DDGS: Energy and nutrient content and digestibility

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Summary

The concentration of gross energy in distillers dried grain with solubles (**DDGS**) is greater than in corn. However, 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. Based on the wide range of digestibility values for lysine in DDGS, it is likely that some ethanol plants do overheat DDGS and destroy some of the lysine in the product. The digestibility of phosphorus in DDGS is approximately 58%. This value is greater than in corn. Therefore, if DDGS is included in the diet, less inorganic phosphorus is needed.

Key words: Amino acids, Digestibility, Dried distillers grain with solubles, Energy, Phosphorus, Pigs

Introduction

Distillers dried grain with solubles (**DDGS**) is increasingly being included in diets fed to swine. Barley, wheat, sorghum, or corn may be used in the production of ethanol and the

resulting DDGS is characterized by the grain that was used. However, even when the same grain is used, variability in the chemical composition of DDGS may be observed (Cromwell et al., 1993; Spiehs et al., 2002). This variability is likely caused by differences in the effectiveness of fermentation, differences in drying temperatures, or differences in the quantities of solubles that are added to the distillers dried grain. Because the product has gone through heat treatment, there is a risk that the digestibility of some amino acids, and lysine in particular, may be reduced because of Maillard reactions (Cromwell et al., 1993). If this is the case, then the variability in concentrations of digestible lysine will increase compared with the variability of total lysine in DDGS.

Pigs have requirements for digestible contents of nutrients such as amino acids and phosphorus and they need energy for maintaining basic body functions. The concentration of energy and digestible nutrients in a feed ingredient, therefore, determine the value of this ingredient in diets fed to swine. During recent years, several experiments have been conducted to measure the concentrations of digestible energy and nutrients in DDGS if fed to swine. It is the objective of the current contribution to summarize these results.

Energy concentration and digestibility

The average concentration of gross energy in 10 samples of DDGS was measured by Pedersen et al. (2006) at 5,434 ± 299 kcal GE per kg dry matter (**DM**). This value is greater than in corn. However, the digestibility of energy in DDGS is lower than in corn and the measured concentration of digestible (**DE**) and metabolizable (**ME**) energy in the 10 sources of DDGS was 4,140 ± 205 and 3,897 ± 210 kcal per kg DM, respectively. These values were not different from the DE and ME that were measured in corn (Table 1). These numbers concur with average values of approximately 4,220 kcal DE and 4,040 kcal ME per kg DM that were measured in two sources of DDGS (Hastad et al., 2004). Based on the chemical composition of a large number of samples of DDGS, values for DE and ME in DDGS of approximately 3,990 and 3,750 kcal per kg DM, respectively, were calculated (Spiehs et al., 2002). Thus, both measured and calculated values are significantly greater than current estimated values for DE and ME in DDGS of 3,441 and 3,032 kcal per kg DM, respectively (NRC, 1998). Because the DE and ME in DDGS are

similar to corn, no energy adjustments in diet compositions are needed if DDGS is included in diets formulated to pigs.

Amino acid concentration and digestibility

The concentration of amino acids in DDGS has been reported in several publications (NRC, 1998; Spiehs et al., 2002; Fastinger and Mahan, 2006; Stein et al., 2006). The concentration of most amino acids in DDGS is 3 to 4 times greater than in corn (Table 2). If calculated as a percentage of crude protein, the concentration of most amino acids in DDGS protein is similar to that in corn protein. The exception to this rule is the dispensable amino acid glutamate, that is present in DDGS protein in a quantity that is lower than in corn protein (Table 2). The reason for the relatively low concentration of glutamate in DDGS may be that yeast cells prefer to use glutamate as an energy source. The yeast that was used in the fermentation of corn to produce ethanol may, therefore, have utilized some of the glutamate in corn, leaving a smaller amount in DDGS protein.

Values for apparent and standardized ileal digestibility of amino acids were determined at South Dakota State University in 37 samples of DDGS originating from 36 different ethanol plants in the Midwest (Stein et al., 2005; 2006; Pahm et al., 2006a and b). The diets used to measure the apparent ileal digestibility values in these experiments consisted of 67% DDGS, 27% cornstarch, 1% soybean oil, 3% sugar, and vitamins and minerals. The basal endogenous losses were determined using a protein-free diet and the standardized ileal digestibility values were calculated. The results of the experiments showed that some variation exist for amino acid digestibility among different samples of DDGS (Table 3). 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 in turn has lowered the calculated digestibility of lysine in these samples. Further work is needed to identify the reasons for this heat damage and to establish procedures for the production that allow ethanol plants to dry the products without heat damaging it. Nonetheless, the 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. Values for apparent and standardized ileal digestibility in 5 different sources of DDGS also have been published (Fastinger and Mahan, 2006). The digestibility of lysine in these

samples varied from 38.2 to 61.5%, thus confirming that lysine is the most variable amino acid in DDGS in terms of digestibility.

Phosphorus concentration and digestibility

The phosphorus concentration in more than 200 samples of DDGS was measured by Spiehs et al., 2002. Results of this worked showed that the average concentration of phosphorus in DDGS is 0.89% (DM basis). However, the value reported by NRC (1998) is only 0.83% (DM basis), and the average phosphorus concentration (DM-basis) in 24 samples of DDGS were measured at South Dakota State University at 0.79% (Stein et al., 2005; 2006; Pedersen et al., 2006). Therefore, there seems to be some variation in the estimated concentration of phosphorus in DDGS.

The apparent total tract digestibility of phosphorus in DDGS was measured in 2 experiments involving a total of 14 samples of DDGS (Stein et al., 2005; Pedersen et al., 2006). On average, an apparent total tract digestibility value for phosphorus in DDGS of 55.9% was reported (Table 4). The corresponding value for corn was 21.5%, which was significantly lower than in DDGS. Previously, the relative availability of phosphorus in DDGS has been reported at 77 and 85% (NRC, 1998; Fent et al., 2004). These values seem high and would suggest that almost all the P in DDGS is digestible to the pig and only little is bound in the phytate complex. However, recent data suggest that P digestibility may be improved by the addition of microbial phytase to diets fed to pigs (Xu et al., 2006). Microbial phytase is expected to improve P digestibility only if some P is bound in the phytate complex, thus indicating that not all the P in DDGS is available to pigs. Moreover, relative availability values are expected to be greater than values for apparent total tract digestibility and may vary dependent on the availability of phosphorus in the reference source of phosphorus that is used in these experiments. Therefore, the apparent total tract digestibility cannot be calculated from the relative availability data. At this point, therefore, a value of 58% for the apparent total tract digestibility of P in DDGS should be used.

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 in turn would make more

phosphorus available for absorption. As a consequence, if DDGS is included in diets fed to swine, the utilization of organic phosphorus will increase and the need for supplemental inorganic phosphorus will be reduced. This will not only reduce diet costs but also reduce the quantities of phosphorus that are excreted into the manure from the animals.

Fiber concentration and digestibility

The concentration of fiber in DDGS is greater than in corn. Values for ADF and NDF of 17.5 and 37.1% (DM-basis), respectively, have been published (NRC, 1998). These values concur with average values of 16.0 and 42.0% that were measured by Spiehs et al. (2002). Very limited information is available on the digestibility of ADF and NDF by growing pigs. However, unpublished data from South Dakota State University showed that the apparent total tract digestibility of ADF and NDF in DDGS is 65.9 and 63.1%, respectively (Table 4). These values were the average of 4 sources of DDGS. The relatively low digestibility of ADF and NDF and the relatively high concentration of these components in DDGS explain why the average total tract digestibility of DM in DDGS is low compared with corn as shown by Pedersen et al. (2006).

Conclusions

Digestibility values for energy, amino acids, phosphorus, ADF, and NDF have been measured in several sources of DDGS. These values indicate that the concentration of digestible and metabolizable energy in DDGS is equivalent to corn. The digestibility of amino acids in DDGS is not more variable than in other feed ingredients with the exception of lysine that may vary considerably because of heat damage. Therefore, during the production of DDGS, care should be taken not to damage the lysine in the product by excessive heating. Procedures to estimate the degree of heat damage in sources of DDGS are needed.

Because of the relatively high digestibility of phosphorus in DDGS, less inorganic phosphorus is needed in diets containing DDGS. The excretion of phosphorus in the manure

from pigs fed diets containing DDGS will also be reduced compared with pigs fed diets containing no DDGS if the inclusion of inorganic P is reduced in diets containing DDGS.

At this point, only limited information is available on the variability in digestibility of energy and nutrients within the same plant over time. This is clearly an area that needs more research because most producers procure DDGS from the same plant.

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

Item	Ingredient:	Corn	DDGS			
			Average	Standard deviation	Lowest value	Highest value
Gross energy, kcal/kg DM		4,496	5,434	299	5,272	5,592
Apparent total tract digestibility, %		90.4	76.8	2.73	73.9	82.8
Digestible energy, kcal/kg DM		4,088	4,140	205	3,947	4,593
Metabolizable energy, kcal/kg DM		3,989	3,897	210	3,674	4,336

[a] From Pedersen et al., 2006.
[b] Data are means of 11 observations per treatment.

Table 2. Concentration of crude protein and amino acids in dried distillers grain with solubles (DDGS) and in corn [1]

Item Ingredient:	DDGS		Corn		DDGS:corn
	% of DDGS	% of CP	% of Corn	% of CP	ratio
Crude protein	31.20	100	9.21	100	3.39
Indispensable AA					
Arginine	1.26	4.02	0.43	4.72	2.89
Histidine	0.88	2.81	0.28	3.02	3.15
Isoleucine	1.16	3.73	0.31	3.41	3.70
Leucine	3.54	11.35	1.10	11.93	3.22
Lysine	0.89	2.87	0.28	3.02	3.22
Methionine	0.70	2.24	0.19	2.10	3.62
Phenylalanine	1.52	4.86	0.45	4.85	3.40
Threonine	1.13	3.61	0.35	3.80	3.22
Tryptophan	0.20	0.63	0.05	0.52	4.05
Valine	1.60	5.14	0.45	4.85	3.59
All indispensable AA	11.27	36.11	3.44	37.37	3.27
Dispensable AA					
Alanine	2.01	6.44	0.68	7.34	2.97
Aspartic acid	2.21	7.08	0.63	6.82	3.52
Cysteine	0.79	2.54	0.22	2.36	3.65
Glutamic acid	3.96	12.69	1.80	19.54	2.20
Glycine	1.11	3.57	0.37	4.06	2.97
Proline	2.21	7.09	0.74	8.00	3.00
Serine	1.23	3.93	0.43	4.72	2.82
Tyrosine	1.05	3.36	0.34	3.67	3.10
All dispensable AA	16.19	51.90	5.65	61.36	2.87
All AA	27.81	89.13	9.09	98.73	3.06

[1]Data calculated from Stein et al., 2006.

Table 3. Standardized ileal digestibility (%) of amino acids in 37 samples of DDGS by growing pigs

Item Digestibility:	Average	Standard deviation	Lowest value	Highest value
Crude protein	72.8	5.33	63.5	84.3
Indispensable amino acids				
Arginine	81.1	5.18	74.1	92.0
Histidine	77.4	4.58	70.0	85.0
Isoleucine	75.2	4.77	66.5	82.6
Leucine	83.4	3.85	75.1	90.5
Lysine	62.3	7.61	43.9	77.9
Methionine	81.9	4.12	73.7	89.2
Phenylalanine	80.9	3.94	73.5	87.5
Threonine	70.7	5.26	61.9	82.5
Tryptophan	69.9	6.98	54.2	80.1
Valine	74.5	4.72	65.8	81.9
Dispensable amino acids				
Alanine	77.9	4.46	69.7	85.0
Aspartic acid	68.6	4.75	59.4	75.9
Cysteine	73.1	4.64	65.6	80.7
Glutamic acid	80.4	5.48	67.4	88.3
Glycine	63.5	10.97	46.8	87.0
Proline	74.4	22.12	32.0	125.9
Serine	75.6	5.14	59.6	82.8
Tyrosine	80.9	3.79	74.6	88.9

Table 4. Apparent total tract digestibility (%) of P, ADF, and NDF in dried distillers grain with solubles fed to growing pigs[1, 2]

Item Digestibility:	Average	Standard deviation	Lowest value	Highest value
Phosphorus	58.1	11.0	51.0	68.0
ADF	65.9	1.6	62.4	69.9
NDF	63.1	13.6	53.6	72.8

[1] Values for the digestibility of P are means of 14 samples of DDGS and values for the digestibility of ADF and NDF are means of 4 samples of DDGS.

[2] Unpublished data from South Dakota State University.