Assessing the Feeding Value of Reduced-Oil DDGS in Swine and Poultry Feeding Programs

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One of our primary goals in food animal production is to increase caloric and nutritional efficiency of converting dietary energy and nutrients into meat, milk, and eggs. To do this, we need to develop practical strategies for minimizing the risk and economic losses resulting from overfeeding and underfeeding energy and nutrient, manage variability within feed ingredient sources, and capture more economic value.

The U.S. fuel ethanol industry is evolving into biorefineries and is implementing several new process technologies that are changing the energy and nutrient composition of corn co-products produced. Corn oil extraction from thin stillage after ethanol distillation is the most notable and widely adopted new technology. Currently, over 85% of the 214 ethanol plants in the U.S. are extracting some of the oil through a centrifugation process, resulting in over 1.13 billion kg of distiller's corn oil (DCO) produced in 2014 (Renewable Fuels Association, 2015). About 53% of DCO is used for biodiesel production, 43% is used as a high energy ingredient in animal feeds (primarily poultry and swine), and 4% is used for other industrial purposes (Renewable Fuels Association, 2015).

Partial oil extraction prior to manufacturing distiller's dried grains with solubles (DDGS) has led to increased variability in nutrient content among DDGS sources, and has caused many nutritionists to expect that the metabolizable energy (ME) content of DDGS would be reduced. This perception has led to reduced market demand, dietary inclusion rates for swine and poultry, and questions about how to manage the increased variability in nutritional composition of reduced-oil DDGS and its economic value.

Effect of partial oil extraction on ME content of DDGS

The NRC (2012) edition for swine was one of the first key references to attempt to categorize the energy and nutrient composition of DDGS sources based on oil content. For example, low oil (< 4%) DDGS was estimated to contain 3,102 kcal/kg ME, while medium oil (> 6% and < 9%) DDGS estimated ME is 3,396 kcal/kg ME, compared with traditional high oil (>10%) containing 3,434 kcal/kg ME. However, there were few, if any published ME values for low and medium oil DDGS sources available at the time the NRC (2012) feed composition tables were compiled. Furthermore, the last edition of the poultry NRC (1994) has no designation for TME or AME content differences based on DDGS oil content. Therefore, the use of these published values for accurate assessment of variable ME content among DDGS sources are not reliable when formulating swine and poultry diets containing DDGS. In fact, research studies conducted at the University of Minnesota, Auburn University, and USDA-ARS have shown that oil (crude fat) content of DDGS is a poor predictor of ME content for swine and poultry (Figure 1 and 2). The poor relationship between crude fat and ME content among DDGS sources appears to be primarily caused by differences in apparent total tract digestibility of ether extract (55 to 82%) and total dietary fiber (23 to 55%) among various DDGS sources for swine. As a result, some low oil (5% crude fat) DDGS sources contain as much or more ME content than some high oil (> 10% crude fat) DDGS sources.
Since energy is the most expensive component of animal feeds, and ME content varies significantly among DDGS sources, and static published “book values” do not accurately represent actual ME content among DDGS sources with variable oil content, dynamic determinations should be used to capture value. Prediction equations have been developed and validated to provide an accurate, inexpensive and rapid method of estimating ME content of DDGS sources based on chemical composition for swine (Urriola et al., 2014). The most accurate estimates with the least prediction error and bias involve first calculating digestible energy (DE) content, and then using the DE estimate to calculate ME content:

\[
\text{DE, kcal/kg DM} = -2,161 + (1.39 \times \text{GE, kcal/kg}) - (20.7 \times \% \text{NDF}) - (49.3 \times \% \text{EE})
\]

Prediction error = 144 kcal/kg  Bias = 19 kcal/kg

\[
\text{ME, kcal/kg DM} = -261 + (1.05 \times \text{DE, kcal/kg}) - (7.89 \times \% \text{CP}) + (2.47 \times \text{NDF}) - (4.99 \times \% \text{EE})
\]

Prediction error = 149 kcal/kg  Bias = -82 kcal/kg

Where GE = gross energy, NDF = neutral detergent fiber, EE = ether extract (crude fat), and CP = crude protein. Use of these equations resulted in highly accurate ME estimates for DDGS with oil content > 6% based on growth performance and carcass composition results from a swine grower-finisher experiment (Wu et al., 2015).

Similarly, the best AME prediction equation for poultry (Meloche et al., 2014) is:

\[
\text{AMEN kcal/kg} = 3,673 - (121.35 \times \text{CF}) + (51.29 \times \text{EE}) - (121.08 \times \text{Ash}) \quad R^2 = 0.70
\]

Where CF = crude fiber and EE = ether extract (crude fat).
While this equation was obtained from a cross-validation study comparing predicted vs. measured AME values from published studies in broilers, it has not been validated with growth performance trials.

**Effect of partial oil extraction on amino acid content and digestibility of DDGS**

It has been well documented that the amino acid content and digestibility also varies among DDGS sources. While it is reasonable to assume that the crude protein and amino acid content would increase with partial oil removal in DDGS, this is not often the case when comparing amino acid content among DDGS sources with variable oil content. Part of this inconsistency is due to the low correlation between crude protein and lysine content of corn and corn co-products, but is also due to inherent variability in protein and amino acid content among corn sources as well as impacts of various ethanol and co-product production processes.

Unfortunately, limited studies have been conducted to determine the effects of reduced-oil content in DDGS on amino acid digestibility for pigs and broilers. A study conducted at the University of Illinois showed that amino acid digestibility is slightly reduced as the crude fat content decreases in DDGS when fed to swine (Curry et al., 2014). Similar results were found in a broiler study showing that apparent amino acid digestibility coefficients for lysine, methionine, threonine, tryptophan, and arginine were reduced as the amount of oil in DDGS was reduced (Dozier et al., 2015). The causes of this reduction in amino acid digestibility are unclear. To manage variability in amino acid digestibility, prediction equations have been developed to estimate standardized ileal digestible amino acid content in heat damaged DDGS for swine (Almeida et al., 2013), but not for reduced-oil DDGS for swine and poultry.

**Commercial application of prediction equations for DDGS**

A few companies have adopted, modified, or developed proprietary ME and digestible amino acid content prediction equations for DDGS in swine and poultry diets based on these published studies. For example, Nutriquest (Mason City, IA) has developed a subscription service called Illuminate® to provide comparative economic value differences among DDGS sources for swine and poultry, as well as provide dynamic energy and nutrient loading values for use in feed formulations that include DDGS.

**The “disconnect” between DDGS price and value**

Variability in energy and nutrient content within ingredient sources, like DDGS, often causes nutritionists to use conservative ME and digestible amino acid estimates for those ingredients to avoid underfeeding nutrients which can cause suboptimal animal performance. As a result, full economic value is not captured. Furthermore, purchase price of commodity feed ingredients are based on minimum guarantees for crude protein and crude fat, but swine and poultry diets are not formulated using these analytical measures but rather, are formulated on a ME and digestible amino acid basis. As a result, DDGS is often marketed at a lower price than the actual economic value it provides in complete swine and poultry diets. This “disconnect” between price and value is due to using two related but different analytical measures, where the use of ME and digestible amino acid content provides the most accurate assessment of actual economic value in swine and poultry diets. Due to this “disconnected” relationship between market price and economic value in diets, actual DDGS value often exceeds the price paid by as much as $100 per metric tonne. Furthermore, there can also be as much as a $90 difference per metric tonne in economic value between the lowest and highest value DDGS sources when used in swine grower-finisher diets. However, these value differences can only be captured by using ME and digestible amino acid equations to determine dynamic estimates among variable DDGS sources, and use these estimates in feed formulation for the DDGS sources being used.

In summary, the variability in nutrient content of reduced-oil DDGS can be managed by using ME and digestible amino acid prediction equations. Accurate determination of ME and digestible amino acid content of DDGS is essential for capturing the most economic value, identifying highest value sources, and determining the need to make dietary energy and amino acid adjustments in feed formulations to ensure optimal pig and poultry growth performance.

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