UTILIZATION OF ETHANOL BYPRODUCTS BY INDIANA LIVESTOCK

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Introduction

The ethanol industry is receiving considerable attention in Indiana, across the productive regions of the Midwest, and within the Eastern Corn Belt. Ethanol production provides significant benefits to producers by adding value to corn, to communities through job creation, and to the state with added revenue generation. According to Purdue University economists Chris Hurt and Otto Doering, corn growers, beef producers, and the dairy industry stand to gain the most from increased ethanol production. Proper production and utilization of distiller's byproducts as a feed ingredient has the potential to significantly increase its value, mitigate any negative impact on the environment, and make Indiana's livestock industry more attractive and competitive in both the domestic and global marketplaces as the price of corn increases in response to the ethanol demand.

Literature Review

As a result of increased ethanol production in Indiana and nationally, a greater proportion of the corn produced in the United States is and will be used for ethanol production. Livestock continue to be the largest consumer of domestically produced corn, consuming more than 60% of the corn produced (http://www.ncga.com/livestock/main/index.asp). Therefore, increased corn demand from non-livestock entities, such as ethanol plants, may alter livestock rations due to decreased corn availability and/or increased corn prices. Distiller's dried grains with solubles (DDGS), a byproduct of the ethanol industry, has been priced over the past year from 80-105% of the price of corn. Distillers dried grains with solubles could be used to partially offset decreases in corn availability or increases in corn prices. However, a better understanding of the nutritive value of DDGS, and how processing methods may alter nutrient content and/or availability is needed across all livestock species. In addition, there are several fractionation processes starting to be implemented by some ethanol plants that will provide a wide variety of co-products coming from these plants with potential uses in livestock feeding programs. These new co-products will be a result of fractioning out the protein, fiber, and oil portions of the corn on the front end of the plant or the byproduct post-fermentation, creating the possibility for a multitude of feed products that can be produced in the future by blending these fractionation streams.

Poultry and Swine

The nutrient content of DDGS between plants and within a given plant is quite variable with values ranging from 87-93% for dry matter, 23-29% for protein, 3-12% for crude fat, 3-6% for ash and .59-.89% for lysine (Table 1; Cromwell et al., 1993; Spiehs et al., 2002). As mentioned previously, the drying process of grain can result in damaged proteins that greatly reduce the digestibility of certain amino acids such as lysine. For example, lysine digestibility of DDGS can range from 59-84% in poultry (Parsons et al., 2006). Likewise, Stein et al. (2006) reported lysine digestibility values for DDGS from modern ethanol plants ranged from 43.9% to 77.9% for DDGS fed to pigs. Additionally, the energy content of DDGS can be variable due in part to caramelization of starch during the drying process and variable levels of solubles, which contain the corn oil, being applied to the distillers grains. For example, the metabolizable energy (ME) can range between 1185 and 1388 kcal/lb. (Batal and Dale, 2004; Parsons et al., 2006). Phosphorus content in DDGS typically ranges from 0.62% to 0.77% (versus that of corn at 0.3%; Parsons et al., 2006). The bioavailability (versus potassium monophosphate), however, is at least two to three times greater than that of corn and can range between 62% and 100% in poultry (Parsons et al., 2006). However, Stein et al. (2005) reported an apparent total tract digestibility of P from DDGS of only 55.9% in pigs. Parsons et al. (2006) noted considerable variation in the sodium content of DDGS samples ranging from 0.05% to 0.17%, which is considerably greater than the sodium content of corn (0.02%). Therefore, sodium content of DDGS should be monitored closely for poultry, as excessive levels will increase water in the excreta and create manure management problems.

With the variability in nutrient content and nutrient availability in DDGS, it is difficult to formulate a diet containing DDGS. If the nutrient availability is overestimated, then a decrease in performance may be observed. Shurson et al. (2004) reported a reduced growth performance when DDGS was included in grow-finish pig diets at greater than 10% of the diet. However, Cook et al. (2005) did not observe a reduction in pig growth rate with up to 30% DDGS in grow-finish pig diets when the diet was formulated on an estimated digestible amino acid basis. Cook et al. (2005) did, however, report a linear decrease in carcass weight and yield as DDGS with each incremental 10% inclusion in the diet. This reduction in carcass weight represents approximately a $30/ton discount needed for the price of DGGS for swine because of lost saleable carcass weight when animals were fed for a constant time. This lost carcass weight needs to be further researched to be certain it is a consistent response in pigs.

In addition to performance concerns, the high oil content and fatty acid profile of DDGS may negatively impact pork fat quality. Dietary fat composition can have a marked impact on carcass fat composition, and including DDGS in swine rations can decrease the firmness of the fat, increasing the risk of oxidation, and decreasing the sliceability of the belly. This change in the pork/fat quality is due to the increased corn oil intake when DDGS is fed to pigs. The corn oil is very unsaturated and has a high amount of 18:2 fatty acids, which will make the pork fat soft, increase the iodine value, and create these problems in pork quality.

In consideration of rapid testing of nutrient availability for poultry, Novus International, Inc. (St. Charles, MO) has developed an Immobilized Digestibility Enzyme Assay (IDEA). Thus far, 150 DDGS samples have been analyzed (2002-2005), of which 50 have been subjected to a precision fed rooster bio-assay. Notably, the IDEA assay had a 0.88 correlation with prediction of in vivo lysine digestibility from roosters (Fiene et al., 2006). Recent data from Novus (2006) demonstrated the variability of lysine digestibility between and within a plant, within plant variations ranging from 3% to almost 20% in lysine digestibility.

Notably, the majority of poultry and swine research has been done on relatively “random” DDGS samples with little history on processing methodology. The little work that has been reported has been with samples that had varied treatments prior to fermentation (Parsons et al., 2006). Pre-processing included a conventional dry grind method, a modified dry grind process, a quick germ quick fiber process, an elusive process, and a high protein DDGS and germ meal were all compared after similar drying times and temperatures after fermentation. Notably, these processing methods had little or no effect on the digestibility of amino acids in DDGS.

Beef

Growth and Carcass

Based on nutrient composition, DDGS are considered a good source of energy and protein in cattle diets and have effectively replaced corn grain and protein supplementation in finishing rations. In fact, when fed at levels to supply adequate protein and energy, replacing a portion of corn with DDGS has resulted in equal and sometimes greater performance of cattle (Ham et al., 1994; Gordon et al., 2002). However, published results of feedlot studies using distiller’s grains have not defined the maximal inclusion rate to optimize carcass quality. In a compilation of the literature, Dr. Chris Reinhardt, Kansas State University Beef Cattle Extension Specialist, analyzed carcass characteristics from cattle fed corn byproducts at differing inclusion rates from over 13 studies (CAB, 2006). In that analysis, a decrease in marbling score and an increase in numerical yield grade was noted as level of distillers grains increased in the diet. The mechanism behind this is likely related to a reduction in digestible starch content of the diet when distiller's grains are included (Pingle and Trenkle, 2006).

As today's beef industry migrates to a grid carcass pricing system, placing premiums for higher grading carcasses and discounts for low quality carcasses, maintaining a desirable degree of marbling and yield grade will be critical for producers trying to generate greater financial gains through value-added marketing opportunities.

Beef Reproduction
Historically, overfeeding protein in the beef segment has been of little concern because protein is one of the most expensive nutrients included in diets. However, the predicted availability and overall low cost of DDGS may result in its over-utilization. Very little research has been published on the effects of corn co-products on reproductive performance in beef cattle. Butler et al. (1998) and McCormick et al. (1999) have reported that increasing the degradable protein fraction of gestating and lactating dairy cow diets has resulted in decreased reproductive efficiency. It is hypothesized that this is likely attributed to an increase in plasma urea nitrogen (PUN) levels that results in alterations of the uterine pH. However, little research has been published on the effects of feeding diets high in corn byproducts (high in ruminal undegradable protein). It is hypothesized that supplying excess amounts of protein in the form of DDGS, a rich source of non-degradable protein, will lead to increased plasma urea nitrogen, altered uterine pH, and lower reproductive performance (fertility and embryo survival) in beef females similar to those reported with rumen degradable protein.

Dairy
The protein needs of dairy cattle are met through a combination of ruminal protein synthesis and feed protein that escapes rumen digestion. Feed protein sources that undergo heating during processing are subject to irreversible damage that renders proteins indigestible by even the cow. Predicting rumen and intestinal availability of proteins is a major challenge in ruminant nutrition but is essential in providing rations that best meet the needs of high producing dairy cows and minimize environmental impact. Heat damage from improperly drying DDGS contributes to reductions in intestinal availability of amino acids. Because the ruminant is unique in its digestion and absorption of proteins (i.e., amino acids), the bioavailability assays developed for monogastrics cannot be applied to feeds used for dairy cattle. The current "gold standard" for assessing ruminal degradation and intestinal availability of proteins for ruminants requires a combination of in situ ruminal digestibility followed by in vitro assay to determine the digestibility of the residual protein (Calsamiglia and Stern, 1995). Variation in processing of DDGS results in variations in co-product quality and animal response, but this has not been systematically quantified. Therefore a rapid and inexpensive predictor of DDGS quality is essential in (1) determining the best practices at the plant in processing and drying of DDGS and (2) determining the feed value and therefore pricing strategies for DDGS when used in dairy cattle rations.

Indiana Livestock Use of DDGS
An informal survey across the Indiana poultry industry revealed typical use of 5% to 7% DDGS in poultry diets (high being 10 to 11%) with several companies not utilizing any DDGS. Likewise, most swine producers are feeding no more than 10% DDGS, if they are using DDGS at all. Depending on economics and comfort with DDGS nutrient variability as indicated previously, both industries could expand their use of DDGS. In swine, we could see utilizations as high as 25-30% in late nursery and early grow-finish and gestation phases of production, with 0-10% use in the other phases.

The ethanol plants under consideration for construction in Indiana will use dry grind technologies, at least initially, and will generate an estimated 1.4 -1.9 million tons of dry distiller's grains with solubles

(DDGS) within the state of Indiana. Typical dietary inclusion levels of DDGS (dry matter basis) have been approximately 20% for beef and dairy, 10% for swine, and 5% for poultry. Using these inclusion levels and the Indiana livestock inventory (USDA Agricultural Statistics, 2006), Indiana could currently utilize a maximum 1.33 million tons (70-90.5%) of the projected DDGS production. However, currently there are several challenges associated with feeding DDGS and the realistic usage would be closer to 30-50% of the available supply. If we could find a better processing method and a more consistent, economical byproduct, there is an opportunity to increase the livestock industry in the state, with beef and dairy having the most potential.

Dietary inclusion levels, especially in the non-ruminant species (swine and poultry), could be increased if wet milling technologies were added to the ethanol process. This would allow the corn germ (which contains most of the protein, fat, and phosphorus) and the hull (which contains most of the fiber) to be removed. The cost of adding these wet milling technologies will likely prevent their incorporation into most new plant construction because there is little economic incentive to add value to the byproducts being generated with the current market prices (approximately $2.40/gal plus $0.51/gal subsidy) for ethanol. This processing method has the potential to create alternative value-added byproducts that are more consistent.

The challenges to adding DDGS to livestock and poultry feeds can be divided into four main areas:

1. Variation in nutrient content and nutrient availability between batches (within and between plants).
2. Byproduct handling, storage and transportation.
3. Effect on animal performance, end-product quality, and nutrient management.
4. Producer education.

Summary

Growth in the ethanol industry presents tremendous opportunities for Indiana in terms of job creation, adding value to corn that can enhance crop producer profitability, tax revenues, and reduction of dependence on foreign oil. For the benefits to be completely realized, however, information is needed on how ethanol byproducts can be efficiently, effectively, and profitably transported, handled, stored, and utilized by Indiana's livestock industry.

Table 1. Composition of corn and distillers dry grains with solubles.

Nutrient/Component[a]	Corn	Distiller's Dry Grains + Solubles[b]		
	Reference	Range	Digestibility[c]	Available[c]
Crude protein, %	8.5-9.9	28-32	60-90	16.8-28.8
Lysine, %	0.20-0.28	0.85-0.90	40-90	0.34-0.81
Methionine, %	0.16-0.20	0.40-0.55	50-90	0.20-0.50
Crude fiber, %	1.5-3.3	5-14	?-100	?-14
Fat, %	3.5-4.7	3-12	85-90	3-12
Phosphorus, %	0.28-0.34	0.7-1.3	55-90	0.39-1.17
Sodium, %	0.00-0.02	0.05-0.17	100	0.05-0.17
Sulfur, %	0.12	0.4-0.8	100	0.4-0.8
Particle size, microns	---	<400->600	---	---

[a]Values are reported as a percent of total dry matter.

[b]All things being equal, the value of DDGS (85% DM) is ≤ $110/t when corn is $2.20/bu and SBM is $175/t. When product variation, transportation, handling, and storage are considered, DDGS value is realistically worth <$70-80/t.

[c]Values include variation between animal species.

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