Corn DDGS Value in Swine and Poultry Feed Formulations

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ABSTRACT

Dried distiller's grains and solubles (DDGS) is a co-product of dry-mill ethanol production from grains. It is fast becoming a popular ingredient for poultry and livestock feed because of its value as a source of energy, protein and phosphorus. As US ethanol production is expected to increase tremendously over the next few years, more opportunities to abundantly use DDGS for feed will be available to the Southeast Asian region. DDGS quality may vary depending on several factors. Thus, when using DDGS, protein, fat, fiber and phosphorus must be quantified and estimates on energy, amino acids and amino acid digestibilities must be calculated. Concerns on color, smell, keeping quality and mycotoxins should also be taken into account. Feed formulations must be based on content of digestible amino acids and available phosphorus. Swine can effectively utilize rations containing up to 20% DDGS without any reduction in performance nor meat quality. On the other hand, meat birds can be fed diets with 10% DDGS without significantly affecting growth and feed conversion; egg layers can tolerate feed containing a maximum of 15% DDGS while maintaining egg production. Given present DDGS and local ingredient prices, inclusion of corn, soybean meal and mono-dicalcium phosphate in Philippine diet formulations may be reduced, consequently decreasing feed cost.

INTRODUCTION

Distillers dried grains with solubles (DDGS) is a co-product of the dry mill ethanol production from grains. Though corn is the primary feedstock used in the United States, sorghum and barley are also utilized in a number of locations.

In ethanol production, the starch is fermented to obtain ethyl alcohol, but the remaining components of the grain kernel (endosperm, germ) preserve much of the original nutritional value of the grain, including energy, protein and phosphorous. Dry mill plants recover and recombine these components into a variety of animal feed ingredients. DDGS is a popular dried form of these combined components, available to domestic and international customers as an ingredient for animal rations.

The ethanol industry in the United States is expanding rapidly, resulting in a fast-growing supply of DDGS in the marketplace. In January 2007, the Renewable Fuels Association reported that 112 operating dry mill ethanol plants have a combined capacity of 5.53 billion gallons of ethanol annually, and that 83 more plants are either under construction or expanding, which could add another 6.0 billion gallons of production capacity within the next two years. DDGS production from these ethanol plants reached 8.5 million metric tons in calendar year 2006, and is expected to climb to 36 million tons by 2010. DDGS offers an opportunity for cost savings in animal feed rations, and will be available in abundant quantities in the coming years. (DDGS Users Handbook, 2007)

Within the past three years, DDGS exports to Southeast Asia have tremendously increased, from 25,000 metric tons in 2004 up to 192,000 metric tons by end of last year. The Philippines is the corn co-product's largest user, making up approximately one-third of the region's import volumes. On the other hand, DDGS consumption in Indonesia and Vietnam may reach a two-fold increase before the end of 2007. A table summarizing exports to the SEA region is shown below:

Table1. US DDGS Exports to Southeast Asia (MT)

	2004	2005	2006	Jan-Jun '07
Indonesia	11,516	46,523	43,764	31,323
Malaysia	12,475	34,475	29,970	16,971
Philippines	958	11,758	62,465	35,088
Thailand	10	12,802	38,140	18,871
Vietnam	633	19,869	17,979	27,092
TOTAL	25,592	125,427	192,318	129,345

NUTRIENT COMPOSITION

Several studies have been undertaken to determine the feeding value of DDGS to both swine and poultry. Research have either estimated energy, crude nutrient concentration or digestibility values. When buying DDGS, the following nutrient specifications may be used as a guide:

Moisture- maximum 12%
Crude protein- minimum 26.5%
Crude fat- minimum 9.5%
Crude fiber- maximum 8%

Alternatively, since there is considerable variability in protein and fat values, a number of buyers specify for "Profat" (percentage protein + percentage fat) not to fall below 36%. In addition, a number of DDGS users may look for guarantees in terms of available phosphorus (minimum 0.55%), acid detergent fiber (maximum 12%), neutral detergent fiber (maximum 40%) and lysine to protein ratio (minimum 2.8)- these specifications though are not very common in most transactions.

Once proximate analysis results of DDGS have been determined, values for metabolizable energy, total amino acids and digestible amino acids can be calculated from a number of prediction equations. Most of these equations were derived from university and/or industry trials and have repeatedly proven to be sufficiently accurate.

ENERGY

Swine metabolizable energy (SME) values from literature and recent studies ranged from 3032-3897 kcal/kg. Estimates from the NRC (1998) suggests a lower value as their prediction was based on the higher crude fiber and lower crude fat levels of DDGS taken from traditional ethanol plants. In contrast, the higher fat and lower fiber in material produced from new generation ethanol plants yield relatively higher SME, as investigated by Shurson (2002) and Pederson et al (2007). Stein (2006), confirmed in an energy digestibility trial that DDGS SME value is equal to, if not greater than that of corn.

Metabolizable energy (TMEn) values from university studies ranged from 2820-2899 kcal/kg as obtained by Noll (2004), Lumpkins and Batal (2005), Fastinger, et al (2006), Batal and Dale (2006), and Parsons et al (2006). It is important to note that these recent estimates of energy are substantially higher than the value of 2,480 kcal ME/ kg reported by the NRC (1994).

A summary of energy estimates are indicated in the next two tables:

Table 2. DDGS Swine ME estimates, kcal/kg

ME	**Source**
3032	NRC 1988
3370	Spiehs 1999
3592	Shurson 2002
3897	Pedersen et al. 2005
Equal to corn	Stein 2006

Table 3. DDGS Poultry TMEn estimates, kcal/kg

ME	**Source**
2480	NRC 1994
2834	Noll 2004
2864	Fastinger 2006
2820	Batal and Dale 2006
2899	Lumpkins and Batal 2006
2858	Parsons et al 2006

AMINO ACIDS

Novus International Inc. has developed regression equations towards the estimation of amino acids in DDGS. However, due to the differences in processing methods (drying time and temperature, etc) and nutrient variability of corn used as feedstock in ethanol production, equations for lysine, arginine and tryptophan registered correlation values below 50%. Nonetheless, the values obtained from these formulas are comparable with that of published DDGS amino acid data and may be effectively used as a guide by feed formulators.

Table 4 . Novus International, regression equations for amino acid prediction in DDGS

Amino Acid	Equation	R2
Arginine	y = 0.07926 + 0.03938*CP	0.48
Cystine	y = 0.11159 + 0.01610*CP + 0.00244*Fat	0.52
Isoleucine	y = -0.23961 + 0.04084*CP + 0.01227*Fat	0.86
Leucine	y = -1.15573 + 0.13082*CP + 0.06983*Fat	0.86
Lysine	y = -0.41534 + 0.04177*CP + 0.00913*Fiber	0.45
Methionine	y = -0.17997 + 0.02167*CP + 0.01299*Fat	0.78
TSAA	y = -0.12987 + 0.03499*CP – 0.00229*Fat2 + 0.05344*Fat	0.73
Threonine	y = -0.05630 + 0.03343*CP – 0.00141*Fat2 + 0.02989*Fat	0.87
Tryptophan	y = 0.01676 + 0.0073*CP	0.31
Valine	y = 0.01237 + 0.04731*CP + .00054185*Fat2	0.81

Batal and Dale (2006), Fiene et al. (2006), Parsons et al. (2006), Fastinger et al. (2006) produced data on digestibility of amino acids. For most of the amino acids, results obtained between trials were numerically consistent. Lysine values however, showed a larger variation between values obtained. Dr Park Waldroup from the University of Arkansas recently summarized the numbers from these experiments and came up with values from the group's weighted average, a shown in the following table:

Table 5. Amino acid digestibility coefficients of DDGS, Poultry

Amino acid	N = 8	N = 47	N = 20	N = 5	Weighted Average
Arginine %	84.1	85.2		88.3	85.3
Histidine %	84.1			85.3	84.5
Isoleucine %	83.3	81.8		84.1	82.2
Leucine %	88.6	89.3		90.2	89.3
Lysine %	69.6	65.9	71	76.5	68.5
Methionine %	86.8	86.1	88	88.5	86.8
Cystine %	73.9	77.6	77	81.6	77.3
Phenylalanine %	87.5			88.0	87.7
Threonine %	74.5	74.6	76	77.5	75.1
Tryptophan %	82.8	83.9		88.2	84.1
Valine %	79.3	81.8		81.4	81.4
Serine %	81.9			84.3	82.8

Digestibility coefficients for amino acids in swine were determined from the University of Illinois. Stein (2007) in a recent article showed that there is a large variability in amino acid values, especially for lysine. The average values he obtained were however quite similar to values obtained from studies at Kansas State University. Details follow in the next two tables:

Table 6. Digestibility coefficients of amino acids in DDGS, Swine

Amino Acid	**Range**	**Average**	**NRC**
Lysine	44 – 78	63	59
Threonine	62 – 83	71	65
Methionine	74 – 89	82	75
Tryptophan	54 – 80	69	-
Isoleucine	67 – 83	76	79
Arginine	74 - 92	81	-
Valine	66 – 82	75	67

Source: Stein, 2007, University of Illinois

Table 7. Digestibility coefficients of amino acids in DDGS, Swine

Amino Acid	**%**	**Amino Acid**	**%**
Lysine	62	Isoleucine	75
Threonine	71	Leucine	83
Methionine	82	Valine	75
Cystine	82	Arginine	-
Tryptophan	70	Phenylalanine	-

Source: KSU Swine Day, 2007, Kansas State University

PHOSPHOROUS

In Philippine diet formulations, phosphorus is one of the more expensive nutrients, next to energy and lysine. The most notable studies on phosphorus availability in DDGS were conducted by Lumpkins and Batal (2005) and Martinez, Amezcua et al (2005) for poultry and Widmer et al (2007) and Pederson (2007) for swine. Average availability were 61% for poultry and 59% for swine.

Table 8. Phosphorus availability in DDGS

Author	Year	Species	% Availability of Phosphorus
Lumpkins and Batal	2005	poultry	68
			54
Martinez, Amezcua et al.	2005	poultry	62
			62
Widmer et al.	2007	swine	59
Pedersen et al	2007	swine	59

QUALITY CONSIDERATIONS

Bulk density and particle size

In a study at the University of Minnesota, DDGS samples were taken from 16 ethanol plants situated in Minnesota, South Dakota and Missouri. Bulk density averaged 35.7± 2.79 lbs/ft^3 with a range of 30.8 to 39.3 lbs/ft^3. Coefficient of variation for this survey was 7.8%

Particle size was also determined from the same set of samples. Data set average was 1282± 305 microns with a range 612 to 2125 microns. There is considerably a large variation for this parameter, with CV=24%. Since mean particle size for mash feeds intended for poultry and swine is 600-800 microns, the result obtained suggests the need to further grind DDGS.

Color and Smell

Color can give a rough estimation of DDGS quality. In most cases, golden DDGS will be of high quality. However, DDGS which is darker in colour may be due to syrup added back to the Dried Distiller's Grains. New ethanol plants would produce DDGS of better quality and colour compared to older plants.

It is worthwhile noting that DDGS with golden color will have higher L-values (an indication of "lightness"). Data from Batal (2007) suggests a high correlation value between L-value and lysine digestibility.

Shelf Life and Fat Stability

Unless the moisture of DDGS exceed 12%, its shelf life appears to be many months. This was obtained in a 16-week study in Mexico where the corn co-product was subjected to temperatures of 8.4-28 degrees centigrade. This was further confirmed in a 10-week trial in Taiwan where environmental temperatures averaged more than 32 degrees centigrade and humidity was in excess of 90%.

Mycotoxins

The fermentation process used in production of DDGS concentrates the mycotoxins three-fold. Zearalenone, aflatoxin, vomitoxin, fumonisin and T2 toxin may be present if in DDGS if the grain delivered to the ethanol plant is contaminated. However, the risk of contamination is very low since most US ethanol plants monitor incoming grain quality with approved test kits and reject deliveries that may be contaminated.

If ELISA test kits are used on DDGS, false positive determinations often occur and are invalid. It is suspected that DDGS contain certain salts and oxidizers that affect detection. (Shurson,2005). Currently, ELISA test kits for vomitoxin and fumonisin have been validated against standard methods and found acceptable for use. On the other hand, High Performance Liquid Chromatography (HPLC) and Thin Layer Chromatography (TLC) are the only acceptable test methods for the other mycotoxins.

Preliminary results from a study to monitor mycotoxin level of > 25 batches of DDGS shipped from an Iowa plant to a feedmill in Taiwan indicated that aflatoxin, T2 toxin, vomitoxin and zearalenone were below the limit of detection. On the other hand, fumonisin was detected at < 3 ppm. Mycotoxin levels did not change during shipping from the ethanol plant until DDGS arrived in the feedmill.

INCLUSION OF DDGS IN ANIMAL DIETS

Research has indicated that DDGS can be included in swine and poultry diets without affecting performance. Broilers can use up to 10% of the corn co-product while chicken egg layers can effectively utilize an inclusion of 15%. For swine, starter pigs can use a conservative inclusion level of 10%; grower-finishers may use 15-20% without a reduction in growth rate, deterioration of feed conversion nor a change in carcass quality. Breeder swine may be fed similar levels.

USING DDGS EFFECTIVELY

To efficiently maximize the nutrient value of DDGS, the following key points must be remembered:

1. Obtain analytical information from the supplier
   - nutrient variability between suppliers
   - establish nutrient matrix

2. Choose the golden color
   - high amino acid digestibility

3. Formulate on digestible amino acid basis
   - pay attention to minimums for lysine, tsaa, threonine, tryptophan and arginine

4. Maximize DDGS contribution by using available phosphorus values

5. Introduce at lower levels in formulations, especially for young animals

More information on DDGS can be obtained from the DDGS User's Handbook available from the US Grains Council

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