# Use of U.S. DDGS in Practical Swine Diet Formulations

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## Introduction

Corn dried distiller's grains with solubles (DDGS) is an excellent high energy, mid-protein, high available phosphorus ingredient that can be used as a partial replacement for corn, soybean meal, and inorganic phosphate in practical swine diets. The potential for diet cost savings when adding DDGS to swine diets depends on knowledge of nutrient levels and digestibility, dietary inclusion rates, cost of competing ingredients, and diet formulation method used.

## Ranges in nutrient content and digestibility among DDGS sources

Nutrient content and digestibility can vary substantially among DDGS sources (Table 1). In order to avoid underfeeding or overfeeding of nutrients and determining economic value of the DDGS sources, it is important to obtain current nutrient profiles (including amino acid levels) from the ethanol plant where the DDGS is produced. For example, if the assumption for concentration of total lysine in DDGS is 0.80% in the diet formulation software being used, but the actual total lysine content of the source is 0.65%, the amount of supplemental lysine provided by some dietary level of DDGS will be overestimated, and pig performance will be reduced unless the amount of other protein supplements are increased, the dietary DDGS inclusion rate is very low (< 10%), or the amount of safety margin above the requirement is high enough to compensate for this difference. On the other hand, if the assumption for total lysine content is 0.65% but the actual lysine content of the DDGS source being used is 0.80%, the amount of lysine added to the diet would be in excess of the pig's requirement and unnecessarily increase diet cost.

In general, when evaluating DDGS sources for use in swine diets, choose sources that have a Minolta L* (lightness of color) reading higher than 50 to ensure above average lysine digestibility. Alternatively, select sources that have a level of total lysine that is at least 2.80% of the crude protein content to assure higher than average amino acid digestibility.

**Table 1. Averages and ranges in composition of selected nutrients (100% dry matter basis) among 32 U.S. corn DDGS sources** (www.ddgs.umn.edu).

| Nutrient | Average (CV, %)[a] | Range |
|---|---|---|
| Dry matter, % | 89.3 | 87.3 - 92.4 |
| Crude protein, % | 30.9 (4.7) | 28.7 - 32.9 |
| Crude fat, % | 10.7 (16.4) | 8.8 - 12.4 |
| Crude fiber, % | 7.2 (18.0) | 5.4 - 10.4 |
| Ash, % | 6.0 (26.6) | 3.0 - 9.8 |
| ME, kcal/kg | 3,810 (3.5) | 3,500 – 4,050 |
| Lysine, % | 0.91 (12.6) | 0.61 - 1.11 |
| SID lysine, % | 0.56 (18.4) | 0.33 – 0.77 |
| Methionine, % | 0.63 (12.1) | 0.52 – 0.78 |
| SID methionine, % | 0.52 (12.6) | 0.40 – 0.66 |
| Threonine, % | 1.13 (7.96) | 0.94 – 1.32 |
| SID threonine, % | 0.80 (10.2) | 0.68 – 0.96 |
| Tryptophan, % | 0.24 (16.4) | 0.13 - 0.31 |
| SID tryptophan, % | 0.16 (15.8) | 0.10 – 0.21 |
| Phosphorus, % | 0.75 (19.4) | 0.42 - 0.99 |
| App. dig. P, % | 0.44 | 0.32 – 0.53 |

[a]CV = coefficient of variation (standard deviation divided by the mean x 100)

**Recommended maximum dietary inclusion rates for DDGS in various production phases**

If feed cost savings is achieved at low dietary inclusion rates (5 to 10%) for DDGS, even greater cost savings can be realized when using higher inclusion rates because greater amounts of competing energy, protein, and phosphorus sources can be reduced in the formulation. However, when diets are formulated on an available phosphorus basis along with the addition of phytase (enzyme), the contribution of available phosphorus from DDGS is maximized at a dietary inclusion rate of about 20%, and the use of higher feeding levels of DDGS will result in overfeeding phosphorus above the pig's requirement. Therefore, the reduction in diet cost savings is linear up to a 20% DDGS inclusion rate under this diet formulation scenario, but is reduced at higher feeding levels because the economic contribution of available phosphorus from DDGS is maximized resulting in less of a reduction in diet cost savings. Stein and Shurson (2008) recently conducted a comprehensive literature review of DDGS performance studies for swine in various phases of production. Twenty-five studies have been conducted to evaluate growth performance of growing-finishing pigs fed increasing levels of DDGS (Table 2). The majority of those studies showed no effect of feeding diets containing 20 to 30% DDGS on average daily gain (ADG, 72%) or average daily feed intake (ADFI, 65%), but results from some grower-finisher studies showed a reduction in feed intake and growth rate. It appears that the different growth performance responses obtained in these studies can be attributed to the diet formulation method and nutrient values used.

**Table 2. Summary of growth performance responses from feeding diets containing up to 30% DDGS to grower-finisher pigs.**

| Performance Measure | Number of Published Studies | Increased | Reduced | Not Changed |
|---|---|---|---|---|
| ADG | 25 | 1 | 6 | 18 |
| ADFI | 23 | 2 | 6 | 15 |
| Gain/Feed | 25 | 4 | 5 | 16 |

Based upon research results reported in the scientific literature, the recommended maximum dietary inclusion rates for DDGS in swine diets are as follows:

| | |
|---|---|
| Weaned pigs (> 7 kg BW) | 30% |
| Growing-finishing pigs | 20 - 30% |
| Gestating sows | 50% |
| Lactating sows | 30% |

**Cost of competing ingredients**

Dried distiller's grains with solubles must be economically competitive compared to the primary energy sources (grain), and to a lesser extent with protein and inorganic phosphorus sources in the diet, in order to be used in least cost swine diet formulations. Therefore, price of DDGS and competing ingredients along with accurate nutrient values for energy, amino acids, and phosphorus of all ingredients must be known in order to properly assess the value of DDGS. For example, if a swine grower diet is formulated on a total lysine basis using a DDGS inclusion rate of 10%, the amount of limestone would need to be increased by 1.5 kg/metric tonne and the amount of corn, soybean meal (44% CP), and dicalcium phosphate would be reduced by 88.5, 10, and 3 kg per metric tonne, respectively, in order to maintain similar dietary ME, lysine, and phosphorus levels.

General Guideline:

Additions/1000 kg diet
+ 100 kg DDGS x ______ $/kg = $______
+ 1.5 kg limestone x ______ $/kg = $______
TOTAL ADDITIONS (A) $______

Subtractions/1000 kg diet
- 88.5 kg corn x ______ $/kg = $______
- 10 kg SBM (44%) x ______ $/kg = $______
- 3 kg dical. phos. x ______ $/kg = $______
TOTAL SUBTRACTIONS (S) $______

(S – A) = Feed cost savings/ton by adding 10% DDGS to the diet

Depending on the diet formulation method used, DDGS can have different economic and nutritional values under the same feed ingredient cost scenario and nutrient profiles. Using current feed ingredient prices, there can be as much as a $20 to $30/ton difference in value between high quality, digestible DDGS sources and lower quality, less digestible DDGS sources in swine diets.

**Diet formulation methods used**

Many different approaches can be used to formulate practical swine diets, and depending on the approach that is used, can affect the relative economic and nutritional value as well as the maximum dietary inclusion rate to avoid a reduction in pig performance using DDGS. For example, if diets are formulated on a crude protein basis (Table 3), total dietary lysine content will be adequate at a 10% dietary inclusion rate but will be below the pig's requirement of 0.75% when added at 20% of the diet even when 0.15% synthetic lysine is added (Table 4). Diets can also be formulated on a total amino acid basis, but at digestible amino acid levels can become limiting when more than 10% DDGS is added to the diet because amino acid digestibility is lower in DDGS than in corn and soybean meal. Ideally, diets should be formulated on an SID (standardized ileal digestible) amino acid basis using recommended amino acid ratios of essential amino acids relative to digestible lysine content. However, amino acid digestibility coefficients for DDGS among sources vary widely as shown in Table 1, making it difficult for nutritionists to use appropriate values for the DDGS sources being used in the formulation.

**Table 3. Example diets containing 0, 10, and 20% DDGS formulated on a crude protein basis.**

| Ingredient | 0% DDGS | 10% DDGS | 20% DDGS |
|---|---|---|---|
| DDGS, % | - | 10 | 20 |
| Corn, % | 78.1 | 73.0 | 67.9 |
| Soybean meal 47%, % | 19.7 | 14.8 | 9.8 |
| Dicalcium phosphate, % | 0.85 | 0.78 | 0.70 |
| Limestone, % | 0.70 | 0.80 | 0.90 |
| Salt, % | 0.30 | 0.30 | 0.30 |
| L-lysine HCL, % | 0.15 | 0.15 | 0.15 |
| Vitamin and Mineral Premix, % | 0.20 | 0.20 | 0.20 |
| **TOTAL, %** | 100 | 100 | 100 |

**Table 4. Nutrient composition of example diets containing 0, 10, and 20% DDGS formulated on a crude protein basis.**

| Nutrients | 0% DDGS | 10% DDGS | 20% DDGS |
|---|---|---|---|
| Crude Protein, % | 16.00 | 16.00 | 16.00 |
| ME Swine, Kcal/kg | 3365 | 3305 | 3247 |
| Lysine, % | 0.92 | 0.82 | **0.72** |
| Methonine, % | 0.26 | 0.27 | 0.28 |
| Threonine, % | 0.59 | 0.58 | 0.57 |
| Tryptophan, % | 0.18 | 0.16 | 0.15 |
| Calcium, % | 0.52 | 0.55 | 0.57 |
| Phosphorus, % | 0.51 | 0.53 | 0.54 |
| Ca:P Ratio | 1.02 | 1.04 | 1.05 |
| Salt, % | 0.37 | 0.41 | 0.45 |

From a dietary energy perspective, diets should be formulated on a net energy (NE) basis. However, reliable estimates for the NE content of feed ingredients, especially for DDGS, are limited causing most nutritionists to formulate swine diets on a metabolizable energy (ME) or modified ME basis. Some nutritionists, in some countries around the world, still formulate diets and evaluate feed ingredients with even less precision using digestible energy (DE) as the measure of energy content. Again, depending on the energy system used, the relative economic and nutritional value as well as the maximum dietary inclusion rate for DDGS is affected.

Phosphorus is the third most expensive nutrient supplied in swine diets and formulation methods to achieve desired phosphorus levels also vary. Diets can be formulated on a total phosphorus basis, but since the digestibility of phosphorus in corn and soybean meal is low, and phosphorus digestibility in DDGS is relatively high, the likelihood of overfeeding this expensive nutrient is high when using high dietary inclusion rates (> 10%) for DDGS. Diets should be formulated on an available P basis to account for the high availability of phosphorus in DDGS and minimize the need for inorganic phosphorus supplementation. When the enzyme phytase is added to DDGS diets, even greater amounts of inorganic phosphate can be removed without compromising pig performance as shown in Table 5.

**Table 5. Diet composition when 18.8% DDGS and phytase are added to a corn-soybean meal swine grower diet.**

| Ingredient | Corn-SBM-1.5 kg Lysine | 18.8% DDGS + Phytase |
|---|---|---|
| Corn, kg | 798.3 | 636.3 |
| Soybean meal 44%, kg | 176.9 | 159.4 |
| DDGS, kg | 0.0 | 188 |
| Dicalcium phosphate, kg | 11.6 | 0.0 |
| Limestone, kg | 7.2 | 9.8 |
| Salt, kg | 3.0 | 3.0 |
| L-lysine HCl, kg | 1.5 | 1.5 |
| VTM premix, kg | 1.5 | 1.5 |
| Phytase, 500 FTU/kg | 0.0 | 0.5 |
| TOTAL, kg | 1000.0 | 1000.0 |

**Summary**

The success of feeding swine diets containing DDGS and the potential for diet cost savings depends on knowledge of nutrient levels and digestibility, dietary inclusion rates, cost of competing ingredients, and diet formulation method used. In order to avoid underfeeding or overfeeding of nutrients and determining economic value of the DDGS sources, it is important to obtain current nutrient profiles (including amino acid levels) from the source being used. If feed cost savings is achieved at low dietary inclusion rates (5 to 10%) for DDGS, even greater cost savings can be realized when using higher inclusion rates because greater amounts of competing energy, protein, and phosphorus sources can be reduced in the formulation. The price of DDGS and competing ingredients along with accurate nutrient values for energy, amino acids, and phosphorus of all ingredients must be known in order to properly assess the economic and nutritional value of DDGS. Many different approaches can be used to formulate practical swine diets, and depending on the approach that is used, the relative economic and nutritional value as well as the maximum dietary inclusion rate and pig performance can be affected.