ENERGY AND NUTRIENT DIGESTIBILITY IN DISTILLERS DRIED GRAIN WITH SOLUBLES FED TO GROWING PIGS

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ABSTRACT

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. The digestibility of phosphorus in DDGS is approximately 58%. This value is greater than in corn. Therefore, pigs fed DDGS need less inorganic phosphorus in the diet than pigs fed diets containing no DDGS.

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[1, 2]. This variability is likely caused by differences in the effectiveness of the fermentation, drying temperatures, or the amounts 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[1]. 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 at 5,434 ± 299 kcal GE per kg DM[3]. 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 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[4]. 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[2]. These calculated values are slightly lower than the values measured in energy balance experiments. However, 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[5]. It is, therefore, concluded that recent research indicates that the energy concentration in DDGS is equivalent to that in corn.

AMINO ACID CONCENTRATION AND DIGESTIBILITY

Values for apparent and standardized ileal digestibility of amino acids were determined in 14 samples of DDGS originating from 13 different ethanol plants in Minnesota and South Dakota[6, 7]. 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 variations exist for amino acid digestibility among different samples of DDGS (Table 2). This is true in particular for lysine that is more variable than all other 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 five sources of DDGS originating from other parts of the US also have been published[8]. These values confirmed 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 in 24 samples of DDGS were measured at South Dakota State University at 0.79% (DM-basis). 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 only two experiments involving a total of 14 samples of DDGS[3, 6]. On average, an apparent total tract digestibility value for phosphorus in DDGS of 58% was reported. The corresponding value for corn was 21.6%, which was significantly lower than in DDGS. Previously, the relative availability of phosphorus in DDGS has been reported at 77 and 85%[5, 9]. However, 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.

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.

CONCLUSIONS

Digestibility values for energy, amino acids, and phosphorus 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 considerable 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.

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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]

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] Data are means of 11 observations per treatment.

Table 2. Standardized ileal digestibility (%) of amino acids in 14 samples of DDGS by growing pigs

Item	Digestibility:	Average	Standard deviation	Lowest value	Highest value
Crude protein		70.5	3.96	63.5	77.6
Indispensable amino acids					
Arginine		78.6	3.80	74.1	89.9
Histidine		75.2	4.64	70.0	88.9
Isoleucine		72.7	4.36	67.4	84.2
Leucine		81.9	4.16	75.5	91.3
Lysine		59.0	7.19	43.9	78.4
Methionine		80.3	3.98	73.9	89.2
Phenylalanine		79.0	3.78	73.5	89.4
Threonine		69.9	5.96	62.2	87.2
Valine		71.7	4.30	67.3	87.2
Dispensable amino acids					
Alanine		75.7	4.27	69.7	87.6
Aspartic acid		66.9	4.66	59.4	80.2
Cysteine		72.4	4.46	66.0	85.8
Glutamic acid		76.7	6.11	67.4	91.4
Glycine		57.2	6.36	46.8	76.7
Proline		66.9	9.40	57.8	88.8
Serine		72.1	5.10	59.6	80.9
Tyrosine		80.9	3.74	74.6	89.9