?
Nursery, week 0-2	0	20
Nursery, after week 2	20	30
Grower	20	35
Early finisher	20	35
Late finisher	20	20

[1] Recommended inclusion rates are based on a review of experiments in which DDGS was included in diets fed to swine.
[2] Maximum inclusion rates are the maximum concentrations of DDGS that have been successfully used under field conditions. These inclusion rates are not always based on experiments published in the peer reviewed literature and it may not be possible to successfully use these concentrations of DDGS under all circumstances.

absence of mycotoxins in DDGS before it is purchased.

Formulating diets using DDGS

When formulating diets with DDGS, it is recommended that energy values that are similar to corn are being used for DDGS. Diets should be formulated based on standardized ileal digestible amino acids and digestible phosphorus. Because the protein in DDGS is relatively low in lysine, additional crystalline L-lysine needs to be included in the diet when DDGS is used. If more than 20% DDGS is included in the diet, 0.015% of crystalline L-tryptophan also needs to be added to the diet for each additional 10% DDGS that is being used.

If diets for gestating sows are formulated with DDGS, less soybean meal can be removed from the diet because gestating sows have a relatively greater requirement for digestible tryptophan than lactating sows and growing pigs. Because DDGS has a low concentration of tryptophan, it is possible to maintain a proper tryptophan concentration in gestation diets only if the reduction in soybean meal is limited to 2.40% for each 10% DDGS that is included in the diet. As a consequence, if 10% DDGS is included in gestating diets, the concentration of corn in the diet can be reduced by 7.40%.

Inclusion rates of DDGS

The inclusion of 20 to 30% DDGS in diets fed to growing pigs has resulted in excellent pig performance in many experiments (Table 6). However, reduced feed intake of diets containing DDGS, and therefore, also reduced pig performance has been reported from some experiments. The reduced feed intake may have been related to the specific source of DDGS that was used in these experiments or caused by increased crude protein levels in the DDGS containing diets.

It has been shown that sometimes, pigs prefer to eat diets containing no DDGS rather than

diets containing DDGS. However, if an acceptable quality of DDGS is used and if diets are carefully formulated using the principles outlined above, producers will be able to use at least 20% DDGS in diets fed to nursery pigs from 2 weeks post-weaning and to growing and finishing pigs without experiencing any reduction in pig performance. Greater inclusion rates may be used if a good source of DDGS is available and some producers are successfully using 30 to 35% DDGS in diets fed to growing pigs.

Inclusion of up to 20% DDGS in lactation diets and up to 40% in gestation diets has also been reported to have no effect or a slightly positive effect on reproductive performance of sows. It is, therefore, recommended that DDGS can be included in diets fed to sows at these concentrations. An overview over current recommendations for the inclusion of DDGS in diets fed to swine is presented in Table 7.

Other consequences

The relatively high concentration of fat in DDGS may increase problems with feed bridging in bins and feeders (Table 8). In some cases, therefore, it may be necessary to modify storage and delivery systems if DDGS is used. Diets containing DDGS are also bulkier than diets without DDGS. As a rule of thumb, for each 10% DDGS that is included in the diet, the volume of the diet will increase by approximately 3% compared with a corn-soybean meal diet. This means that if a feed bin has the capacity to hold 8 tonne of a corn-soybean meal diet that same bin will only be able to hold 7.6 tonne of feed if 20% DDGS is included in the diet.

The fat in DDGS has a relatively high concentration of unsaturated fatty acids, which may cause increased belly softness of pigs fed diets containing DDGS. This may become a problem if the finishing diet contains more than 20% DDGS, but not all packers discount pigs with soft bellies. Presently, research is being conducted to investigate possibilities for preventing pork bellies from becoming softer if high concentrations of DDGS are used in the diets.

Table 8: Expected consequences of feeding distillers dried grains with solubles (DDGS) to pigs.

Item	What you can expect
Flowability	May become a problem in bins and feeders
Diet bulk	Will increase by approximately 3% for each 10% DDGS in diet
Feed intake	No effect if good quality DDGS is used
Daily live gain	No effect if good quality DDGS is used
Feed conversion	No effect if good quality DDGS is used
Dressing percentage	May be reduced by up to 0.5 percentage units for each 10% DDGS in diet
Belly softness	May become a problem if more than 20% DDGS in finishing diet
Intestinal health	Some evidence for improvement, more research needed
Litter size	May increase if DDGS included in gestating diets, more research needed
P excretion	Will be reduced if diet formulated correct
N excretion	Will increase slightly if diet formulated correct

The inclusion of DDGS in diets fed to nursery and growing pigs may improve intestinal health and reduce problems with ileitis. Many producers, therefore, prefer to have 20% DDGS in all diets fed to these categories of pigs, but research to demonstrate the health benefits of using DDGS has been inconclusive. Increased litter sizes of sows fed diets containing DDGS has also been reported from one experiment, but more research in this area is needed to verify the positive effects of DDGS on litter size.

Economics of using DDGS

Because DDGS replaces both corn and soybean meal in diets fed to pigs, the economic value of DDGS depends on the cost of corn and soybean meal. Before including DDGS in diets fed to swine, producers are advised to make their own calculations based on local prices for corn, soybean meal, and DDGS.

Conclusions

The usage of DDGS in diets fed to swine is rapidly increasing. Many producers are including 20% DDGS in diets fed to all categories of swine. While this level of inclusion is generally recommended, some producers are successfully using greater inclusion rates and it is possible that up to 35% DDGS can be included in diets fed to nursery pigs and growing finishing pigs.

However, because of the risk of producing pork with soft bellies, the inclusion of DDGS in finishing diets should be limited to 20% until more research has been conducted to investigate the effects of higher inclusion rates on belly firmness of pigs.

Likewise, it is generally not recommended that DDGS is included in diets fed to nursery pigs during the initial 2 weeks post weaning, but some producers have successfully included up to 20% DDGS in these diets as well.

Regardless of the category of pigs being fed and the inclusion level, it is important that diets containing DDGS be carefully formulated based on concentrations of digestible amino acids and digestible phosphorus. Sources of DDGS that have a lysine to crude protein ration that is lower than 2.80 should not be used in diets fed to swine. ■

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A list of references is available from the author.