TESTIMONY OF

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Introduction of Testifier

Dr. Gerald Shurson is a Professor in the Department of Animal Science at the University of Minnesota. He received his B.S. degree in Animal Science and Agricultural Economics at the University of Minnesota and his M.S. and Ph.D. degrees in swine nutrition from Michigan State University. Dr. Shurson was Assistant Professor and Extension Swine Specialist for 4 years at The Ohio State University before returning to the University of Minnesota. As a Professor at the University of Minnesota he currently has responsibilities for on-campus undergraduate and graduate teaching and advising, as well as research and extension programs related to swine nutrition and management. He devotes his time extensively to working with pork producers and feed industry professionals on nutrition and management related issues. During the past ten years, Dr. Shurson's research program has primarily focused on evaluating the nutritional value of distiller's dried grains with solubles (DDGS) in swine diets. His expertise is nationally and internationally recognized and he has presented his research findings at numerous symposiums and conferences. He works very closely with the U.S. Grains Council to provide educational programs and assess export market opportunities for DDGS. Dr. Shurson has served in several professional leadership roles including: Director, Midwest Section, American Society of Animal Science Board; Director, University of Minnesota Swine Center; and President, Midwest Section, American Society of Animal Science.

WHAT WE KNOW AND DON'T KNOW ABOUT FEEDING DISTILLER'S BY-PRODUCTS TO LIVESTOCK AND POULTRY

Introduction

Fuel ethanol production is one of the fastest growing segments in American agriculture. In 2006, 110 ethanol plants located in 19 states around the U.S. used 1.8 billion bushels of corn (17% of total production) and 26% of the U.S. sorghum crop to produce 4.9 billion gallons of ethanol (Renewable Fuels Association, February, 2006). Corn is the primary grain used in wet mills and dry-grind ethanol plants because of its high fermentable starch content compared to other feed stocks. Approximately 18% of fuel ethanol is produced by wet-mills after the starch is separated from the corn kernel, and these plants produce wet or dried corn gluten feed, corn gluten meal, and corn germ meal as the primary by-products. Dry-grind ethanol plants represent the fastest growing segment of the fuel ethanol industry in the U.S., and produce the majority (82%) of fuel ethanol. By-products from dry-grind ethanol plants include wet and dry distiller's grains, wet and dried distiller's grains with solubles, modified "wet cake" (a 50% moisture blend of distiller's grains and solubles), and condensed distiller's solubles. In 2006, the U.S. ethanol industry produced 12 million metric tonnes of distiller's grains, and some industry experts predict that 20 million metric tonnes of distillers grains will be produced by the year 2012 (Renewable Fuels Association, February, 2006). Approximately 30% of the distiller's grains with solubles are marketed as a wet by-product for use in dairy operations and beef cattle feedlots located near ethanol plants. The remaining 70% of distiller's grains with solubles is dried (DDGS) and marketed domestically and internationally for use in dairy, beef, swine and poultry feeds. In 2006, approximately 46% of distiller's grains were fed to dairy cattle, 42% to beef cattle, 3% to poultry, and 9% to swine (Renewable Fuels Association, February, 2006). Considerable opportunity exists to increase the use of distiller's by-products in all livestock and poultry sectors, but perhaps the greatest opportunities for increased DDGS usage are in the swine and poultry industries.

Nutrient Composition and Digestibility of Distiller's Grains

Corn dried distiller's grains with solubles (DDGS) is considered a high energy, mid-protein ingredient, that is low in the essential amino acid lysine. Nutritionally, DDGS is higher in crude fat (10-11%) and higher in total and available phosphorus than other grain by-products produced by the wet milling and brewing industries (i.e. corn gluten feed, corn gluten meal, and brewer's grains). The relatively high level of available phosphorus in DDGS significantly reduces the need for supplemental inorganic phosphorus in monogastric (swine and poultry) diets, when diets are formulated on an available phosphorus basis. Because of these nutritional characteristics, DDGS partially replaces some of the corn, soybean meal, and inorganic phosphorus commonly used in complete animal feeds.

Like many by-products, the nutrient content and digestibility of DDGS varies among sources. A number of factors contribute to the variability in nutrient content including, variation in nutrient content of corn, different production processing technology used in ethanol plants, and the amount of solubles added to the grains fraction before drying. Variation in particle size, amount of solubles added to the grains fraction before drying, and drying time and temperature cause variation in nutrient digestibility, especially lysine, among dry-grind ethanol plants. To manage the diversity in nutrient content and quality among DDGS sources, DDGS buyers should specify source and buy directly from ethanol plants that produce DDGS with the desired nutrient content and quality.

Until more accurate *in vitro* procedures can be developed, color measurement with Minolta or Hunter lab spectrophotometers appears to be the most consistent predictor of lysine digestibility among DDGS sources. Dark colored corn DDGS has a lower amino acid (particularly lysine) digestibility and can lead to reduced growth performance when fed to swine and poultry compared to light colored, golden DDGS sources. Color of corn DDGS can vary from being very light, golden yellow in color to being very dark brown in color. However, color may not be a good indicator of lysine digestibility in sorghum DDGS sources. Color of corn DDGS samples appears to also be moderately correlated with total lysine content, where lighter colored samples tend to have more total lysine. Use of acid detergent insoluble nitrogen as a predictor of protein and amino acid digestibility in DDGS is not as accurate as for heat damaged forages. Although the use of enzyme assays such as IDEA™ and pepsin/pancreatin, and reactive lysine procedures are promising *in vitro* procedures for predicting digestible crude protein and amino acid content, more refinements are needed to improve their accuracy before they could be utilized effectively in the commercial feed industry. Calibrations for amino acids and energy in DDGS can be developed using Near Infrared Spectrophotometry (NIRS), but the quality of these calibrations is dependent on the calibration method used. If accurate NIRS calibrations can be developed, this procedure could be an excellent tool for quickly and inexpensively assessing nutrient content in DDGS.

Physical and Chemical Characteristics of DDGS

Physical and chemical characteristics of DDGS vary among sources and can influence its feeding value and handling characteristics. These characteristics include color, smell, particle size, bulk density, pH, flowability, shelf life stability, and hygroscopicity (ability to attract moisture). High quality, golden corn DDGS has a sweet, fermented smell. Dark colored DDGS sources that have been overheated have a burned or smoky smell. Average particle size for DDGS is approximately 700 μm, but the range in particle size is extremely large (200 to 1217 μm) among sources. Low particle size may contribute to poor flowability through feed ingredient handling systems. Bulk density ranges from 23 to 35 pounds/cubic foot among DDGS sources and affects the volume of storage space needed in feed mills, as well as transportation cost/ton. The pH of DDGS sources averages 4.1 but can range from 3.6 to 5.0. Unfortunately, some sources of DDGS can have some very undesirable handling characteristics due to poor flowability under certain conditions. Very few research studies have attempted to characterize factors that affect flowability of DDGS. Results from one study showed relative humidity greater than 60% seemed to reduce flowability of a DDGS sample, and many other factors have been suggested as possible controllers of flowability such as particle size, content of solubles, dryer temperature, moisture content at dryer exit, and others. Only one recent research study has been conducted to determine whether preservatives and mold inhibitors are necessary to prevent spoilage and extend shelf life of DDGS. Unless the moisture content of DDGS exceeds 12 to 13%, the shelf life of DDGS appears to be stable for many months. It appears that under humid climatic conditions, DDGS will increase in moisture content during long-term storage. It is difficult to pellet DDGS, and adding DDGS to swine and poultry diets significantly reduces the throughput of pellet mills. This has been a major barrier for using DDGS among some of the large swine and poultry integrators in the southern U.S. Research studies to evaluate factors that improve flowability, improve pellet quality and pellet mill throughput, and the value of adding preservatives to extend shelf-life of distiller's grains are needed.

Feeding Wet and Dry Distiller's Grains to Dairy Cattle

Corn DDGS is a very good protein source for lactating dairy cows, and is a good source of ruminally undegradable protein (RUP), or by-pass protein, for cattle. It also is important to recognize that dark colored corn DDGS usually indicates heat damage of the protein, which may lead to reduced milk production. Corn DDGS is also a very good energy source for dairy cattle, with energy values equal to or slightly greater than corn. Corn DDGS contains high amounts of neutral detergent fiber (NDF) but low amounts of lignin. This makes DDGS a highly digestible fiber source for cattle, and reduces digestive upsets (acidosis) compared to when corn is fed. In general, distiller's grains are considered to be highly palatable, and research supports this because dry matter intake is increased when distiller's grains are included up to 20% of the dry matter in dairy cow diets. Cows fed diets containing 4 to 30% distiller's grains produce the same amount of milk as cows fed diets containing no distiller's grains. However, when cows are fed diets containing more than 30% DDGS, milk yield tends to decrease. Milk fat percentage often varies among dietary inclusion levels of distiller's grains but yield of milk fat does not appear to be significantly affected by dietary inclusion level. Milk protein percentage is unaffected for cows fed diets containing 0 to 30% distiller's grains, and the form (wet or dry) of the distiller's grains does not appear to alter milk composition. However, milk protein percentage decreases by about 0.13 percentage units when distiller's grains are included at concentrations greater than 30% of the diet compared to cows fed control diets. Other dietary factors that may affect milk production and milk composition when distiller's grains are added to diets for lactating dairy cows include type of forage, ratio of forage to concentrate, high oil content of distiller's grains, and formulating diets on an amino acid basis. Type of forage fed can affect dry matter intake, and milk protein percent and yield, but has minimal affect on milk production or milk fat percent.

When formulating diets containing high levels of distiller's grains, it is important the diet contains adequate amounts of effective fiber from forage. While distillers grains contain similar amounts of NDF or fiber as high quality forages, the particle size of the fiber does not contribute to effective fiber and is quickly digested to volatile fatty acids in the rumen. The high oil content of distiller's grains is a potential concern in dairy cow diets because the corn oil in distiller's grains can potentially cause incomplete biohydrogentation in the rumen resulting in milk fat depression. However, a comprehensive review of previously published studies by Dr. Kalscheur at South Dakota State University did not show a consistent relationship between dietary distiller's grain inclusion and milk fat depression. The amino acid lysine will be deficient in diets where corn feedstuffs are the predominant ingredients in dairy cow diets. Feeding supplemental rumen protected lysine sources with distillers grains in dairy cattle diets has the potential to increase both the percentage and yield of milk protein. Corn DDGS can be effectively used in a total mixed ration by mid-lactating dairy cows under heat-stressed climatic conditions, and is a potential high quality by-product for the dairy industry in sub-tropical and tropical regions of the world. Although there has been limited research to evaluate feeding

DDGS to growing dairy heifers, DDGS has been added to growing beef cattle rations at levels up to 40% of dry matter intake to achieve excellent growth rate and feed conversion.

Feeding Wet and Dry Distiller's Grains to Beef Cattle

Corn distiller's grains is an excellent energy and protein source for beef cattle in all phases of production. It can effectively be used as an energy source and be fed up to 40% of ration dry matter intake for finishing cattle with excellent growth performance and carcass and meat quality. However, at high feeding rates, protein and phosphorus will be fed in excess of feedlot steer or heifer's requirements, and as a result, nitrogen and phosphorus levels in manure increase.

The best applications for using DDGS in beef cow diets are in situations where 1) supplemental protein is needed to improve the digestibility of low quality forages, 2) a low starch, high fiber energy source is needed to replace corn gluten feed or soy hulls, and 3) when a source of supplemental fat is needed.

For growing heifers, adding urea to meet the degradable protein intake requirement is not necessary when DDGS is used as an energy source in forage based diets. Distiller's grains can be an effective forage supplement to increase growth at times when availability and/or quality of forage may be limited.

Feeding DDGS to Swine

High quality corn DDGS has a digestible and metabolizable energy value, equal to, or greater than corn for swine. Like the low protein quality (low lysine and poor amino acid balance) of corn, corn DDGS is also low in lysine relative to its crude protein content. After lysine, the next likely essential amino acids to be limiting are threonine and tryptophan. These amino acids should be monitored during diet formulation when using more than 10% corn DDGS in swine diets. Amino acid digestibility can also vary among corn DDGS sources, with true lysine digestibility coefficients ranging from 38 to 63%. Lightness and yellowness of DDGS color appear to be reasonable predictors of digestible lysine content among golden corn DDGS sources for swine. In order to ensure excellent pig performance when adding DDGS to swine diets, only light colored, golden sources should be used and diets should be formulated on a digestible amino acid basis if more than 10% DDGS is included in the diet.

Corn DDGS is an excellent source of available phosphorus for swine and has a relative phosphorus availability of 90% when using dicalcium phosphate as the inorganic phosphorus reference source. When swine diets containing DDGS are formulated on an available phosphorus basis, the amount of inorganic phosphorus supplementation can be significantly reduced, or eliminated in late finisher diets, while meeting the pig's phosphorus requirement. When swine DDGS diets are formulated on an available phosphorus basis, and the enzyme phytase is added to the diet, manure phosphorus excretion can be significantly reduced.

Research results have shown that adding up to 25% DDGS to swine starter diets, and up to 30% to swine grower and finisher diets, can result in excellent growth performance, lean composition of the pork carcass, and muscle quality if diets are formulated on a digestible amino acid basis. However, due to the high content of unsaturated fatty acids and linoleic acid in the corn oil of DDGS, pork fat will become increasingly softer and contain increasing levels of unsaturated fatty acids when the level of DDGS increases in grower-finisher diets. However, recent studies completed at the University of Minnesota show that feeding diets containing as much as 30% DDGS resulted in acceptable pork quality, shelf life of pork loins, and no difference in consumer taste preference of cooked pork loins compared to pigs fed conventional corn-soybean meal based diets. However, bacon, in retail packages at room temperature, processed from pigs fed high amounts of DDGS in their diet has an unacceptable, greasy appearance which would likely reduce consumer acceptability. New research results from studies conducted at the University of Minnesota will help the U.S. pork industry determine acceptable dietary inclusion rates of DDGS in growing pig diets to minimize the effects on pork fat quality. For sows, up to 50% DDGS can be successfully added to gestation diets, and 30% DDGS can be added to lactation diets if DDGS is free of mycotoxins to support good reproduction and litter performance. Some recent research results suggest that feeding high levels of DDGS in gestation and lactation may increase litter size and piglet weight gains. Feeding diets containing DDGS to swine results in a slight increase in manure production due to a slight reduction in dry matter digestibility caused by the relatively high fiber content of DDGS. The nitrogen content of swine manure will increase but the phosphorus concentration will decrease when DDGS is added to the diet. No changes in odor, ammonia, or hydrogen sulfide emissions have been observed in manure from pigs fed DDGS diets. Finally, results from one University of Minnesota research study suggests that feeding diets containing 10% DDGS can reduce the prevalence, length and severity of lesions caused by *L. intracellularis*, the organism that causes ileitis, a common gut health problem in growing pigs.

Feeding DDGS to Poultry

Corn DDGS can supply a significant amount of energy, amino acids, and phosphorus to poultry diets. An energy value of 2755 kcal ME/kg has been determined for DDGS in poultry diets showing DDGS contributes substantially more energy to the diet than the previous value of 2480 kcal ME/kg reported in NRC (1994). Lysine digestibility of corn DDGS can be as high as 83% compared to 65% which is the value reported in the poultry NRC (1994). Lightness and yellowness of corn DDGS color is highly correlated with improved chick weight gain and feed conversion. Recent studies have confirmed that lightness and yellowness of DDGS color appears to be a reasonably good predictor of digestible lysine content among golden corn DDGS sources for poultry. When formulating diets containing corn DDGS, digestible amino acid values should be used especially for lysine, methionine, cystine, and threonine. Diets should also be formulated by setting minimum acceptable levels for tryptophan and arginine due to the second limiting nature of these amino acids in corn DDGS protein. Corn DDGS is also high in total phosphorus (0.73%) and available phosphorus (54 and 68%). The sodium content of corn DDGS averages 0.11% but can range from 0.01 to 0.48%. Therefore, dietary adjustments for sodium content may be necessary if the source of corn DDGS being used contains high levels of sodium, in order to avoid potential problems with wet litter and dirty eggs. Corn DDGS can contain as much as 40 ppm of xanthophyll. The xanthophyll content of corn DDGS has been shown in commercial field and university research trials to significantly increase egg yolk color when fed to laying hens, and increase skin color of broilers when included at levels of 10% of the diet. This is an attractive feature of DDGS among poultry nutritionists in the export market because of consumer preference for dark egg yolk color and yellow skin color. In layer diets, DDGS is a very acceptable feed ingredient and the maximum dietary inclusion level of DDGS should be 15% in high energy commercial diets. Research results have also demonstrated that DDGS from modern ethanol plants is an acceptable ingredient in broiler diets and the recommended maximum dietary inclusion rates are 6% in the starter period, and 12 to 15% DDGS in grower and finisher phases. Results from a recent study conducted in Taiwan showed that adding DDGS at levels up to 18% of the diet for laying ducks had no significant effect on feed intake, feed conversion, or quality of the egg shells, and egg production rate increased in the cold season. Furthermore, egg weight tended to be higher by including 12% or 18% of DDGS in the diets, and egg yolk color was linearly improved with increasing amounts of DDGS in the laying duck diets. Therefore, DDGS can be efficiently used in the diets of duck layers to improve the yolk characteristics without influencing performance.

Summary of Benefits and Limitations of Feeding DDGS in Livestock Diets

USE OF DDGS IN LIVESTOCK DIETS	
Benefits and Limitations for **Lactating Dairy Cows**	
Benefits	***Limitations***
▪ More protein and energy than corn ▪ Feed at up to 20% of ration dry matter ▪ Highly digestible fiber source > fewer digestive upsets ▪ "Golden" DDGS gives best performance ▪ Highly palatable	▪ Low protein (lysine) quality > add other supplements high in lysine > lower milk protein percentage ▪ Manure P excretion increases at high feeding levels ▪ Variable effect on milk fat, but minimal if adequate forage in the ration
Benefits and Limitations for **Finishing Feedlot Cattle**	
Benefits	***Limitations***
▪ More protein and energy than corn ▪ Feed up to 40% of ration dry matter to replace corn > feed excess protein and P ▪ Highly digestible fiber source > fewer digestive upsets ▪ "Golden" DDGS gives best performance ▪ No effect on carcass yield, quality, or eating characteristics of beef	▪ Need to supplement calcium to achieve proper Ca:P ratio > avoid urinary calculi ▪ Manure N and P excretion increases at high feeding levels ▪ Monitor sulfur level of water and diet (< 0.4% ration DM) > avoid polioencephalmalacia
Benefits and Limitations for **Swine**	
Benefits	***Limitations***
▪ Energy value = corn ▪ High available P > reduce diet P supplementation > may reduce manure P excretion ▪ Partially replaces some corn, soybean meal, and dicalcium phosphate and reduces diet cost ▪ Commonly fed at 10% of diet > higher levels can be used if amino acids are supplemented ▪ Only "golden" DDGS should be used > high amino acid digestibility	▪ Low protein (lysine) quality > add other supplements high in lysine and tryptophan ▪ Variability in nutrient content and digestibility among sources ▪ Manure N excretion increases ▪ Belly firmness and pork fat quality may be reduced at high dietary inclusion rates ▪ Fine particle size can contribute to flowability problems in bins and feeders ▪ Difficult to pellet and maintain throughput of pellet

▪ Appears to reduce gut health problems due to ileitis ▪ May increase litter size weaned when fed at high levels to sows ▪ Increases pig weight gain when fed to sows during lactation	mills ▪ Mycotoxin free grain should be used to produce ethanol and DDGS ▪ Short-term feed intake may be reduced when feeding high DDGS diets to sows
Benefits and Limitations for **Poultry**	
Benefits	***Limitations***

▪ Good energy and amino acid source when limited to < 15% of the diet
▪ Source of highly available P
    > reduce manure P
▪ May improve egg yolk and skin color (xanthophyll)
▪ Source of "unidentified growth factors"?
▪ "Golden" DDGS gives best performance
▪ Highly palatable
	▪ Energy value ~ 84% of corn
	▪ Low protein quality
	    > add other supplements high in lys, arg, trp
	▪ Sources high in sodium may increase litter moisture if adjustments to dietary salt levels are not made

Feeding DDGS to Aquaculture

Corn DDGS can be an excellent protein and energy source in aquaculture feeds. Based upon recent research studies, maximum dietary inclusion of DDGS are much higher than previously recommended. Studies have shown that up to 30% DDGS can be included in catfish diets without negative effects on growth performance. For trout, up to 15% DDGS can be added to the diet without lysine and methionine supplementation, whereas up to 22% can be added to trout diets if diets are supplemented with lysine and methionine. Diets for salmon and shrimp can contain up to 10% DDGS in the diet to achieve good performance, but levels up to 40% DDGS in freshwater prawn diets can be used successfully while replacing some or all of the fish meal in the diet. Corn DDGS can be added up to 35% in high protein (40%) tilapia diets without supplemental lysine and tryptophan, and dietary inclusion rates of DDGS can be as high as 82% with lysine and tryptophan supplementation in low protein (28%) tilapia diets.

Feeding DDGS to Horses and Companion Animals

Very little research has been conducted related to feeding diets containing DDGS to horses and other companion animals. Based on the limited research information available, it appears that DDGS is a very suitable ingredient for use in horse, rabbit, and dog diets. Maximum dietary inclusion rates for DDGS are up to 20% for horses and rabbits, up to 10% for growing puppies, and up to 25% in diets for adult dogs. Amino acid digestibility is also likely to be of concern in companion animal diets as it is with swine and poultry diets.

Summary: Maximum Recommended Dietary Inclusion Rates for DDGS.

Specie	Production Phase	Maximum Inclusion Rate
Beef	Finishing beef cattle	40% (% of DM intake)
Dairy	Lactating dairy cow	20% (% of DM intake)
Swine	Weaned pigs (>7 kg)	25%
	Grow-finish	20%
	Gestation	50%
	Lactation	30%
Poultry	Broilers	15%
	Turkeys	15%
	Layers	15%
Aquaculture	Catfish	30%
	Trout	15-22%
	Salmon, shrimp	10%
	Prawn	40%
	Tilapia	35-82%
Equine		20%
Rabbits		20%
Canine	Growing puppies	10%
	Adult dogs	25%

Potential Quality Contaminants in DDGS

Mycotoxins can be present in distiller's grains by-products if the grain delivered to the ethanol plant is contaminated with them. Mycotoxins are not destroyed during the ethanol production process nor are they destroyed during the drying process to produce distiller's grains by-products. However, the risk of mycotoxin contamination in distiller's grains by-products is very low because many ethanol plants monitor grain quality and reject sources that may be contaminated with mycotoxins. When samples of distiller's by-products are tested, only high performance liquid chromatography (HPLC) should be used. HPLC is the mycotoxin detection reference method for DDGS. ELISA tests should not be used to determine if mycotoxins are present in DDGS because ELISA tests result in a high proportion of false positive readings.

Antibiotics such as penicillin G, penicillin B, and virginiamycin are used in very small quantities to control bacterial infections in fermenters during the ethanol production process. However, there appear to be no antibiotic residues in distiller's grains by-products because penicillin is destroyed as the pH in fermenters declines toward the end of fermentation, and virginiamycin appears to be destroyed at a temperature of > 200° F in the distillation towers of dry-grind ethanol plants. Results from two field trials have shown that DDGS can be stored in hot humid conditions for at least 10 weeks without adding antioxidants, with no evidence of oxidative rancidity in the corn oil in DDGS.

The Impact of the Ethanol Industry on the Livestock Industry

The ethanol industry is consuming an increasing proportion of the annual corn crop. Industry experts are predicting that about 20% of the 10.745 billion bushel 2006 U.S. corn crop will be used for ethanol production. As a point of reference, the U.S. livestock and poultry industries consume about 5 billion bushels of corn annually. Therefore, as the ethanol industry continues to grow, there will be increasing competition between the ethanol industry and the livestock and poultry industries for corn supply. This competition for corn has many people in the animal production industry worried about what it will mean to future corn prices and availability.

Researchers at the Food and Agricultural Policy Research Institute at the University of Missouri, have estimated ethanol production and corn use by marketing year from 2006/07 to 2010/11 (FAPRI, 2006, Table 1). By the year 2010/11, ethanol production is projected to increase by 86% of what is projected to be produced in 2006/07, and this will require a 61% increase in corn use for fuel ethanol production compared to current levels. Assuming that there will be no weather problems that affect corn production and yields, the annual U.S. corn crop is also projected to increase by an average of 23% per year through 2010/11, which requires an increase in corn acres planted and a gradual average annual improvement in yield of about 21%. Presumably much of the increase in corn acreage will be at the expense of acreage used to grow other crops (e.g. soybeans) and perhaps some of the acres currently enrolled in the CRP program.

Table 1. Projected ethanol and by-product production, and corn acreage, yield, and usage for ethanol by marketing year through 2010/2011 (FAPRI, 2006).					
	2006/07	**2007/08**	**2008/09**	**2009/10**	**2010/11**
Ethanol produced, billion gal.	4.95	6.29	7.33	8.39	9.20
Corn required, billion bu.	2.15	2.51	2.91	3.22	3.46
Ethanol by-product feeds (dry basis), million tons	14.37	17.40	20.82	23.41	25.45
Corn crop, billion bu.	10.74	11.48	11.99	12.27	12.50
% corn crop	20.01	21.86	24.27	26.24	27.68
Acres planted, millions	79.4	82.9	85.6	86.5	87.0
Yield/acre, bu.	149.0	150.9	152.6	154.5	156.4

The net result of increased ethanol production is increased corn price, increased corn acreage, decreased corn exports, and increased feed use of ethanol by-products (i.e. DDGS).

One of the major concerns for livestock and poultry producers is whether they will have access to ample quantities of reasonably priced corn in the future. The rapid growth of the U.S. ethanol industry has turned some corn surplus regions in the Corn Belt into corn deficit areas due to the high quantities being used by ethanol plants in those locations. This is good news for corn farmers because the price basis has increased in these areas, and if they are shareholders of local ethanol plants, they have been earning an excellent return on their investment by adding value to each bushel of corn they supply to their ethanol plant. However, livestock and poultry producers who purchase corn must compete with the ethanol industry for supply and price. Based upon current ethanol prices and production costs, many modern ethanol plants can afford to pay more than $4 to $5 per bushel of corn to breakeven. With these high breakeven prices, it is understandable why livestock and poultry producers are nervous about their current and future feed costs.

If 25.45 million tons (23.08 metric tonnes) of distiller's by-products are produced in 2010 (Table 2), it could all be consumed by the U.S. livestock and poultry industries if there was 63% market penetration at the maximum dietary inclusion rates for each species shown in Table 3. Although each segment of animal production offers potential for consuming more DDGS, the swine and poultry sectors have the greatest potential for increased DDGS usage. In 2006, the U.S. pork industry used about 1.08 million metric tonnes, which is only about 12% of the theoretical maximum use at 100% market penetration. The U.S. poultry industry consumed an even smaller amount (360,000 metric tonnes) of DDGS in 2006, which is only about 6% of the theoretical maximum use at 100% market penetration. If some of the barriers limiting DDGS use in swine and poultry diets can be overcome, it may be possible to achieve 50% or more in potential market penetration in these industries. Some of the barriers limiting the use of DDGS in swine and poultry diets include:

- Variability in nutrient content and digestibility among DDGS sources
- Low particle size and flowability problems of some DDGS sources
- Perceived risk of mycotoxins in DDGS and fast, accurate, inexpensive methods for monitoring the presence and level of mycotoxins
- Ability to pellet DDGS diets and maintain throughput of pellet mills
- Understanding and managing effects corn oil in DDGS on pork fat quality
- Controversy over palatability and negative effects on feed intake of growing pigs at high dietary inclusion rates
- Fast, accurate, and inexpensive *in vitro* methods to estimate amino acid digestibility among sources
- Net energy values of DDGS sources need to be determined

Table 2. Theoretical Potential of Distiller's By-Product Use in the U.S. Livestock and Poultry Industries (Cooper, 2006).

	Grain-Consuming Animal Units, millions	**Maximum Dietary Inclusion Rate, %**	**1000 Metric Tonnes by % Mkt. Penetration**		
			50%	**75%**	**100%**
Dairy	10.2	20	1,887	2,831	3,774
Beef	24.8	40	9,176	13,764	18,352
Pork	23.8	20	4,348	6,521	8,695
Poultry	31.1	10	2,877	4,315	5,754
Total			18,288	27,431	36,575

Our research group of agricultural economists (Drs. B. Buhr, V. Eidman, D. Tiffany) and animal scientists (Drs. G. Shurson, S. Noll, J. Linn, and A. DiCostanzo) at the University of Minnesota have conducted preliminary evaluations to estimate the impact of higher corn prices as a result of increased corn demand from the ethanol industry, and DDGS use in livestock and poultry diets on various economic costs in the animal industry. An Equilibrium Displacement (Supply and Demand) model was used for this analysis (Lusk and Anderson, 2004). Price assumptions used in this economic model were based upon a December 2006 corn futures price of \$3.46/bu and soybean meal price of \$166.77/ton.

For the pork industry, results from this model using these price assumptions under a "most likely" scenario, suggest that there would be a 12.5% increase in total cost of pork production compared to a historical corn price of \$2.15/bu and soybean meal of \$192.48/ton. Adding DDGS to grower-finisher diets at a 10% inclusion rate would have a moderate benefit of reducing feed costs by about \$0.50/ton (1.25%) compared to higher priced feed without DDGS. However, there would also be a 9.3% increase in pork price at the farm level. The increase in total cost of production could cause a 3.27% reduction in the quantity of pork (carcass basis) produced, and the net quantity of pork imported into the U.S. could increase by 1.1%, 7.9 million fewer pounds of pork would be exported, and consumer cost for pork at the retail level would increase by about 2.5%. These changes appear to be significant and will change the economic dynamics of the entire pork chain.

The U.S. beef industry is much less affected than the pork or broiler industries. Under the "most likely" scenario total cost of production would increase by 4.9%, due to a 40% reduction in feed cost using 40% dietary inclusion rate of wet distiller's grains. Beef price at the farm level is projected to increase by 2.4%, with a minimal reduction (0.6%) in the quantity of beef (carcass basis) produced. The net beef imports would be expected to increase by 1% and consumer price for beef at the retail level would only increase by about 1.16%.

Under the same assumptions used for the pork and beef models, the U.S. broiler industry will be impacted the most under the "most likely" scenario. First of all, feed prices would increase by 30% compared to baseline historical corn and soybean meal prices, and total production costs would increase by about 20%. Adding 10% DDGS to broiler diets would have a small benefit and slightly reduce feed cost by \$0.02/ton (4%) compared to feeding higher priced feed without DDGS. Broiler price at the farm level is projected to increase by 19%, as the quantity of chicken produced declines by 4.8%. The net impact is projected to be a 13.9% increase in the price of chicken at the retail level. The projected increase in the retail price of pork and chicken will likely shift consumer demand more in the direction of beef. Unfortunately, there are no estimates currently available on the impact of higher feed prices on the dairy, layer, and turkey sectors. It is also important to recognize that distiller's grains are always worth more, nutritionally, in dairy cow diets, followed by beef feedlot diets, then poultry, with swine diets being the most likely to not use DDGS if the price relationship with competing ingredients (corn, soybean meal, and inorganic phophorus supplements) relative to DDGS are not in favor of using it economically. This is because different animal species have different abilities to utilize and achieve value in the nutrients that distiller's by-products provide to the diet.

Research Needed to Increase Acceptance and Usage of Distiller's Grains in the Livestock and Poultry Industry

General

- Studies to understand the factors causing poor flowability of DDGS and practical methods to improve it
- Direct scientific studies that validate that there are no detectable or biologically active antimicrobial residues in distiller's by-products
- Ways of improving quality of DDGS pellets and ways of improving pellet mill throughput when manufacturing commercial feeds containing DDGS
- Fast, accurate, and low cost methods of monitoring mycotoxin presence and level in distiller's by-products
- Determine maximum dietary DDGS inclusion rates to support optimal performance while minimizing the quantity of manure, nitrogen, and phosphorus excreted relative manure management plans for all species
- Feeding value of new distiller's by-products resulting from fractionation and new processing technologies used in dry grind ethanol plants for all species
- Evaluation of the effectiveness of mold inhibitors and preservatives for wet and dry distiller's by-products

Swine

- Variability of product. Need rapid analysis techniques to determine, major nutrient (proximate) components, digestible amino acid and digestible phosphorus content of DDGS sources
- Determine optimal dietary inclusion rates and feeding strategies to minimize potential pork fat quality issues in pork carcasses
- Determine methods of improving the energy value of DDGS through improved fiber utilization (e.g. enzymes, processing, etc.)
- Further evaluation of DDGS and its role in improving gut health of pigs
- Evaluation of DDGS feeding levels on reproductive performance and longevity of sows
- Direct determination of the net energy value of DDGS sources for swine

Poultry

- Variability of product. Need rapid analysis techniques to determine, major nutrient (proximate) components, digestible amino acid and digestible phosphorus content of DDGS sources
- Increasing dietary utilization of energy from DDGS (enzymes, processing, etc.)
- How does the inclusion of DDGS affect gut microflora and bird health
- Role of DDGS in ammonia emissions from poultry manure
- Does DDGS have any effect on meat yield and quality
- Studies to determine updated amino acid requirements and responses to diet energy for market turkeys. This is critical if the feed industry moves toward lower energy type diets as energy sources (e.g. corn, fat from rendering) decline.

Dairy

- Impact of the amount and type of forage (corn silage or hay crop forage) in the diet on milk production with increasing dietary levels of DGS.
- Determine cause of and ways to minimize or eliminate milk fat content reductions with increasing DGS in diets.
- Determine if the inclusion of DGS increases the production of conjugated linoleic acid (CLA) in milk.

- Determine why there appears to be milk production differences between feeding dry versus wet DGS.
- Further studies are needed related to amino acid formulation of diets and possible total fatty acid content of diets as methods for enhancing milk production and milk composition with increasing inclusion amounts of DDGS in diets.

Beef

- Evaluate the impact of feeding DGS (particularily wet distiller's grains) on beef quality attributes (color, flavor, shelf life, fatty acid profile).
- Discover strategies that ameliorate the negative effects of high sulfur concentrations in distiller's grains
- Determine the effects of feeding DGS on health, performance and beef quality when fed from conception to consumption.

Summary

Corn dried distillers grains with solubles is an excellent energy, protein, and phosphorus feed ingredient that can be used successfully to support optimal animal performance, and often times, reduce overall diet cost. It has nutritional, handling, and feed manufacturing limitations that can be overcome by conducting research to learn how to manage these limitations. It is also a unique feed ingredient because it is produced from a microbial fermentation process, and may contain unidentified compounds that contribute to improved animal health and performance. As the U.S. ethanol industry continues to grow, a greater quantity of DDGS will be available for feeds in the domestic and export market, and a wider diversity of distiller's by-products with different nutritional characteristics will become available for specific animal feeding applications. Research is needed to understand the growing portfolio of new distiller's products, their value and most appropriate feeding applications. Please refer to the most comprehensive review of scientific information on feeding distiller's grains to livestock and poultry at www.ddgs.umn.edu.

Literature cited

Cooper, G. 2006. A brief, encouraging look at theoretical distiller's grains markets. Distillers Grains Quarterly, First Quarter, p.14-17.

FAPRI July 2006 Baseline Update for U.S. Agricultural Markets. FAPRI-UMC Report #12-06, http://www.fapri.missouri.edu/outreach/publications/umc.asp?current_page=outreach, 12 pages.

Lusk, J.L. and J.D. Anderson. 2004. "Effects of Country-of-Origin Labeling on Meat Producers and Consumers." Journal of Agricultural and Resource Economics 29:185-205.

National Research Council. 1994. Nutrient Requirements of Poultry, 9th Revised Edition, National Academy Press, Washington, DC.

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Education

Ph.D. Michigan State University	**Major: Animal Science – Swine Nutrition**	**1986**
M.S.Michigan State University	**Major: Animal Science – Swine Nutrition**	**1983**
B.S. University of Minnesota	**Major: Animal Science & Agricultural Economics**	**1981**

Professional Experience

Swine Center Director — **University of Minnesota** — **1998-01**
Provide leadership in coordinating multidisciplinary, multi-agency research and educational programs to improve the competitiveness and sustainability of the Minnesota Pork Industry.

Professor — **Dept. of Animal Science, Univ. of Minnesota** — **1998-07**
Teaching (on-campus and extension) 65%; research 25%; service 10%

Associate Professor — **Dept. of Animal Science, Univ. of Minnesota** — **1992-98**
Teaching (on-campus and extension) 65%; research 20%; service 15%

Assistant Professor — **Dept. of Animal Science, Univ. of Minnesota** — **1990-92**
Teaching (on-campus and extension) 65%; research 20%; service 15%

Assistant Professor — **Dept. of Animal Science, Ohio State Univ.** — **1986-90**
Teaching (on-campus and extension) 75%, research 15%; service 10%

Assistant Extension Swine Specialist	**Dept. Animal Science, Michigan State Univ.**	**1981-86**
Swine Herdsman	**Dept. Animal Science, Univ. of Minnesota**	**1977-81**
Assistant Production Manager	**American Feeder Pig Coop, Sauk Center, MN**	**1979-80**
Agronomy Research Assistant	**Univ. of Minnesota**	**1978**

Teaching: Undergraduate and Graduate Students

Courses Taught

ANSC 1100	Introduction to Animal Science	CAPS 5632	Advanced Swine Nutrition
ANSC 4401	Swine Nutrition and Feeding Mgmt	ANSC 693	Expert Systems in Pork Production
ANSC 4601	Pork Production Systems Mgmt	ANSC 8340	Developments in Swine Nutrition
ANSC 4611	Adv. Pork Production Systems Mgmt	ANSC 4609	Analysis of Livestock Production Systems
ANSC 4092	Special Problems		
ANSC 4093	Tutorial		

Students Advised

Undergraduate:	Academic	286	Senior Thesis	14	Internships	58
Graduate (M.S.):	Major Advisor	19	Committee Member	20		
Graduate (Ph.D.):	Major Advisor	23	Committee Member	29		

Academic Quadrathlon Coordinator

Research Activities

Publications

Scientific refereed	27 (11 in progress)	Scientific abstracts:	84
Experiment station reports	64	Conference Proceedings/invited papers:	147
Research Grants:	68 funded ($4,397,500)		

Extension Scholarship

Publications

Extension publications:	48	Popular press articles	107

Pork Industry Committees, Activities and Projects

NCR Pork Industry Task Force, 1992-95
Pork Industry Business Retention and Enhancement Program, 1994-95
NPPC Swine Educators Advisory Committee, 1996-01
NPPC Lean Growth Modeling Committee, 1996-99
NPPC Standardized Production and Financial Records Committee, 1996-00
NPPC Pork Production Curriculum Development Committee, 1996-01
NCR 4-H Swine Curriculum Development Committee, 1989-93

Developed and presented 296 educational meetings for pork producers and industry professionals.
Radio and Television Interviews/Programs: 108

Computer Technology

- Developed SwinePro-A Decision Support System for the Swine Enterprise
- Chaired the steering committee to develop the National Pig Information Database on CD-ROM
- Developed the Swine Software and Internet Directory published by the National Pork Producers Council

International Educational Programs

U.S. Grains Council – China (1998), Panama (2002), Japan (2002), Taiwan (2002, 2003), S. Korea (2003, 2005), Mexico (2003, 2004), Canada (2003, 2004), Malaysia (2004), Vietnam (2004), Indonesia (2004), Philippines (2004)
MN Trade Mission – Japan (2001) Banff Pork Conference – Canada (1999) University of Hannover, Germany (2003)
China Agriculture University, Beijing, China (2002) IPVS – Hamburg, Germany (2004)

Service

National Committees

President, Midwest Section ASAS, 2002-05
Director, Midwest Section ASAS/ADSA, 1995-1999
  Chair, Contemporary Issues Committee, 1995-99
  Chair, Teaching Award Committee, 1995-99
  Academic Quadrathlon Committee, 1991-94
  Placement Committee, 1995-99
  Extension Awards Committee, 1995-99
Member, American Society of Animal Science, 1981-present
  Chair, Nonruminant Nutrition Program Committee, 1999
    Midwest Nonruminant Nutrition Program Committee, 1990-93
National Extension Initiative-Managing Change in Agriculture, 1996-99
NCR-42 Swine Nutrition Research Committee, 1994-present
NCR-89 Swine Confinement Management Research Committee, 1986-90
NCR-171 Applications of Computer Technology in Animal Agriculture, 1989-95

Editorship/Reviews

Editorial Board, Journal of Animal Science, 1993-96
Pork Industry Handbook
Leopold Center Research Grants
Minnesota Pork Journal
Four Textbooks
NCR Extension Publications
CFAR Research Grant Proposals

Awards

Outstanding Teacher Award, College of Ag, Food, and Environmental Sciences Student Board, 1999
Outstanding Extension Specialist Award, Midwest Section ASAS/ADSA, 1995

Committee on Agriculture
U.S. House of Representatives
Required Witness Disclosure Form

House Rules* require nongovernmental witnesses to disclose the amount and source of Federal grants received since October 1, 2004.

Name: **Gerald Shurson**

Address: **University of Minnesota, Dept. of Animal Science**
385 AS/VM, 1988 Fitch Avenue, St. Paul, MN 55108-6012

Telephone: **612-624-2764**

Organization you represent (if any): **University of Minnesota**

1. **Please list any federal grants or contracts (including subgrants and subcontracts) <u>you</u> have received since October 1, 2004, as well as the source and the amount of each grant or contract. House Rules do <u>NOT</u> require disclosure of federal payments to individuals, such as Social Security or Medicare benefits, farm program payments, or assistance to agricultural producers:**

Source **USDA ARS-CPRL (58-6209-5-024)** **Amount:** **$35,000**

Source:____________________ **Amount:**__________

2. **If you are appearing on behalf of an organization, please list any federal grants or contracts (including subgrants and subcontracts) <u>the organization</u> has received since October 1, 2004, as well as the source and the amount of each grant or contract:**

Source:____________________ **Amount:**__________

Source:____________________ **Amount:**__________

Please check here if this form is NOT applicable to you: __________

Signature: Gerald Shurson

* Rule XI, clause 2(g)(4) of the U.S. House of Representatives provides: *Each committee shall, to the greatest extent practicable, require witnesses who appear before it to submit in advance written statements of proposed testimony and to limit their initial presentations to the committee to brief summaries thereof. In the case of a witness appearing in a nongovernmental capacity, a written statement of proposed testimony shall include a curriculum vitae and a disclosure of the amount and source (by agency and program) of each Federal grant (or subgrant thereof) or contract (or subcontract thereof) received during the current fiscal year or either of the two previous fiscal years by the witness or by any entity represented by the witness.*

PLEASE ATTACH DISCLOSURE FORM TO EACH COPY OF TESTIMONY.