Chapter 6

Comparison of Different Grain DDGS Sources –

Nutrient Composition and Animal Performance

Introduction

A variety of feedstocks are used to produce ethanol and DDGS around the world. Grains, such as corn, wheat, and barley vary in starch content (**Table 1**), and those with the greatest amount of starch (e.g. corn) are used to a greater extent because they provide the greatest ethanol yield. Since the nutrient composition of grains used to produce ethanol varies, the nutrient composition of the resulting distiller's grains also varies.

Table 1. Starch content and ethanol yield of various feedstocks[1]

Feedstock	Moisture, %	Starch, %	Ethanol yield (L/MT)
Starch	-	100.0	720
Sugar cane	-	-	654
Barley	9.7	67.1	399
Corn	13.8	71.8	408
Oats	10.9	44.7	262
Wheat	10.9	63.8	375

[1] Saskatchewan Agriculture and Food. 1993

Sorghum (Milo) DDGS

A comparison of the nutrient composition values for sorghum (milo), a sorghum-corn blend, and corn DDGS (Urriola et al., 2009) is shown in **Table 2**. The amount of sorghum and corn-sorghum blends distiller's grains produced by the U.S. ethanol industry is relatively small compared to the amount of corn DDGS produced. Furthermore, most of the sorghum and corn-sorghum blends of distiller's grains are used locally by beef cattle feedlots, and very little is dried to produce DDGS. Thus, significant quantities of sorghum DDGS are currently not available for export.

Sorghum DDGS is slightly higher in crude protein, significantly higher in ADF and ash, and lower in crude fat, and lysine compared to corn DDGS. Although the levels of methionine and threonine are similar, tryptophan levels are substantially higher, and lysine and arginine are lower, resulting in a significantly lower lysine to crude protein ratio compared to corn DDGS. The sorghum-corn blend of DDGS is intermediate in nutrient composition compared with either sorghum or corn, and is dependent on the proportion of each used.

Table 2. Nutrient composition (as-fed basis) of sorghum, sorghum-corn, and corn DDGS[1]

Nutrient, %	Sorghum[2]	Sorghum-Corn[3]	Corn[4]
Dry matter	91.2	93.4	91.3
Crude protein	32.7	30.6	28.4
Crude fat	8.0	8.9	10.1
NDF	34.7	36.3	33.3
ADF	25.3	17.2	11.6
Ash	11.9	5.8	2.75
Arginine	1.10	1.31	1.25
Histidine	0.71	0.80	0.75
Isoleucine	1.36	1.14	1.04
Leucine	4.17	3.66	3.22
Lysine	0.68	0.91	0.85
Methionine	0.53	0.58	0.52
Phenylalanine	1.68	1.51	1.35
Threonine	1.07	1.15	1.05
Tryptophan	0.35	0.29	0.24
Valine	1.65	1.49	1.38
Cystine	0.49	0.57	0.49
Total amino acids	30.1	28.3	25.5
Lysine:Crude protein ratio	2.08	2.98	2.98

[1]Urriola et al., 2009
[2]Distillers dried grains with solubles produced from sorghum.
[3]Distillers dried grains with solubles produced from a blend of corn and sorghum grains.
[4]Distillers dried grains with solubles produced from corn.

These differences in nutrient composition suggest that the energy value and protein quality of sorghum DDGS would be less than for corn DDGS in monogastric animals. Dr. Joe Hancock (Professor, Kansas State University) estimated that the ME_n (kcal/kg) of bronze and yellow sorghum DDGS was 2,677 and 2,866, respectively. These sorghum DDGS values are similar, but slightly lower than the ME_n values reported by Lumpkins and Batal, 2005 (2,827 kcal/kg) and Batal and Dale, 2006 (2,906 kcal/kg) for corn DDGS. High Plains Corporation (Colwich, KS) has estimated that the TDN, $NE_{lactation}$, $NE_{maintenance}$, and NE_{gain} for sorghum distillers grains for ruminants to be 82.8%, 0.87, 0.96, and 0.63 Mcal/kg, respectively.

Urriola et al. (2009) showed that the standardized true amino acid digestibility coefficients of sorghum DDGS for swine were 64.0, 76.5, 70.2, and 72.0% for lysine, methionine, threonine, and tryptophan, respectively, which were slightly higher than in corn DDGS for lysine (61.6%) and tryptophan (64.9%), lower than for methionine (82.8%), and the same for threonine (70.2%). Dr. Joe Hancock (Kansas State University) estimated that the lysine bioavailability for poultry to be between 71 to 73%.

Wheat DDGS

Wheat DDGS is becoming more available for use in animal feeds in Canada, Europe and other parts of the world. Wheat DDGS is higher in crude protein (38%) and ash (5.3%), lower in crude fat (4.6%), and similar in ADF and NDF to corn DDGS (**Tables 2 and 3**). The lower fat content suggests that the energy content in wheat DDGS is lower than corn DDGS. Lysine, methionine, and tryptophan content is also higher in wheat DDGS compared to corn DDGS.

Table 3. Nutrient composition of wheat DDGS.

Nutrient, %	As Fed Basis
Moisture	8.32
Dry matter	91.68
Crude protein	38.48
Crude fiber	6.00
Fat	4.63
Ash	5.28
Calcium	0.10
Phosphorus	0.93
ADF	12.85
NDF	35.50
Starch	1.92
Lysine	0.97
Methionine	0.59
Cysteine	0.83
Threonine	1.09
Tryptophan	0.36
Isoleucine	1.38
Leucine	2.50
Histidine	0.85
Arginine	1.67
Phenylalanine	1.85
Valine	1.74

Nutritional value for swine

Cozannet et al. (2009) conducted a literature review that showed nutrient content of wheat DDGS is highly variable (like that of corn DDGS), where the NDF and starch content averaged 28% and 4.7%, respectively, with minimum and maximum values ranging from 23 to 33% and 2.1 to 10.3% (DM basis), respectively. The average DE content (14.2 MJ/kg DM for swine) and digestible phosphorus (0.60%, dry matter basis) suggest that wheat DDGS is a good source of these nutrients in swine diets. However, the DE content is highly variable (12.8 to 16.0 MJ per kg DM), and is dependent on the NDF level. Lysine content, as a percentage of crude protein ranged from 0.83 to 3.0%, and ileal lysine digestibility ranged from (49 to 72%), which were the most variable nutritional characteristics of wheat DDGS, and likely related to differences in drying processes used among sources.

Nyachoti et al. (2005) conducted a study to determine the nutritional profile and nutrient digestibility in wheat DDGS in growing pigs. Apparent ileal and total tract digestibility of DM, nitrogen and energy were lower in wheat DDGS compared to wheat grain. Furthermore, wheat

DDGS samples had lower apparent ileal digestibility of amino acids compared to wheat, with average values for lysine, threonine and isoleucine in wheat DDGS being 43.8, 62.9 and 68.0%, respectively. The average ileal and fecal DE content in wheat DDGS was 9.7 and 13.5 MJ/kg, respectively, whereas respective values for wheat grain were 13.3 and 14.6 MJ/kg.

Thacker (2006) fed increasing levels of wheat DDGS to 72 pigs during the growing period and reported that ADG, ADFI and nutrient digestibility declined as the level of wheat DDGS increased. However, feeding increasing levels of wheat DDGS during the finishing period did not affect growth performance, but dressing percentage and carcass lean declined at harvest.

Widyaratne and Zijlstra (2007) conducted two experiments to evaluate DE, amino acids, and phosphorus, as well as nitrogen and phosphorus excretion, and growth performance of grower-finisher pigs fed corn, wheat, and a wheat/corn blend (4:1) DDGS. Apparent total tract digestibility of energy was highest for wheat grain (85%) and was not different among DDGS sources (77 to 79%). Total tract DE was higher for corn DDGS (4,292 kcal/kg DM) than wheat/corn DDGS, wheat DDGS and wheat grain samples, 4,038, 4,019, and 3,807 kcal/kg, respectively. Apparent ileal digestibility of lysine was highest for wheat (71%) and was not different among DDGS sources (59 to 63%), whereas the apparent ileal digestible lysine content was highest for corn DDGS (0.51% DM), intermediate for wheat/corn DDGS and wheat DDGS (0.45 and 0.42%, respectively), and lowest for wheat (0.37%). Total tract digestibility of phosphorus was lowest for wheat (15%) and did not differ among DDGS samples (53 to 56%). Total nitrogen excretion was highest for wheat/corn DDGS and wheat DDGS (55 and 58 g/day), intermediate for corn DDGS (44 g/day) and lowest for wheat (36 g/day). Total phosphorus excretion was not different among DDGS sources (11 g/day), and was lowest for wheat (8 g/day). Average daily feed intake and ADG were higher for pigs fed the wheat control diet compared with the DDGS diets, but feed efficiency was similar. These results show that the digestible nutrient content of wheat DDGS is lower than corn DDGS, but higher than wheat. Since feeding DDGS reduced growth performance when using the digestible nutrient content previously determined, these researchers indicated that more research is required to improve the feeding value of wheat DDGS.

Emiola et al. (2009) investigated the effect of supplementing a wheat DDGS-based diet with carbohydrase enzyme blends on growth performance and nutrient digestibilities in growing and finishing pigs. Their results showed that supplementing multiple carbohydrase enzymes in a 30% wheat DDGS-based diet improved growth performance and apparent total tract digestibility of DM, nitrogen, gross energy, and crude fiber in growing pigs and apparent ileal digestibility of nutrients in finishing pigs.

Nutritional value for poultry

Thacker and Widyaratne (2007) conducted a feeding trial to determine the effects of feeding 0, 5, 10, 15, and 20% wheat DDGS on nutrient digestibility and performance in broiler chicks. Dry matter, energy, and phosphorus digestibility linearly declined with increasing levels of wheat

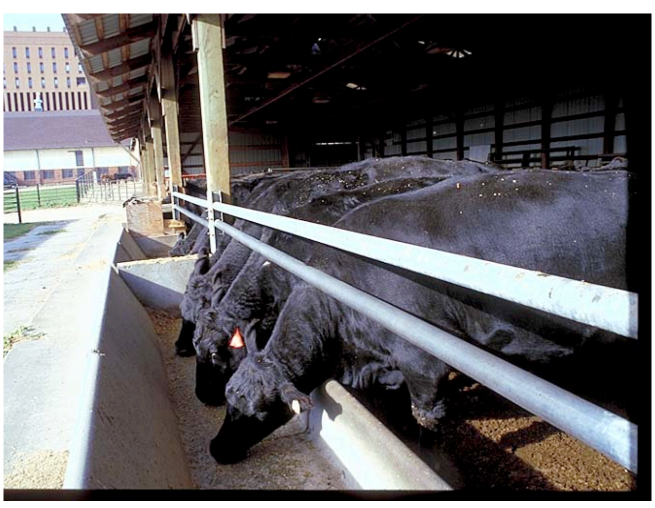
DDGS in the diet. However, there were no differences in weight gain, feed intake, or feed conversion for chicks fed increasing levels of wheat DDGS in the diet, but weight gain and feed conversion tended to decline when the 20% DDGS diet was fed. These results suggest that wheat DDGS can be successfully added to broiler diets and that the low energy and lysine content can be overcome by proper diet formulation.

Richter et al. (2006) fed diets containing up to 20% wheat DDGS to broiler chicks (0-8 weeks of age) and diets containing up to 15% wheat DDGS to young laying hens (9-18 weeks of age), with the addition of non-starch polysaccharide hydrolyzing enzymes. Broiler growth performance was not affected by dietary wheat DDGS level, and adding non-starch polysaccharide hydrolyzing enzymes improved weight gain by 2.5%. However, finishing performance of broilers decreased with increasing level of wheat DDGS in the diet, suggesting a maximum dietary inclusion rate of 5% for wheat DDGS. Dietary level of wheat DDGS had no effect on laying performance or egg quality.

Leytem et al. (2008) determined the impact of feeding 0, 5, 10, 15, and 20% wheat DDGS to broilers on nutrient excretion and phosphorus solubility. Apparent retention of both nitrogen and phosphorus decreased linearly with increasing levels of wheat DDGS in the diet. Nutrient output per kilogram of dry matter intake increased linearly with increased DDGS inclusion rate for nitrogen, phosphorus, and water soluble phosphorus. Increasing dietary DDGS levels increased phosphorus concentration in excreta, and decreased phytate phosphorus concentrations in excreta, which resulted in an increase in water soluble phosphorus and the fraction of total P that was soluble. These results indicate that high levels of wheat DDGS in the diet increase the amount of nitrogen and phosphorus in the excreta which should be accounted for in manure management plans.

Nutritional value for beef cattle

McKinnon and Walker (2008) showed that replacement of barley grain with wheat-based DDGS at 25 and 50% of the total ration DM increased ADG and gain efficiency of backgrounding steers, with no differences in DM intake or composition of gain. Beliveau and McKinnon (2008) conducted a trial to evaluate feeding increasing levels of wheat DDGS on feedlot performance and carcass characteristics of growing and finishing cattle. Their results showed wheat DDGS is an effective replacement for barley grain in cattle diets by providing both energy and protein to the diet. For finishing cattle, wheat DDGS has an energy value at least equal to that of barley grain when fed at levels up to 23% of the diet DM.



Hao et al. (2009) evaluated the impact of feeding 0, 20, 40, 60, and > 60% wheat DDGS on manure nutrient and volatile fatty acid excretion in feedlot cattle. Total nitrogen (feces), phosphorus, pH (manure), and water soluble ammonia, increased when cattle were fed the 40 and 60% DDGS diets compared with the 0% DDGS diet. Isobutyric, valeric, and isovaleric VFAs were found in the highest concentrations in feces from cattle fed the 40 and 60% wheat DDGS diets, even though total VFA content did not change with dietary DDGS level. These research results suggest that manure produced from cattle fed wheat DDGS will provide more nitrogen and phosphorus to crop land, and also increase ammonia emissions and odor, suggesting that wheat DDGS be restricted to a maximum of 20% in cattle diets to minimize excess manure nutrients and malodors.

DDGS from Other Feedstock Sources

Although corn and wheat are the predominant grains used to produce ethanol and DDGS world-wide, other grains and high starch feedstocks are also used, but to a much lesser extent. Limited data on crude protein, crude fat, and crude fiber for DDGS produced from various alternative feedstock have been published, but **Table 4** provides a summary of their general composition differences (Moreau et al., 2012). It is important to recognize that corn DDGS has a higher concentration of crude protein, crude fat, and crude fiber than any of these alternative DDGS sources, which makes it the most valuable feed ingredient derived from ethanol production.

Table 4. Nutrient composition (dry matter basis) of DDGS produced from various grains[1,2]

Nutrient, %	Crude Protein	Crude fat	Crude Fiber
Barley, hulled	17.7	2.5	5.7
Oats	16.0	6.3	2.0
Rye	8.0-10.4	ND	ND
Triticale	10.33	ND	ND
Rice, brown long grain	7.94	2.92	3.5
Rice, short white	6.50	0.52	2.8
Pearl millet	9.73-13.68	6.8	ND
Cassava	1.5-3.0	0.2	3-4

[1]ND = not determined
[2]Adapted from Moreau et al., 2012

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