Feeding Corn and Soybean Co-Products and By-Products to Beef Cattle

A White Paper Written for
Summit Livestock Facilities

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CHAPTER 1: WASTE PRODUCT, BY-PRODUCT, OR CO-PRODUCT

Introduction

Defining terminology can have far-reaching implications. The old adage, "what's in a name is everything," can have substantial impact regarding society's perception of a product. Therefore, the term(s) used to describe left over products from feed processors can affect the status by which it is perceived. However, whether a potential feedstuff is initially referred to as a waste residual, a by-product or a co-product may not be as important in the development of the feedstuff for livestock feed as an industry, as whether or not the resulting feedstuff achieves final co-product status. If a feedstuff is to become a viable self-sustaining product, the resulting product(s) must eventually achieve recognition as a co-product. This recognition is as important as the food/feed items generating the end product.

There is, generally, a recognized sequence of events or series of product development steps that a waste material must pass through to reach co-product status. The sequence of descriptive terms that characterize this progression are, in order of occurrence: waste material, waste product, by-product, co-product.

Generally, waste materials have little, if any, value. The mentality for dealing with these materials centers on the most economical means for disposal. Traditionally, the most economical method for disposal of wastes has been landfilling. Without source separation of contaminants (such as paper, plastic, metal, etc.) from the item destined for use as a feedstuff, landfilling may remain the most economical alternative, even at higher relative costs. If perceived value can be realized from a waste selected for recycling, then waste residuals such as food waste, soybean hulls, distiller's grains, etc. can realistically progress through a series of events culminating in the achievement of co-product status.

In order for any potential feedstuff (heat damaged cereal, condensed distiller's solubles, etc.) to achieve recognition as a waste product, several criteria must be met that include (1) an alternative use must be identified for the waste material, (2) the use must be accurately described, and (3) standards of quality must be established or at least identified.

The first of these three criteria has been achieved, primarily as a result of historical use. Various food wastes have been used as livestock feed for centuries with varying degrees of success. The second criterion has been well-documented for feeding some of the food/feed wastes. The role of processed food residuals will probably be described as a feed additive for combining with other traditional and nontraditional feedstuffs, and eventual end-use in the diets of livestock and companion animals. In some situations, processed food wastes may, depending on age of the animal, stage of the animal's production cycle, and species, serve as the sole dietary ingredient. Standards of quality for food residuals (crackers, cereals, breads, etc.) have not been descriptive, at least for food residual in general. The contents, sources, and uses of food residuals as a feedstuff vary so much that it may be impossible or impractical to establish uniform standards of quality for generic food wastes. However, general descriptors of quality that all categories of food wastes should adhere to may be identified, such as minimum nutrient densities, digestibilities, freedom from pathogens, absence of contaminants, etc. The primary reasons any identified food residual may remain a waste material are:

- low energy or protein content

- high moisture content
- presence of contaminants
- lack of an AAFCO definition
- requirement for expensive processing
- high transportation cost
- lack of FDA approval

While feedstuffs are sources of vitamins and minerals, they are added to diets primarily for their energy and protein value. Dietary energy can be supplied by fat, carbohydrates, and protein when in excess. Feed residuals that are moderate in energy may have a greater contribution as a protein source in most diets. However, lower cost high energy sources are generally in greatest demand, especially as corn grain increases in value. The source and type of food/feed residual affects its use in balancing diets. Food/feed residual may be an excellent source of vitamins depending on the method of processing. Some heat processing methods that utilize excessively high temperatures for extended periods of time may destroy some heat-labile vitamin activity. Food/feed residuals, also, can be an excellent source of some minerals. Too often, however, elements from the original feedstuff are concentrated within the residual waste and elemental toxicity becomes an issue.

A major concern of many nutritionists regarding food/feed residuals is the often high moisture content. The dry matter content of food/feed residual is as variable as number of food/feed wastes available. Reported values range from 90% dry matter for cereals to 20% dry matter for some food/feed processing wastes. High moisture (anything more than 20% moisture) food/feed wastes present handling, storing, processing, and feeding problems. The nutrient content of the waste is in the dry matter portion, not in the water fraction. High water content in food/feed residuals (more than 40% moisture) also, may decrease animal consumption and reduce average daily dry matter intakes, thereby reducing animal performance. Transportation costs are excessive if feed residuals contain high moisture content and may become a limiting factor for food/feed residual utilization. Moisture contents greater than 20% limit the length of the time the residual can be stored (usually 1 to 2 days) prior to processing or feeding without excessive spoiling occurring. High moisture food/feed residuals can be stored for longer periods if they are treated with enzyme/bacterial innoculants to preserve or allow the waste to ferment. A high moisture feed residual can freeze during extreme cold weather, which limits the usability unless precautionary measures are taken. High moisture content is problematic for most processing methods and increases the costs for processing the waste as a feedstuff. In some instances, the energy expenditure to process (dry, dehydrate, or extrude) the waste to remove excess water exceeds its value as a feedstuff. Economical methods for handling wet feed residuals and for removing the water fraction must be identified and investigated if a high moisture (greater than 20%) feed residual progresses from waste-material status to waste-product status.

Another factor that can limit a food/feed residual's progression to by-product status is the presence of contaminants. Paper is a major contaminant in some food waste (cereal and bakery products) and is not recognized as an approved feed additive by the FDA. The presence of incidental paper contamination in food wastes may be tolerated by the FDA if the processor is making a good-faith attempt to remove paper from the food waste. Mechanized technology of grinding and using air pressure to remove paper from dry food wastes, such as cereals, crackers, etc. have been developed and used successfully. The most cost-effective method for separating paper from high moisture food wastes, such as cafeteria or restaurant food waste, is at the source of serving or consumption. Successful source-separation requires extensive and continuous public education. However, practical, consumer education is time consuming.

Most feed residuals have an Association of American Feed Control Officials (AAFCO) definition. One purpose of AAFCO is to develop definitions and policies for animal feeds that can be used by state and federal regulatory agencies to monitor the effectiveness and usefulness of animal feeds. Providing a definitive AAFCO description of a feed residual facilitates its marketability as a by-product. These definitions also provide a basis for recognition for a feed residual as a feedstuff by the FDA, which is essential if it is to receive universal acknowledgement in its progression from waste material to waste product to by-product status.

Because of variability, any feed residual must be processed to create a uniform product with consistent fractional composition. Variability in the dry matter, protein, fat, energy, mineral, and fiber content of a feed residual can limit its use as a feedstuff in livestock and companion animal feeds. Processing (grinding, drying, blending, etc.) of a feed residual improves its marketability. The greater the volume of a product processed daily through one manufacturing plant, the more competitively priced a feed residual becomes as a feedstuff.

Perhaps the greatest factor limiting a feed/food residual's attainment of by-product status is the collection and transportation of the raw unprocessed material from its source of generation to its end-use site. The higher the relative water content, the higher the dry matter transportation cost.

As long as alternative disposal options (landfilling or selling to local feedlots for removal costs) remain low priced, progression of potential waste feedstuffs to by-product status will be slow. As collection costs, residual product generation increases, and availability of an adequate number of feedlots decreases, feed/food residual's recognition as a waste-product will increase proportionately. There are 10 characteristics that a feed/food residual as a waste product must achieve prior to progressing to by-product status (Table1). If any one of these characteristics is lacking or is not successfully addressed, any feed/food waste will not be recognized as a by-product.

Table 1. Characteristics Required For Obtaining By-Product Status

Nutrient dense
High digestibility
Low water content
Absence of contaminants
Capable of prolonged storage
Minimal processing required
Nonprohibitive transportation and handling
Cost effective
High public acceptance
Legal

Several feed/food residuals previously have been cited as a feedstuff of varying yet considerable nutrient density. Diets containing Okra (a by-product of soybeans processed for tofu production), granola bars, bakery waste (bread and cookie discards from supermarkets), soybean hulls (by-product of soy-oil production), distiller's grains (by-product of ethanol production) and brewers grains (by-product of the brewing industry) have been readily consumed by ruminants and non-ruminants. An often recognized assumption is that feed/food residuals, in general, contain substantial amounts of protein and energy. However, classification of these waste products as primarily a protein feedstuff, energy feedstuff, or mineral source, etc. is difficult, if not impossible, because of the variable composition of the waste stream sources generating a specific food/feed residual. While this reported variability in composition may limit the broad classification of some residuals as a particular "type" of feed additive, it does not prevent a particular feed/food residual from being recognized as a by-product. Some feed residuals such as distiller's grains have been established as either economical energy substitutes or as a protein replacement in livestock and companion animal feeds depending on the amount of the residual in the diet. When the niche markets for the many food residuals are considered collectively, food residuals are well on their way towards recognition as by-product feedstuffs.

Less is known about the digestibility of most feed/food residuals than is known about the residuals composition. A general assumption, however, is that the digestibility coefficient for the primary nutrients found in large amounts of a feed residual must be 75% or greater if the residual is to become recognized as an economical feed additive for inclusion in traditional diets.

Some feed/food residuals are high in dry matter (85%). Others are relatively low in dry matter, containing 30% or more water. The high moisture content of some feed/food residuals will limit their usefulness as feed additives unless economical methods for removing the moisture fraction are identified. Because the energy charges associated with drying and dehydration are often cost restrictive, numerous feed/food residual processors blend wet feed waste with other dry feedstuffs to lower the average moisture content prior to processing. This method of lowering the moisture content has proven effective for such processing technologies as extrusion. High transportation costs of high moisture feed residuals and limited storage times can limit some feed residuals from achieving by-product status.

Production of dry product (dry matter equal to or greater than 88%) capable of prolonged storage in either bulk or bagged form is a characteristic common to most by-product feedstuffs. An exception, perhaps is wet corn gluten, a by-product of the corn milling industry and either wet or modified wet distiller's grains (DGS). Wet corn gluten feed (WCGF) and modified wet DGS, with 40 to 60% moisture, almost have limited uses for feeding cattle. Generally WCGF and modified wet DGS (particularly wet DGS; 60% moisture or greater) must be fed within 3 to 4 days following arrival at a cattle-feeding facility or substantial spoilage and nutrient loss will occur. Consequently, these three feed residuals' utilization as feedstuffs maybe limited to large operations in geographic locations near wet milling plants. However, technology does exist to store these wet feedstuffs for extended periods. And, smaller producers can utilize these wet feedstuffs as effectively as large producers. By-product feed additives capable of being utilized in a variety of animal feeds contain at least 88% dry matter. Dehydration, drying, and extrusion are processing methods that should be considered as part of most processing plants if by-product recognition of the feed residual is an objective. To be effective, any feed residual processing regimen should involve minimal processing and nonprohibitive transportation and handling.

The ultimate recognition any feed residual can achieve is that of co-product status. Co-product status infers that the by-product is as valuable or has as much demand as the original product from which it was derived. Co-product recognition implies that the product has a standardized price, uniform composition, and a commercial identity regarding its function or potential uses.

How rapid any feed/food residual attains co-product status is dependent on the length of time required for the waste product to be recognized as a by-product. Co-product recognition is driven by increased demand for a by-product with consistent nutrient composition.

A Historical Perspective of Soybean Meal

The classical success story of a waste obtaining co-product status is the history of soybean meal. The soybean came to America in the 18th century to the Atlantic Coast as ballast in sailing vessels. The first published account of the soybean plant in the U.S. appeared in 1804. It was introduced to the United States from China as an oddity in a garden in Pennsylvania. In 1850, the U.S. Department of Agriculture (USDA) started research to study the use of the crop as forage, green manure, silage or hay. Even up until 1940, there were more acres of soybeans harvested for hay than for beans in the United States.

The first domestically produced soybeans were processed for oil in 1915 in a North Carolina cotton seed mill, though an imported lot of soybeans were processed in Seattle, Washington in 1911 when Pacific Oil Mill brought the soybeans from Manchuria. World War I caused a shortage of edible vegetable oils and the versatile bean filled the gap. The soybean processing industry expanded and the USDA soon encouraged farmers to produce more soybeans for oil, rather than forage. In 1935 when restrictions on corn acreage began, soybeans were one of the alternate crops. World War II, again increased demand for edible vegetable oils. As a result of processing soybeans for their oil content, mounds of soybean meal were generated as a waste with no apparent use. Through some innovative applications, soybean meal was found to have value as a protein supplement in livestock rations. However, growth depressions were sometimes observed when soybean meal was added to non-ruminant diets. Discovery of the anti-nutritional factors present in raw soybeans and their control through adequate heat processing aided in recognizing the true value of soybean meal. Scientific advances demonstrated that soybean meal rations could be fortified with vitamins, especially B_{12} and the limiting amino acid Methionine, thus eliminating the need of supplemental animal protein. Soybean meal had become a waste product.

Originally soy oil was extracted by means of hydraulic or screw press methods which left 3-6% oil in the meal. As more demand for vegetable oil was demonstrated, the solvent extraction method was adopted to remove the majority of the soy oil and use of the meal as a livestock feedstuff increased. Soybean meal was now considered a by-product, in large part due to its consistent nutrient composition.

Today poultry consume about 50% and swine over 30% of all domestically produced soybean meal. The other 20% is consumed by beef and dairy cattle, sheep, fish and humans or is used in industrial applications. Futures contracts for soybean meal are bought and sold on the Chicago Board of Trade and soybean meal is recognized as a commodity of equal status to that of soy oil. Soybean meal is a co-product produced from soybeans. This is the ultimate success story for a material that was once considered a burdensome waste. (This history of soybean meal was written in consultation with Nabil Said, Director of Technical Services for Tripe “F” Inc. Insta-Pro®, Des Moines, Iowa.)

Some sources of feed/food residuals lend themselves to producing a waste product capable of becoming a co-product easier than others. Corn gluten feed, distiller's grains, soyhulls, beet pulp shreds, cotton seed hulls, etc. are examples of waste products that have achieved by-product or co-product status.

Soybean hulls and beet pulp sheds are two examples of waste products that have achieved co-product status. These two feedstuffs have a consistent nutrient analysis, regardless of which company or plant produces the feedstuff. The variability of these two feedstuffs, regardless of source is low. Adequate volumes of product are available on a year around basis, whether through continuous production or because of adequate storage by the processor.

The waste products produced during wet corn milling to produce high fructose corn syrup (corn gluten meal, corn germ meal, wet or dry corn gluten feed and condensed fermented extractives) have consistent nutrient compositions and are consistently available. These by-products have achieved co-product status and consequently the prices of these co-products are stable and price discounts are seldom available.

The waste products produced during the dry grind process to produce ethanol (dried distiller's grains, dried distiller's grains with solubles, modified wet distiller's grains, modified wet distiller's grains with solubles, wet distiller's grains with or without solubles and condensed distiller's solubles, sometimes referred to as syrup) too often do not contain consistent nutrient compositions. Not only does the moisture content vary, but considerable variation exists in crude protein, fat, energy, and mineral (especially phosphorous and sulfur) composition (table 2).

This variation exists not only between ethanol plants but, also, within plants from month to month and sometimes from week to week. Livestock producers must be vigilant in requesting current nutrient analysis reports. The by-products from ethanol production have not obtained co-product status and its appears the majority of ethanol companies are several years away from the consistency of production required to obtain co-product status for these by-products as an industry standard.

There are a few ethanol plants, or groups of ethanol plants where production by-products have reached co-product status. For example, the dried distiller's grains with solubles product produced as Dakota Gold® is a true co-product. The lower fat modified distiller's grains with solubles produced by the ADM plant in Peoria, IL has the consistency and limited variation in nutrient content to qualify as a co-product. On an industry-as-a-whole scale, however, distiller's grains products do not qualify as co-products. As an industry, distiller's grains lack of consistency in nutrient composition allow for considerable variation in price per unit weight. These variations in nutrient composition create difficulty for nutritionists when balancing diets but provide opportunity for entrepreneurs who can manage risk in creating least cost rations.

CHAPTER 2: SOYBEAN HULLS

Producers and nutritionists alike have an increased interest in by-product feeds due to their attractive costs. Research has shown several by-product feeds as excellent energy and protein sources. For traditional feeds, fractionation of carbohydrate, protein and ruminal degradation rates are fairly well established. Much less is known about high fiber by-product feedstuffs which compounds ration formulation, especially with regard to carbohydrate utilization.

Several factors influence the composition of by-products including grain quality and consistency in processing procedures. Variation in nutrient composition is one of the major problems associated with using by-product feedstuffs. Similar to forage testing, it is imperative that every batch of by-product purchased be analyzed for nutrient composition, particularly CP (crude protein), NDF (neutral detergent fiber) and ADF (acid detergent fiber). Replacement of high starch feedstuffs, such as barley or corn, with highly digestible fibrous by-products, especially when forage is the primary dietary ingredient, can alleviate some of the digestive disturbances associated with grain supplementation such as acidosis (grain over load and off feed), reduction of cellulytic activity in the rumen and lower concentrations of milk fat as related to lactating beef cows and backgrounding/growing feedlot cattle. Some of these fibrous by-product feeds such as soybean hulls may enhance rumination and may serve as an energy source.

Soybean hulls are a by-product of processing soybeans for oil and meal. Crude protein and NDF will vary but consistently average around 10% and 67%, respectively. One of the really unique properties of soybean hulls is that the NDF fraction approaches 95% ruminal digestibility. This high level rumen digestibility makes soyhulls comparable to corn as an energy source for cattle fed predominantly forage diets.

One study fed soyhulls as a substitute for concentrate at low (27%) and high (50%) levels to lactating dairy cattle. While there were no effects of soyhulls on the apparent digestibility of dry matter (DM) or CP, digestion of both NDF and ADF increased linearly with increasing substitution of soyhulls. Another study that substituted soyhulls for bromegrass hay at 15, 30, 45 and 60% of the diet observed linear increases in dry matter and cell wall (NDF) digestibilities as soybean hulls in the diet increased. When beef cows were fed low quality hay diets substituted with 2.2, 4.4, and 6.6 pounds per day of soybean hulls, linear increases in total feed intake, organic matter (total dry feed) digestibility and ADF digestibility occurred. Total ruminal VFA concentration also, increased linearly. When soybean hulls replaced corn as an energy supplement for growing beef calves concentrations of rumen acetate were higher and propionate were lower in steers fed soybean hulls. Several studies comparing soybean hull and corn supplementation for heifers grazing corn stalks observed improved gains for both supplements but soybean hulls supported higher gains than corn. Soybean hull diets produced gains in heifers that cost 4.5 to 5.5¢ per pound of gain less than control diets supplemented with corn (shelled corn = $2.50:bu).

Apparently, supplementing diets predominately composed of forage (either high quality or low quality roughage) with soybean hulls rather than corn improves overall performance. This increase in performance may, in part, be due to maintenance of stable rumen microbial populations when soybean hulls replace corn supplementation.

However, when soybean hulls were substituted for corn at 0, 20, 40 and 60% of diet dry matter in high concentrate beef finishing diets, feed efficiency (gain:feed) and average daily gain (ADG) decreased linearly. It appears, therefore, that replacing corn with soyhulls on high concentrate diets is not beneficial. This may be partly due to a shift in VFA production from a propionate fermentation to an acetate fermentation. Consequently, replacing corn with soybean hulls in high concentrate diets may actually decrease net energy available to the animal. Replacing oats with soybean hulls for growing replacement heifers may be an excellent cost effective management practice. Soybean hulls seem to be more beneficial as a supplement for growing heifers and production cows that are grazing or are fed hay compared with feedlot diets for finishing cattle.

Several years ago, we (Illinois State University) conducted a feedlot receiving study to evaluate the effects of four receiving diets that included soyhulls on pre-finishing performance, and subsequent finishing performance and carcass characteristics of steers. One hundred seventy-six Angus-Continental crossbred steers weighing 580 ± 23 pounds were fed diets consisting of mixed grass hay (brome, orchard and blue grass) fed ad libitum and a supplement fed at 1% of body weight (BW) containing either wheat midds and soyhulls (DI), corn gluten feed and ground shelled corn (D2), corn gluten feed and soyhulls (D3) or corn gluten feed (D4). The receiving period (P1) was 53d. The steers were harvested following a finishing period (P2) of either 195d or 204d. All steers were fed the same shelled corn-soybean meal-corn silage based diet ad libitum during the finishing period. Diet 1 contained 14.7% CP, 2.8% ether extract (EE), 52.8% NDF and 25.9% ADF. Diet 2 contained 15.2% CP, 4.4% EE, 32.6% NDF and 8.7% ADF. Diet 3 contained 14.1% CP, 3.4% EE, 60.8% NDF and 36.8% ADF. Diet 4 contained 24.0% CP, 4.3% EE, 35% NDF and 12.1% ADF. TheP2 diet contained 15.6 ± 3.2% CP, and 10.2 ± 4.8% ADF. No differences (P> 0.05) between dietary treatments were observed in number of steers treated for respiratory disease during PI though the D1 and D3 steers had more numeric pulls for medicinal treatment than D2 and D4 steers. No significant differences were observed between dietary treatments for ADG, ADFI, DMI or G:F during P1. No differences (P > 0.05) in P2 ADG, ADFI, DMI, G:F or any of the carcass traits were observed. Supplementing grass hay receiving rations with various combinations of wheat midds, soyhulls, corn gluten feed and ground shelled corn can result in similar steer performance during the receiving period with no effect on finishing performance or carcass characteristics. However, when supplementing grass hay diets with limited concentrate (1% of body weight), replacing shelled corn with soyhulls and wheat midds, or corn gluten feed and soyhulls may not reduce morbidity and may increase the number of steers requiring treatment for respiratory illness during the receiving period. Reduced pulls for steers fed diets containing shelled corn and/or corn gluten could be partially do to increased dietary energy concentration. The higher fiber diets containing wheat midds and soyhulls, when limited to 1% of body weight, may not provide enough energy to help steers cope with disease stress.

In another study, 192 Angus cross steers weighing 570 pounds were used in an 84 day receiving trial to determine the value of soyhulls and dried distiller's grains with solubles (DDGS) in low and high concentrate pre-finishing diets. The diets consisted of grass hay fed ad libitum and one of six pelleted supplements: shelled corn based, fed at 1% BW (SCI) or 2% BW (SC2); soybean hull based, fed at 1% BW (SH1) or 2% BW (SH2); shelled corn/DDGS based, fed at 1% BW (DDGS1) or 2% BW (DDGS2). No mortalities occurred during the 84d trial. There were significant differences, however, between dietary treatments in the number of steers observed with respiratory illness. Significantly more cattle receiving the shelled corn SC1 and SC2 based supplements required treatment for respiratory illness than the steers receiving either the soybean hull SH1 and SH2 or dried distiller's grains with solubles (DDGS1 and DDGS2) based supplement. None of the steers fed the 1% SH, 2% SH or 1% DDGS based supplements required pharmaceutical treatment during the first 28d on feed, but 46.9% of the steers fed the 2% corn (SC2), 9.4% of the steers fed the 1% corn (SC1) and 18.8% of the steers fed the 2% DDGS (DDGS2) based supplements required treatment on one or more occasions. Of the 192 steers in the trial, 12.5% required treatment one or more times. In addition, the total number of treatments were significantly greater for steers fed the corn based supplements than for the other dietary supplements. Perhaps the higher concentrate diet (SC2) resulted in lower rumen pH values that may have contributed to more respiratory illness. The higher fiber diets, especially the SH1 and SH2 based diets, appeared to promote smoother acclimation to full feed status. Steers exhibiting body temperatures more than one degree above normal (101.5 °F), combined with labored breathing and/or reduced appetite were selected for respiratory treatment. The number of treatments required was determined according to recovery to normal status on an individual steer basis. There were no significant differences in the initial starting weights of the steers. Steers receiving the 2% SH diet had faster ADG than the steers receiving the other five dietary treatments. Steers receiving the 2% corn gained significantly slower during the first 12d of the trial. These differences could be a direct result of the combination of total energy intake and health differences between these two groups of steers compared to the other dietary treatments.

Steers fed the 1% SH diet consumed significantly less daily dry matter intake (DMI) during the first 12d than steers fed the other dietary treatments. Steers receiving the 2% SH and 2% DDGS diets had significantly higher daily DMI during the first 12d than steers receiving the other dietary treatments. Steers fed the 1% SH and 2% SH diets had the highest G:F ratios while steers fed the 2% corn based diets had the lowest G:F ratios during the first 12d of the trial. Over the 84 day trial, steers fed the diets at the rate of 2% BW (SC2, SH2 and DDGS2) had higher ADG than steers fed the diets at 1% BW. No significant differences in ADG within either rate of consumption (1% or 2% BW) were observed between dietary treatments (C, SH, and DDGS).

Steers fed at the rate of 2% BW had significantly higher daily DMI than steers fed at the rate of 1% of BW. Steers fed SH at 1% BW had the lowest ($P < 0.05$) daily DMI. No significant differences in daily DMI were observed for steers fed the 1% corn or 1% DDGS diets. Steers fed 2% corn and 2% SH had significantly higher daily DMI than steers fed the 2% DDGS diet and significantly higher G:F ratios than steers receiving the other dietary treatments. The data suggest that feeding SH or DDGS at 2% BW is equal to or more advantageous than feeding corn at 2% BW. In addition, the data suggests that steers receiving grass hay ad libitum will have superior performance when fed C, SH or DDGS based supplements at 2% BW as opposed to 1% BW.

Fecal grab samples from steers fed supplements at the 2% BW level had significantly greater phosphorous (P) concentrations than fecal grab samples from steers fed supplements at the 1% BW level. An interesting observation was that P concentrations in the 2% SH and 2% DDGS grab samples were significantly lower than the P concentration of the 2% C fecal grab samples.

This data may suggest that the phosphorous in the co-products (SH and DDGS) is more digestible than phosphorous in corn when fed at higher concentrations (2% BW vs. 1% BW). However, fecal grab sample data may not be reflective of total fecal collection concentrations. Until total fecal collection in a metabolism study is obtained, P concentration in fecal grab samples should not be interpreted to represent P availability in co-products. None-the-less the observations noted are interesting.

In summary, feeding supplements at 2% BW inclusion rates supports significantly higher ADG in steers during a receiving period when steers are fed grass hay ad libitum compared to 1% supplement inclusion rates. Soybean hull based supplements improved steer performance during the first 12d of an 84d growing trial. Feeding a SH based supplement at 2% BW for 84d can result in similar steer performance to feeding either corn or DDGS based supplements at 2% BW. The co-products (SH and DDGS) appear more efficacious than corn based supplements when fed at a 2% BW inclusion rate.

Another study conducted at Illinois State University evaluated the effects of high fiber receiving rations containing wheat middlings and soybean hulls with an without Yucca Schidigera Extract – Sarsaponin (YS) on the performance of beef steers. In this study 176 Angus crossbred steers weighing 625 pounds were used. The receiving phase of this study referred to as P1 (18 days) and P2 (31 days) consisted on the first 49 days in the feedlot. During Phase 1 (P1) all cattle were fed grass hay ad libitum and a receiving ration at 2% of BW (wet wt. basis) containing 12.5% CP and 22% crude fiber (CF) with or without YS (1100 ppm) for 18d. During Phase 2 (P2) cattle were fed grass hay ad libitum and a ration at .95% of BW containing either wheat midds and soybean hulls (WS) or shelled corn and protein concentrate (SP) in a 75:25 ratio for 31d. All cattle were fed the same corn silage – shelled corn based diet during Phase 3 (P3). Phase 3 ran from day 50 in the feedlot until harvest. Similar performance ($P > 0.05$) was observed during P1 for steers whether or not the diet contained YS. During P2, steers consuming WS had significantly higher ending BW, significantly higher daily DMI and no significant difference in ADG or G:F ratio. No significant interactions were observed between P1 and P2 diets on P2 and P3 steer performance or carcass characteristics at harvest. Receiving diets supplemented with wheat midds and soybean hulls resulted in similar to greater steer performance compared to diets containing SP. Supplementing grass hay receiving rations with wheat midds and soybean hulls compared to shelled corn and a traditional protein concentrate can result in similar to greater steer performance during the receiving period with no effect on finishing performance. Supplementing receiving diets with Yucca Schidigera Extract did not improve steer performance.

In a study conducted at Illinois State University in the early 2000's the results were mixed when evaluating corn and soybean co-products in beef cattle finishing diets. This study evaluated the effects of diets containing 0, 25, or 40% dried distiller's grains with solubles (DDGS) and 44% soyhulls (SH), and length of time on feed (156, 187, or 263d) on the feedlot performance of 192 Angus crossbred steers (initial wt. = 766 pounds). Following an 84d receiving period (P1) in which steers were fed diets containing either shelled corn (SC), SH, or DDGS at 1 or 2% BW, steers were blocked by intake level and assigned within blocks to six dietary treatments (P2) with 4 replicates (24 pens, 6 or 10 steers/pen). Treatments were: 70.5% SC, 13.5% grass hay (GH), 13.5% soybean meal (T1); 59.0% SC, 13.5% GH, 25% DDGS (T2); 40.0% DDGS, 44.0% SH, 13.5% GH (T3); T3 fed for 28d (T4), 56d (T5), or 84d (T6) followed by T2 fed to harvest.

Steers were harvested after 156, 187, or 232d on the P2 diets. Data were analyzed using previous dietary treatment (P1) and harvest date as covariates; no interactions were observed between covariates and P2 treatments. Carcass measurements were similar between P2 treatments except for liver abscess scores, where T1 was significantly higher than T2 – T6. As expected, length of time on feed increased carcass weight, rib fat, KHP, marbling score and yield grade. Total dry matter intake (DMI) was similar between T1 and T2 but was significantly higher for T3 – T6. Average daily gain (ADG = 3.3 pounds) and feed efficiency (G:F = 0.12) were similar between T1 and T2 but was significantly higher for T3 – T6 (ADG = 2.2; G:F = 0.11). No significant differences in cost of gain were observed between treatments. Mean carcass measurements were carcass weight = 887 pounds, rib fat = 0.81 inches, ribeye area = 13.1 sq. in., KHP = 2.8 ± 0.1%, marbling score = 7.64 ± 0.1 (7 = avg. choice), yield grade = 4.24 ± 0.1, liver score = 1.5 ± 0.2 (range = 1-5) and dressing percent = 62.5 ± 0.2. These data suggest that feeding finishing cattle higher rates of DDGS and SH will result in similar quality and yield grades but will require higher total feed intake with lower ADG than diets containing whole shelled corn or than diets limited to 25% DDGS. In this study, 85% of the steers graded low choice or higher. However, steers fed the 40% DDGS/44% SH diet for the entire finishing period had significantly low ADG, higher average daily feed intake (ADFI) and less desirable feed efficiency (G:F) values. In this study, steers fed a shelled corn (SC) based diet that included 25% DDGS had similar ADG, ADFI, and, G:F performance as steers fed the shelled corn, control diet. Using the following prices SC = 6.7¢:lb. ($3.75:bu), soybean meal = 13.94¢:lb. ($278:ton), DDGS = 5.5¢:lb. ($110:ton) and SH = 5.5¢ ($110:ton), a feeding cost analysis was conducted. Costs per lb. of diet were 7.43¢ for the SC based diet, 6.19¢ for the 25% DDGS diet, and 5.48¢ for the 40% DDGS/44% SH based diet. Inclusion of co-products significantly reduced cost:lb. of gain compared to the SC based diet. Total cost of feed to harvest was greatest for the DDGS/SH based diet and lowest for the 25% DDGS diet. Gross dollar return over feed cost was highest for the 25% DDGS diet followed by the SC based diet and lowest for the 40% DDGS/44% SH diet. Total days on feed were 156 for the SC and 25% DDGS diets, and 232d for the 40% DDGS/40%SH diet. Two additional treatments were included in this study i.e. the 40% DDGS/44% SH diet was fed for the first 28 days or the first 56 days followed by the 25% DDGS diet fed until harvest. Because no differences in quality grades or yield grades were observed between diet treatments, steers fed either of the last two diet regimens returned more gross dollars over feed costs than either the steers fed the SC based diet or the 40% DDGS/44% SH based diet to harvest but returned less gross dollars over feed cost than the steers fed the 25% DDGS based diet.

The conclusions of this study were that 1) the shelled corn diets containing 25% DDGS can return more gross dollars over feed cost than diets without DDGS inclusion, 2) diets replacing shelled corn with high inclusion rates of DDGS and SH should be fed no longer than 30% of the total finishing period, and 3) steers can be fed a 40% DDGS/44% SH diet throughout the finishing period without negatively affecting quality grade or yield grade. However, feeding a diet containing 40% DDGS/44% SH will result in slower ADG and a longer feeding period to obtain similar quality and yield grades. Relative prices for traditional feeds and co-products will determine whether higher inclusion rates of co-products are economical.

Collectively, our studies suggest that receiving and/or back grounding diets for feeder calves containing higher levels of soybean hulls (fed at 2% of body weight) are equal to or more efficacious than diets containing shelled corn. However, for high concentrate finishing diets soyhulls, as a major dietary feedstuff, may not provide enough energy support optimum (maximum) weight gain. Our recommendations are to utilize soybean hulls in receiving / back grounding diets that are higher roughage diets and to limit soyhull use in finishing diets to 10 – 15% of the diet dry matter as a fiber source. A major drawback to feeding soybean hulls is availability in a local area and subsequent transportation cost. Soybean hulls are light weight and have a low bulk density. Therefore, truckers are limited in the tons of hulls they can haul in any one trailer. Soybean hulls are generally sold in bulk, requiring appropriate on farm storage facilities. Soyhulls are available in two forms – meal or pellets. Pelleting generally adds $5:ton to the cost. Pellets result in more uniform mixes when preparing TMR's (total mixed rations) if the other feedstuffs are considered dry matter feedstuffs (less than 20% DM). In dry feedstuff TMR's, meal often settles out of the mixture. If one or more of the TMR feedstuffs, is a high moisture feedstuff (greater than 20% DM) then soyhull meal can be uniformly mixed by adhering to the higher moisture feedstuff. Either soyhull meal or pellets can be top-dressed successfully in a feed bunk.

CHAPTER 3: CORN GLUTEN FEED

As we begin this discussion, perhaps a quick review of the composition of the corn kernel and the co-products produced from processing the corn kernel is in order. Yellow Dent Shelled Corn contains 61.0% starch, 3.8% oil, 8.0% protein and 11.2% fiber at 16% moisture. Corn Gluten Feed is a co-product of the corn wet milling industry. The process involved in the corn wet milling industry begins with cleaning shelled corn to remove any foreign material. In order to prepare the corn for milling and the separation process, the corn is soaked in water and sulfur dioxide, swelling the kernels. In the soaking process (steeping) essential nutrients are absorbed by the water (steep liquor). When the soaking or steeping is complete, this water or liquor is drawn off and concentrated. During the subsequent wet-milling process, the corn germ is separated from the kernel. The germ is processed to remove the oil. After the germ has been removed, the remaining portion of the kernel, containing the bran (exterior portion or hull of the kernel), gluten and starch are screened and the bran removed. The bran or fiber is then mixed with steep liquor and sold as dry corn gluten feed (DCGF) or as wet corn gluten feed (WCGF). Approximately 12 – 15 pounds of DCGF are produced per bushel of corn processed. The starch can be used to produce fructose sweetener or ethanol. The nutrient composition of corn gluten feed typically is 21% protein, 8.4% fiber, 3.5% fat, 0.1% calcium, 0.23% sulfur and 1.0% phosphorus. Generally, DCGF contains approximately 10% moisture and WCGF contains 40 – 60% moisture.

Research conducted at the University of Illinois under the direction of Larry Berger in the 1980's demonstrated the value of DCGF and WCGF in the diets of finishing beef cattle. Table 2 shows the results of some of that work. When affordable, corn gluten feed can be an attractive feedstuff for inclusion in cattle diets. Tables 3 and 4 are modified from tables originally developed years ago by Dan Loy, Iowa State University Extension Beef Specialist. These tables compare the feed replacement value of wet and dry corn gluten feed relative to the price of soybean meal and corn grain. At current prices, DCGF and WCGF are reasonably priced FOB, but depending on transportation distance from plant to feedlot these two co-products may be too expensive compared to shelled corn.

TABLE 2. Performance Of Finishing Steers Fed Three Levels Of Wet Corn Gluten Feed

Wet Corn Gluten Feed (%)	0	50	50	70	70	90
Item	90% Conc. With 10% Corn Silage	With 10% Corn Silage	Without Corn Silage	With 10% Corn Silage	Without Corn Silage	Without Corn Silage
Daily gain, lbs.	2.73[a]	2.95	2.90[bc]	2.77[e]	2.92[bce]	2.68[bc]
Dry Matter intake, lbs.	17.4[a]	19.4	18.8	19.5[d]	18.9[d]	17.8
Feed / gain	6.40	6.57	6.48	7.04[e]	6.47[e]	6.64
Dressing Percentage	63.5	63.6	64.5	63.8	64.1	63.4
Quality Grade	9.77	9.52	9.77[c]	9.58	10.32[c]	8.80[c]
Yield Grade	2.79	1.76	2.77	2.70	1.13	2.49
Livers Condemned	11.8[a]	14.7	35.3[e]	11.8[e]	23.5[ce]	32.4[c]

[a] Significantly different from the average of the WCGF treatment (P < 0.5).
[b] Linear treatment effect (P < 0.5).
[c] Quadratic treatment effect due to corn silage (P < 0.6).
[d] Treatment effect due to corn silage (P < 0.5).
[e] treatment effect due to corn silage (P < 0.5).
[F] 9 = High Good; 10 = Low Choice; 11 = Average Choice.

TABLE 3. Value Of Dry Gluten As A Protein & Energy Source

Cost of Soybean Meal ($/T)						
Cost of Corn ($/bu.)	100	125	150	175	200	220
Value of Dry Corn Gluten Feed ($/T)						
2.00	79.66	88.66	97.66	106.66	115.66	122.86
2.25	85.12	94.12	103.12	112.12	121.12	128.32
2.50	90.58	99.58	108.58	117.58	126.58	133.78
2.75	96.03	105.03	114.03	123.03	132.03	139.23
3.00	101.49	110.49	119.49	128.49	137.49	144.69
3.25	106.95	115.95	124.95	133.95	142.95	150.15

Table 4. Value Of Dry Gluten As A Protein And Energy Source

Cost of Soybean Meal ($/T)										
Cost of corn ($/bu.)	200	225	250	275	300	325	350	375	400	425
Value of Dry Corn Gluten Feed ($/T)										
3.25	142.95	151.95	160.95	169.95	178.95	187.95	196.95	205.95	214.95	223.95
3.50	148.41	157.41	166.41	175.41	184.41	193.41	202.41	211.41	220.41	229.41
3.75	153.87	162.87	171.87	180.87	189.87	198.87	207.87	216.87	225.87	234.87
4.00	159.33	168.33	177.33	186.33	195.33	204.33	213.33	222.33	231.33	240.33
4.25	164.79	173.79	182.79	191.79	200.79	209.79	218.79	227.79	236.79	245.79
4.50	170.25	179.25	188.25	197.25	206.25	215.25	224.25	233.25	242.25	251.25
4.75	175.71	184.71	193.71	202.71	211.71	220.71	229.71	238.71	247.71	256.71
5.00	181.17	190.17	199.17	208.17	217.17	226.17	235.17	244.17	253.17	262.17
5.25	186.63	195.63	204.63	213.63	222.63	231.63	240.63	249.63	258.63	267.63
5.50	192.09	201.09	210.09	219.09	228.09	237.09	246.09	255.09	264.09	273.09
5.75	197.55	206.55	215.55	224.55	233.55	242.55	251.55	260.55	269.55	278.55
6.00	203.01	212.01	221.01	230.01	239.01	248.01	257.01	266.01	275.01	284.01
6.25	208.47	217.47	226.47	235.47	244.47	253.47	262.47	271.47	280.47	289.47
6.50	213.93	222.93	231.93	240.93	249.93	258.93	267.93	276.93	285.93	294.93
6.75	219.39	228.39	237.39	246.39	255.39	264.39	273.39	282.39	291.39	300.39
7.00	224.85	233.85	242.85	251.85	260.85	269.85	278.85	287.85	296.85	305.85
7.25	230.31	239.31	248.31	257.31	266.31	275.31	284.31	293.31	302.31	311.31

TABLE 5. Value Of Wet Gluten As A Protein & Energy Source

Cost of Soybean Meal ($/T)						
Cost of Corn ($/bu.)	100	125	150	175	200	220
Value of Dry Corn Gluten Feed ($/T)						
2.00	44.50	49.53	54.56	59.59	64.61	68.6
2.25	47.55	52.58	57.61	62.64	67.66	71.6
2.50	50.60	55.63	60.66	65.69	70.71	74.7
2.75	53.65	58.68	63.71	68.74	73.76	77.7
3.00	56.70	61.73	66.76	71.79	76.81	80.8
3.25	59.75	64.78	69.81	74.84	79.86	83.8

Table 6. Value Of Wet Gluten As A Protein And Energy Source

Cost of corn ($/bu.)	Cost of Soybean Meal ($/T) 200	225	250	275	300	325	350	375	400	425
	Value of Dry Corn Gluten Feed ($/T)									
3.25	79.86	84.89	89.92	94.95	99.98	105.01	110.04	115.07	120.10	125.13
3.50	82.91	87.94	92.97	98.00	103.03	108.06	113.09	118.12	123.15	128.18
3.75	85.96	90.99	96.02	101.05	106.08	111.11	116.14	121.17	126.20	131.23
4.00	89.01	94.04	99.07	104.10	109.13	114.16	119.19	124.22	129.25	134.28
4.25	92.06	97.09	102.12	107.15	112.18	117.21	122.24	127.27	132.30	137.33
4.50	95.11	100.14	105.17	110.20	115.23	120.26	125.29	130.32	135.35	140.38
4.75	98.16	103.19	108.22	113.25	118.28	123.31	128.34	133.37	138.40	143.43
5.00	101.21	106.24	111.27	116.30	121.33	126.36	131.39	136.42	141.45	146.48
5.25	104.26	109.29	114.32	119.35	124.38	129.41	134.44	139.47	144.50	149.53
5.50	107.31	112.34	117.37	122.40	127.43	132.46	137.49	142.52	147.55	152.58
5.75	110.36	115.39	120.42	125.45	130.48	135.51	140.54	145.57	150.60	155.63
6.00	113.41	118.44	123.47	128.50	133.53	138.56	143.59	148.62	153.65	158.68
6.25	116.46	121.49	126.52	131.55	136.58	141.61	146.64	151.67	156.70	161.73
6.50	119.51	124.54	129.57	134.60	139.63	144.66	149.69	154.72	159.75	164.78
6.75	122.56	127.59	132.62	137.65	142.68	147.71	152.74	157.77	162.80	167.83
7.00	125.61	130.64	135.67	140.70	145.73	150.76	155.79	160.82	165.85	170.88
7.25	128.65	133.69	138.72	143.75	148.78	153.81	158.84	163.87	168.90	173.93

As shown in table 2, ADG peaks when the diet contains 50% WCGF and 10% corn silage. These performance results with WCGF are similar to more recent studies we (Illinois State University) have conducted with modified wet distiller's grains in which we have observed two things. One, if 10-15% roughage is included in the diet, higher levels of distiller's grain can be included in the diet. Two, greater biological performance is observed when moderate amounts of distiller's grains are fed. Table 2, also, shows that higher inclusion levels of WCGF corn be fed (70-90% inclusion) successfully but performance (ADG, DMI, F/G) and quality grade may lowered. Therefore, the relative price paid for WCGF is the determining factor whether or not to include higher levels WCGF into finishing rations.

Another important point regarding including DCGF or WCGF in finishing diets is the relatively lower sulfur concentration (0.23%) compared to distiller's grains. The sulfur concentration in distiller's grain can range from 0.4 to over 1.0%. Sulfur toxicity or polio encephalomalacia (PEM) is seldom a problem in diets containing corn gluten. However, just like shelled corn, DCGF and WCGF are low in calcium and high in phosphorous; and, similar to distiller's grain, DCGF and WCGF have a reverse Ca:P ratio. Therefore, diets containing corn gluten feed must be supplemented with calcium. Numerous feed companies produce a balancer (premix designed to supplement diets containing corn gluten feed). These premixes may contain calcium (Ca), thiamin (vitamin B), an ionophore and other trace minerals or vitamins necessary to maximize performance when including corn gluten feed. At Illinois State University we mix our own simple premix that contains Ca, thiamin, Rumensin® and on occasion ammonium chloride that we add to each TMR (total mixed ration).

Some innovative feedlot operators/consulting nutritionists recommend including both corn gluten feed and distiller's grain in finishing diets. Including both feedstuffs has been a way to reduce ration costs by including more corn by-products when the diet already included 40-45% distiller's grain by adding 20-30% corn gluten feed. Diets that include both distiller's and gluten can work very well, but as I will discuss in Chapter 4 including up to 70% distiller's grains is feasible. Because corn gluten feed has a similar crude fiber value but lower ADF concentration (acid detergent fiber) compared to distiller's grains, corn gluten feed may have more value in backgrounding or growing diets than in finishing diets for cattle that are fed high forage diets- either grazing grass or crop residues, or in dry lot fed TMR's.

CHAPTER 4: CORN DISTILLER'S GRAINS

Introduction

Distiller's Grains, either wet distiller's grains with solubles (WDGS) or modified wet distiller's grains with solubles (MWDGS) or dried distiller's grains with solubles (DDGS) are co-products of the corn dry milling industry. Accordingly, distiller's grains can be defined by moisture content: WDGS = greater than 65% moisture, MWDGS = 40 to 60% moisture and DDGS = 15% moisture or less. The ethanol process begins by cleaning shelled corn followed by grinding to produce a corn meal. The corn meal is then combined with water and alpha amylase enzyme, heated to 180 °F, placed into fermentation vats, and cooled to 90 °F where yeast and gluco-amylase enzyme are added. During fermentation CO_2 is captured. Following fermentation for 40-60 hours ethanol is produced through a distillation process and the resulting whole stillage undergoes evaporation to produce condensed distiller's solubles, or is dried to produce DDGS or is collected in high moisture state to produce WDGS or MWDGS. Dry milling will typically produce 2.8 gallons of ethanol, 18 pounds of DDGS and 18 pounds of CO_2 per bushel. Condensed distiller's solubles is generally 29% protein, 9-12% fat and 4% fiber; DDGS is typically 27% protein, 11% fat and 9% fiber. Wet DGS (WDGS or MWDGS) can contain 30-70% moisture while DDGS is usually 10-12% moisture.

Efficiency Improvement

Distiller's grains can be used for either protein supplementation or energy supplementation of finishing, backgrounding, or heifer / cow diets. Considerable difference exists between corn gluten feed (wet milling) and distiller's grains (dry milling) in terms of nutritional value, primarily based on how the products are made during milling. The energy value of wet distiller's grains is approximately 125% the value of corn in finishing diets. Performance may be improved even further if cattle are experiencing acidosis. When dried, the energy value of DDGS is reduced to approximately 110-115% of the value of dry shelled corn. In the 84-day study described in Chapter 2 where-in steers were fed one of three diets during a receiving period (ground shelled corn based, soybean hull based or shelled corn/DDGS based) feeding the corn/DDGS diet provided similar to superior feedlot performance compared to the shelled corn based diet. Based on the rates of gain and feed intakes observed in that study, the energy values of soybean hulls and DDGS are underestimated by NRC and were approximately 104 and 117% the energy value of shelled corn, respectively.

Estimated average daily gains based on NRC – 2000 ingredient values and requirements are presented in Table 7 along with actual daily gains. Actual daily gains exceeded predicted ADGs on all treatments by .38 to 1.19 lb. except with the 2% BW corn concentrate treatment in which actual (2.60 lb.) and predicted (2.53 lb.) ADG were very similar. The wheat-midds/soybean hull and corn/DDGS concentrates fed at 1% of BW exceeded the predicted ADG by the largest amounts (1.11 and 1.05 lb.). An adjusted predicted ADG was calculated based on the actual ADG relative to the corn concentrate treatments. These ADG values were then used to estimate NEm and NEg that would be necessary in soy hulls and DDGS in order for these ADGs to be achieved based on NRC-2000 requirements and energy values for corn and other ingredients. These calculated energy values for soy hulls and DDGS are shown in Table 8. Based on these calculations, soy hulls have an energy value equal to 104 to 105% of corn, compared to current NRC values which are 79 to 83% of corn. Current NRC energy values for DDGS are about 97%

of corn. Performance data from this trial suggest an energy value for DDGS of 117% or more compared to shelled corn.

Table 7. Actual vs. Predicted ADG (lb.) For The 84-Day Growing Period.

Treatment Concentrate Level	Concentrate Type	Actual	NRC Predicted[a]	Adjusted Predicted[b]	Actual % of Corn
1	Corn	1.99	1.14	1.14	–
1	Soybean hulls	1.89	.78	1.08	95
1	Corn/DDGS[c]	2.18	1.13	1.25	109.5
2	Corn	2.60	2.53	2.53	–
2	Soybean hulls	2.92	2.10	2.84	112.3
2	Corn/DDGS	2.81	2.46	2.74	108.1

[a] predicted ADG based NCR, 2000.

[b] Adjusted predicted = actual ADG as a % of corn treatments x NRC predicted for corn.

[c] Corn distiller's dried grains with solubles.

Table 8. Estimated NEm And NEg (Meal/kg) For Soybean Hulls And DDGS Based On Adjusted Predicted ADG From Table 7

	NEm	% of corn		NEg	% of corn
Soybean Hulls	2.354	105		1.608	103.7
DDGS[b]	2.755	123		1.710	116.8
Corn	2.25			1.55	

[a] Estimated NEm and NEg for soybean hulls and DDGS necessary for diets with these ingredients to achieve the adjusted predicted ADGs.

[b] Corn distiller's dried grains with solubles.

The data from this study suggest that feeding soy hulls or corn/DDGS concentrates at 2% of BW is equal to or more advantageous than feeding a corn based concentrate at 2% of BW during a cattle feedlot receiving or adaptation period. In addition, the data suggest that steers receiving grass hay *ad libitum* will have superior performance (ADG) when fed any of the concentrates at 2% of BW as opposed to 1% of BW.

With the by-product based concentrates (soybean hulls, DDGS) fed in this study, rates of gain of steers exceeded predicted gain based on NRC requirements. In a previous study NRC energy values predicted ADG very closely for steers fed a corn-based concentrate, but underestimated the gain for a wheat midds/soy hulls-based concentrate. In this study, the corn based concentrate fed at 2% of BW was the treatment in which actual ADG was similar to predicted ADG. Clearly, in this and the other studies, current NRC estimates of the energy value of by-products such as wheat middlings, corn gluten feed, DDGS and soybean hulls do accurately predict the rate of gain of cattle fed grass hay-based diets.

Dr. Terry Klopfenstein and colleagues at the University of Nebraska conducted a pen level metanalysis of 20 trials involving 3,365 steers, wherein WDGS replaced dry rolled corn (DRC) or a DRC and high moisture corn (HMC) blend for calf feds or yearlings.

Replacement of corn with up to 40% of diet DM as WDGS resulted in superior performance compared to cattle fed no WDGS (Table 9). Dry matter intake, ADG, F:G, 12th rib fat, and marbling score improved as WDGS inclusion level increased. The feeding value of WDGS was consistently greater than corn when WDGS was included up to 40% of diet DM. The feeding value was greater at lower WDGS inclusion levels and decreased as inclusion level increased. All steers fed in the data sets were part of the University of Nebraska-Lincoln system, wherein the research feedlot utilizes spring born, predominately black, crossbred steers weaned in the fall for most research trials. After an initial receiving period, the largest steers are fed as calf-feds in the winter, the medium steers are fed as short yearlings in the summer after wintering on cornstalks, grazed on grass the following summer, and finished in the fall to market by 24 months of age. Season of feeding and steer age are confounded in this system. This study indicated greater feeding value of WDGS for yearlings than calf-feds. As expected, calf-feds were more efficient than yearlings (Table 10). The feeding value of WDGS regardless of corn processing type, was greater for yearlings than for calf-feds. The feeding value of WDGS was a constant 136% of DRC and a constant 124% of a DRC and HMC blend for calf-feds due to linear improvement in F:G as WDGS replaced corn. Yearling performance improved quadratically as WDGS level increased, regardless of corn processing type. The feeding value of WDGS for yearlings decreased linearly in both DRC and blended corn diets. Feeding value of WDGS replacing 20-40% of diet DM for yearlings decreased from 159 to 143% of DRC, and from 146 to 131% for a blend of DRC and HMC.

The feeding values of DRC and a blend of DRC and HMC were similar for 0% WDGS fed steers within cattle type. The feeding value of WDGS was greater when WDGS replaced DRC as compared to a corn blend at any inclusion level of WDGS.

Only one trial has evaluated feeding WDGS, replacing HMC with WDGS in diets and feeding WDGS to replace DRC. That trial evaluated replacing each corn type with up to 40% of diet DM as WDGS. The DRC 0% WDGS fed cattle performed similarly to the winter DRC-only fed cattle. The HMC had 115% of the feeding value of DRC in the trial. The improvement in F:G of increasing WDGS from 0 to 40% WDGS in HMC diets is less than the improvement in F:G of DRC and corn blend due to HMC having greater feeding value than DRC. As HMC is replaced by WDGS, the feeding value replacement is less than the feeding value differential of WDGS and DRC. These data suggest the combination of 47.5% of diet DM as HMC and 40% of diet

DM as WDGS has a feeding value equal to 122% of DRC. The results of the trial reiterate the conclusion that the feeding value of WDGS was superior to DRC and HMC. The feeding value of WDGS was greater for yearlings than for calf-feds. The feeding value of WDGS was greater in DRC diets than in corn blended diets. The combination of WDGS and HMC provided cattle performance superior to DRC with or without WDGS.

Table 9. Finishing Steer Performance When Fed Different Dietary Inclusions Of Wet Distiller's Grains Plus Solubles (WDGS)

WDGS Inclusion[1]	0WDGS	10WDGS	20WDGS	30WDGS	40WDGS
DMI, lb./day	23.0	23.3	23.3	23.0	22.4
ADG, lb.	3.53	3.77	3.90	3.93	3.87
F:G	6.47	6.16	5.96	5.83	5.78
12th rib fat, in	0.48	0.52	0.54	0.55	0.55
Marbling score [2]	528	535	537	534	525
Feeding value, %[3]		150	143	136	130

[1] Dietary treatment levels (DM basis) of wet distiller's grains plus solubles (WDGS), 0WDGS = 0% WDGS, 10WDGS = 10%, 20WDGS = 20% WDGS, 30WDGS – 30% WDGS, 40WDGS = 40% WDGS.

[2] 500 = Small.

[3] Percentage of corn feeding value, calculated from predicted F:G relative to 0WDGS F:G, divided by WDGS inclusion.

Table 10. Finishing Steer Performance When Calf-Feds Or Yearlings Were Different Dietary Inclusions Of Wet Distiller's Grains Plus Solubles (WDGS) Replacing Dry-Rolled Corn (DRC) Or A Blend Of DRC And High-Moisture Corn (HMC)

WDGS Inclusion[1]	0WDGS	10WDGS	20WDGS	30WDGS	40WDGS
Winter Calf-feds					
DRC diet, F:G	6.17	5.95	5.75	5.56	5.38
Feeding Value, % of DRC[2]		136	136	136	136
DRC and HMC Blend, F:G	6.17	6.02	5.89	5.76	5.63
Feeding value, % of Corn Blend[2]		124	124	124	124
Summer Yearlings					
DRC diet, F:G	6.76	6.34	6.05	5.86	5.76
Feeding value, % of DRC[2]		167	159	151	143
DRC and HMC Blend, F:G	6.76	6.41	6.19	6.06	6.02
Feeding value, % of Corn Blend[2]		154	146	138	131

[1] Dietary treatment levels (DM basis) of wet distiller's grains plus solubles (WDGS), 0WDGS = 0% WDGS, 10WDGS = 10%, 20WDGS = 20% WDGS, 30WDGS – 30% WDGS, 40WDGS = 40% WDGS.

[2] Percentage of respective corn processing type feeding value, calculated from predicted F:G relative to 0WDGS, F:G divided by WDGS inclusion.

The feed efficiency advantage of steam-flaked corn (SFC) over dry-rolled corn (DRC) was much lower in finishing rations containing 35% wet distiller's grains plus solubles (WDGS) than in rations containing no WDGS, according to University of Nebraska research.

In this study crossbred yearling steers weighing 779 lbs. were used to evaluate the effects of feeding different ratios (0, 25, 50, 75 and 100%) of DRC and SFC in rations containing 35% WDGS on a dry-matter basis. Flake density of the SFC averaged 31.5 lbs./bu. The roughage component of all diets was corn silage and alfalfa hay, and a liquid supplement was fed.

Steers fed 100% SFC had a lower dry matter intake (23.7 vs. 25.6 lbs./day) and similar daily gain compared to steers fed 100% DRC. In cattle fed 100% SFC with no WDGS, overall feed to gain (F:G) was improved, while conversion efficiency of the corn grain portion of the diet was enhanced by 12.3% compared to steers fed 100% DRC with no WDGS. This represents a fairly typical response to steam flaking compared to dry rolling. In contrast, F:G was not different across the two corn processing ratios for the cattle fed 35% WDGS. Conversion efficiency of the corn grain portion of the diet was improved only 4.3% in the cattle fed all SFC with WDGS compared to steers fed all DRC with WDGS. Dry matter intake (24.2 vs. 25.3 lbs./day), average daily gain (4.38 vs. 4.77 lbs./day) carcass weight (885 vs. 920 lbs.), and the USDA Yield Grade (3.6 vs. 3.9) were all greater in the steers fed 35% WDGS compared to cattle fed no WDGS, regardless of the corn-processing method.

Feedlot owners and managers operating steam flakers and feeding higher levels of WDGS should evaluate the current cost-benefit comparison of steam flaking corn. Steam flaking may not be necessary. Dry rolling may be an attractive alternative.

Common Misconceptions and Frequently Asked Questions About DGS

Just like almost any subject, the greater the notoriety, the greater the number of misconceptions regarding its use. This section addresses some of the misconceptions regarding the feeding of corn distiller's grains to beef cattle.

Misconception No. 1: Corn gluten and corn distiller's grains are the same thing.

Some facts: Corn gluten is the by-product from converting corn grain into fructose. Corn gluten can be sold as corn gluten meal (CGM) or as corn gluten feed (CGF). Corn gluten meal is much higher in protein (around 46%) than corn gluten feed (around 25%). Corn gluten feed is sold as either dry (10% moisture) or wet (40 - 60% moisture). Corn distiller's grains with solubles

(DGS) is the by-product from converting shelled corn to ethanol. It too, can be sold dry (DDGS) or wet (WDGS - ranging from 40% to 70% moisture). Generally DGS is higher in protein, fat and energy than CGF. Four rules-of-thumb can be considered when using these by-products in cattle diets:

- pound for pound, CGF is priced lower than DGS but CFG contains less net energy for gain than DGS.
- the addition of DGS to finishing rations raises dietary energy level more than CGF when replacing shelled corn.
- when low cost roughage is available, DGS is more attractive than CGF when added at higher dietary levels.
- when dietary roughage is expensive CGF inclusion may lower feed costs.

Some feedlot operations are including both CGF and DGS into finishing diets as replacements for corn grain when by-product inclusion levels exceed 45% of the diet dry matter (DM). While research at Illinois State University has shown that finishing diets can include up to 70% DGS (addressed in a later section), several producers have combined CGF and DGS to increase by-product inclusion up to 60% of the diet DM.

Misconception No. 2: I'm a cattle feeder with a small feedlot, I can't feed high moisture DGS (WDGS) because it will spoil too fast.

Some facts: Research at Illinois State University has reported two, low cost methods for storing high moisture DGS. When very low volumes of DGS are fed daily (feeding 50 cattle or less) a vacuum method can successfully store wet DGS. When higher volumes of DGS are fed daily (feeding 200 - 300 cattle) the salting method works very well. At Illinois State University we fill a 20' wide by 80' long by 10' high bunker with wet DGS, level the top, hand sprinkle one lb. of salt per one square foot and cover with a plastic tarp. We feed wet DGS year around with minimal storage loss. These low cost storage methods work well for modified wet DGS (40% - 60% moisture) but not well for high moisture DGS (greater than 60% moisture).

Misconception No. 3: All corn DGS are the same.

Some facts: Corn DGS varies substantially from plant to plant and within a plant from one time to another time. Distiller's grains can vary in nutrient content based on the amount of condensed distiller's solubles (CDS) also, known as syrup, the plant adds to the distiller's grains. Protein content, amount of fat, phosphorous percent and sulfur concentration are primary nutrients that can vary substantially. Only purchase DGS, from plants with a current (weekly) nutrient analysis.

Misconception No 4: I don't have a feed mixer so I can't include DGS in my diets.

Some facts: Certainly a portable, batch, feed mixer (and there are several makes and models available) facilitates the use of by-product feedstuffs, their incorporation into balanced diets and their correct distribution in rations. Portable vertical grinder-mixers have been a great invention for making cost effective diets containing modified wet CGF and DGS in combination with lower cost roughages. However, CGF and DGS can be effective dietary ingredients when top dressed onto corn silage or ground hay, or when fed at a bunk separate from hay feeders.

It is more accurate and diets can be optimized when a home mixed, pre-mix containing an ionophore, thiamine and calcium carbonate can be added to shelled corn, DGS and corn silage in a horizontal portable mixer and bunk distributed similar to the way rations are fed at the ISU Farm. But, several companies sell supplements specifically designed to complement rations containing CGF and DGS as either a top dress or as part of a total mixed ration.

A general summary statement is that CGF and DGS can be utilized effectively by larger and smaller cattle operations and by both feedlot and cow-calf producers.

How much DGS can I feed?

There are basically two types of DGS – dried/90% dry matter (dried distiller's grains with solubles – DDGS) and wet/60-40% dry matter. Therefore, in order to feed the same amount of nutrients, diets must be formulated on a dry matter (DM) basis. Approximately twice as much wet DGS must be fed compared to DDGS. Moisture content of DGS is a huge concern because it can affect total ration intake. Ethanol plants can produce three types of DGS from a moisture perspective: dry (90% DM), modified wet (35-55% DM) and wet (60+% DM).

How much DGS can I feed to feeder cattle?

Historically, we have fed up to 25% of the diet DM with excellent results. More recently several research studies have successfully fed up to 40% of the diet DM as DGS. Much of the published industry information suggests no more than 50% of the diet DM should be composed of DGS. Several studies feeding higher levels of DGS (up to 70% of the diet DM) are being or have been conducted. Feeding more than 40% of the diet DM as DGS has lowered ration intake, decreased average daily gain, altered feed efficiency, changed carcass quality grade in some cases and may or may not affect cost of gain – depending on the cost of DGS relative to other ingredient costs.

Is the high sulfur content of DGS of real concern?

Yes, it is. The sulfur content of distiller's grain can range from 0.33% to 1.23% on a dry matter basis. High dietary sulfur contents can cause health problems from two perspectives – sulfur toxicity and polio encephalomalacia (PEM). Sulfur levels above 0.4% can cause sulfur toxicity resulting in loss of appetite, diarrhea, muscular twitching, dyspnea and inactivity symptoms, and ultimately death. Sulfur toxicity complications can be magnified if the drinking water is high in sulfur. When including DGS with higher sulfur contents into cattle diets, producers should also, test the drinking water for sulfur concentration, especially if the water has a sulfur odor. Some ethanol plants that add the solubles fraction to DGS and then dry the product (DDGS) create a DDGS high in sulfur. Not all DGS are created equal.

High DGS sulfur contents can cause thiamine (Vitamin B1) deficiency by decreasing the population of rumen bacteria that produce thiamine. Thiamine deficiency, polioencephalomalacia (PEM) can be prevented by adding supplemental thiamine. Typical thiamine supplementation levels range from 100 to 200 mg thiamine per head per day. Several companies manufacture and sell premixes containing thiamine that are specifically designed for beef cattle rations.

Where can I get DGS and is it economical to feed?

Many producers are located within 50-80 miles of an ethanol plant. As more ethanol plants are built, more producers will be located within 50-80 miles of a plant. As the distance DGS must be hauled, especially wet DGS, increases above 50 miles, the low purchase cost advantage for DGS is absorbed by the increased transportation costs. Because all feedlots are located near (within 10 miles) a grain elevator, transportation costs for shelled corn are often not included though they should be. Because ethanol plants are usually further distance from the feedlot, transportation costs must be added to the purchased cost so accurate comparisons between shelled corn and DGS can be made.

Do I need to feed a different mineral if I feed DGS?

Yes, you do. Distiller's grains are relatively high in phosphorous (P) and low in calcium (Ca) with an inverse Ca: P ratio. Including ground limestone into total mixed rations can balance the Ca:P ratio. Several feed companies offer mineral mixes specifically designed for diets with higher DGS inclusion levels. Feeding normal 1: 1, Ca: P mineral mixtures will only compound the high P content of DGS.

While distiller's grains can be an economical feedstuff, DGS are not a necessary component in all rations. Distiller's grains offer cattle producers opportunities that may or may not be profitable for every management scenario.

Wrestling with Input Costs – What Are My Choices?

Many commodity prices have doubled over the past four years while livestock prices have remained fairly consistent. Actually market hog prices have dropped, then rebounded some and fed cattle prices are at near record levels (on a live weight and carcass weight basis) even after peaking near $130:live cwt. Even so, high feed costs are making it difficult to realize profits and in some instances, difficult to break even. So what are our choices?

Actually each livestock feeder has three choices. They are:

- Sell the livestock. Cut your losses or take a profit and quit the business. Some producers/feeders are making this choice. In the cattle industry this scenario bothers me a great deal. I worry about the long term effects of lower cattle numbers on the viability of the beef industry. Fewer beef cows translates into less cattle on feed and ultimately a smaller market share of the retail meat case. A reduced market share may mean higher beef/cattle prices shorter term, but longer term it relates to a smaller, less viable industry. Expansion of this choice suggests the commercial beef industry either consolidates and both vertically and horizontally integrates following the swine and poultry industries or it withers and follows the sheep industry.

- For folks in the cow-calf industry, keep doing what you have always done, realizing it's a hobby anyway. Fifty percent of the beef cows are owned by 90% of the producers and many beef cow herds represent a 3rd or 4th income source. Making $50:head profit on 30 calves is only $1500 anyway, so relative to other family income sources, it just doesn't matter.

For Feedlot operators, you can hang-in-there, feeding the same ole way and eventually go broke or you can adapt to change. Innovative marketing strategies are available. Custom feeding options could be considered.

- Feed alternative feedstuffs and reduce the largest variable expense associated with feeding cattle and raising cows. This choice makes real world sense for those producers who want to help maintain a viable beef industry.

Table 11 has commodity prices typical for 2006 (then) and now (2008 to present). This table compares the prices of various feedstuffs in terms of price per unit weight on an as is, moisture included basis; of price per pound of total digestible nutrients (TDN); and, of price per pound of crude protein (CP). This table shows that per pound of TDN, corn silage is the most economical feedstuff with the exceptions of wet distiller's grains (DGS) and corn gluten feed (CGF) whether the price of shelled corn is higher (2008) or lower (2006). Not counting non-protein nitrogen (NPN) feedstuffs (urea and anhydrous ammonia), soybean meal has always been and continues as the best CP buy with the exception, on occasion of DGS and CGF. For beef cows in the corn belt (sometimes now referred to as the ethanol belt) hay has always been and continues to be too expensive to feed to beef cows for energy (TDN) compared to corn silage. The problem always has been for the smaller scale cow herd (30 cows or less). It is difficult to feed enough corn silage each day to keep the stored feedstuff from spoiling. Therefore, many producers have chosen hay as the primary roughage (energy source). Also, hay can be lower cost to harvest and store than corn silage.

Given the wider spread availability of DGS and CGF today compared to previous years, more producers are considering, and are correct to do so, these feedstuffs as alternatives to shelled corn, soybean meal and hay. Combining wet DGS and CGF with small grain straws and soybean stubble, corn stalks and maybe ground cobs or even husklage generated by seed corn plants are viable considerations for both cow herds and finishing cattle. Another consideration is to treat round bales of corn stalks, soybean stubble and wheat/oat/barley straw with anhydrous ammonia (A.A.). Treating low energy feedstuffs with A.A. is not a new approach to reducing feed costs. Much research was conducted during the 1980's utilizing A.A. Ron Lemenager did a lot of this work at Purdue University with good results. With low commodity prices during the 1980's and 1990's many producers had no need to use the combination of A.A. and low quality residue, but, perhaps now is the time to reconsider this feed source.

Table 11: High Prices (2008) vs. Low Prices (2006)

	(2006)				(2008)			
Feedstuff	unit	lb.	lb:TDN	lb:CP	unit	lb.	lb:TDN	lb:CP
Corn	$2.50:bu	4.46¢	5.63¢	59.63¢	$7.00:bu	12.50¢	15.78¢	1.67¢
CS[a]	$18.75:T	0.94¢	3.35¢	29.01¢	$52.50:T	2.63¢	9.39¢	81.7¢
SBM	$180:T	9.0¢	11.76¢	20.0¢	$400:T	20.0¢	26.14¢	44.44¢
SH	$70:T	3.50¢	6.0¢	32.05¢	$140:T	7.0¢	12.01¢	64.1¢
DGS[b]	$30:T	1.50¢	3.62¢	12.76¢	$65:T	3.25¢	7.85¢	27.65¢
DDGS[c]	$90:T	4.50¢	5.68¢	20.0¢	$180:T	9.0¢	11.36¢	40.0¢
CGF[d]	$33:T	1.65¢	4.23¢	19.5¢	$68:T	3.4¢	8.71¢	40.0¢
DCGF[e]	$90:T	4.50¢	5.95¢	27.47¢	$175:T	8.75¢	11.58¢	53.41¢
Urea	$400:T	20.0¢		0.7¢	$800:T	40.0¢		0.14¢
Cobs	$120:T	6.0¢	16.66¢		$200:T	10.0¢	27.77¢	
Straw	$1.50:b	3.75¢	10.51¢		$200:T	5.0¢	14.01¢	
A.A.	$481:T	24.1¢		0.05¢	$830:T	41.5¢		0.08¢
Hay	$120:T	6.0¢	13.26¢	62.69¢	$200:T	10.0¢	22.1¢	104.49¢
WM	$73:T	3.65¢	5.94¢	22.28¢	$140:T	7.0¢	11.39¢	42.97¢

[a]24T, 180bu:ac ▪ [b]53% moisture; [c]10% moisture ▪ [d]53% moisture; [e]9% moisture

Since feed cost represents the largest variable expense for both cow-calf and feedlot operations, reducing feed cost through the use of alternative feeds such as distiller's grains (DGS), corn gluten feed (CGF), soyhulls (SH) and low quality forages treated with non-protein nitrogen (NPN) such as urea and anhydrous ammonia is a wise management option. The use of alternative feedstuffs requires the adaption of three best management practices (BMP). These are:

1) obtain a nutrient analysis of each feedstuff being considered.
2) balance diets based on nutrient analyses, especially for localized feedstuffs (DGS, CGF, hays, stovers, etc.).
3) feed using the total mixed ration (TMR) concept.

Shelled corn, soybean meal, oats and other traditional feedstuffs do not vary as much in nutrient composition as do alternative feedstuffs. Therefore, frequent analyses of nutrient composition may not be necessary. Low quality forages such as small grain straws and stubble hays, and feedstuffs raised/obtained locally such as corn silage, DGS, CGF and SH can vary considerably in dry matter (DM) content, crude protein (CP), total digestible nutrient (TDN) and mineral composition (calcium, phosphorous, sulfur, etc.). Consequently, it is important to obtain nutrient analyses for these feedstuffs on a routine basis. In the case of alternative feedstuffs such as DGS, an analysis of the individual load or each week's delivery should be obtained because of plant production variability. In one review we conducted during the fall of 2007, crude protein of DGS produced at one plant over a 6 month period varied as much as 10 percentage points, ether extract (crude fat) varied 12 percentage points, calcium varied 50 percentage points, phosphorous varied 23 percentage points and sulfur varied 33 percentage points. This type of variability can result in nutrient deficiencies and in the case of phosphorous and sulfur nutrient toxicities.

When using alternative feedstuffs it is important to feed cattle using the TMR approach as compared to top dressing DGS, CGF, SH, etc. over a forage or as compared to self-feeding forage and limit feeding DGS, CGF, SH, etc. in a separate feed bunk. In order to optimize feed and nutrient intake, especially when including low quality roughage residues such as ground corn stalks, straws, etc. providing a balanced diet necessitates feeding a TMR. Otherwise cattle, especially more timid cattle, may not receive enough CP and energy to optimize performance. Accordingly, the following rules of thumb may apply when feeding alternative feedstuffs.

Rules of Thumb No. 1

- DGS/CGF are not synonymous
- DGS/CGF/DGS/Corn cannot be replaced lb. for lb.
- DDGS/DGS fed at < 20% diet DM = CP feedstuff
- DDGS/DGS fed at > 20% diet DM = energy feedstuff

Rules of Thumb No. 2

- Urea should not exceed 1% of diet DM
- Urea should not exceed ½ of the supplement protein
- Urea should not exceed ⅓ of the total protein

Rules of Thumb No. 3

DGS/Feedlot Cattle

- Safe inclusion rate = 25% of diet DM
- Ok inclusion rate = 35 – 45% of diet DM
- Questionable rate = 50 – 70% of diet DM

Rules of Thumb No. 4

DGS/Late Gestation/Early Lactation – Beef Cows

- Grass hay diet

  4 lbs. DDGS or 8 lbs. wet DGS = CP requirements

- Corn silage diet

  15 lbs. DDGS or 30 lbs. wet DGS = CP requirements, and equals 35 – 40% diet DM

Rules of Thumb No. 5

CGF/Feedlot Cattle

- Wet CGF recommended rate of inclusion is 50% DMI
- Dry CGF recommended rate of inclusion is 25% DMI
- Inclusion rates of wet CGF as high as 90% have been successfully fed.

Rules of Thumb No. 6

Higher Inclusion Rates of DGS/CGF for Feedlot Cattle

- Could decrease dry matter intake
- Could reduce average daily gain
- Could lower quality grades and marbling scores

Rules of Thumb No. 7

Higher Inclusion Rates of DGS/SH for Feedlot Cattle

- Could increase incidence of bloat
- Could lower average daily gain
- Could lower quality grades/ marbling scores

These rules of thumb set the stage for reviewing sample diets using alternative sample diets containing alternative feedstuffs and for comparing the feed savings that can be realized when including DGS, CGF and SH.

There are numerous diets containing by-products that can be utilized in feedlot and cow-calf operations. The following contains a few sample diets we have fed at Illinois State University.

Example Diets Containing By-Products

Table 12. Show Heifer Diet*

Feedstuff	Pounds:Day
34% protein supplement	2
Beet pulp with molasses	6 – 12
Whole oats	1 – 6

*Can feed as a 50:50 ratio of BP to oats up to 100T BP.

Table 13. Lactating Cow Diet[a]

Feedstuff	Pounds:Day
Corn silage	74.4
Wet DGS	21.4
Limestone	0.3
Rumensin[b]	0.4
TMS	0.5

[a] Wet weight basis
[b] Provides 200 mg:cow:day

Table 14. Late Gestation: Early Lactation Cow Diet[bc]

Feedstuff	Pounds:Day
Corn silage	57.0
DDGS	5.2
Limestone	0.04
Rumensin Premix[c]	0.20
TMS	0.10

[a] Provides 200 mg:cow:day
[b] Provides 11.6% crude protein
[c] Wet wt. basis

Table 15. Late Gestation: Early Lactation Cow Diet[ac]

Feedstuff	Pounds:Day
Corn silage	55.0
Corn gluten feed	6.6
Limestone	0.07
Rumensin Premix[b]	0.2
TMS	0.1

[a] Provides 11.6% crude protein
[b] Provides 200 mg:cow:day
[c] Wet wt. basis

Table 16. Bred Heifer Diet[ac]

Feedstuff	Pounds:Day
Corn silage	54.6
Corn gluten feed	5.0
Limestone	0.04
Rumensin Premix[b]	0.20
TMS	0.10

[a] Provides 11.6% crude protein
[b] Provides 200 mg:cow:day
[c] Wet wt. basis

Table 17. Bred Heifer Diet[ac]

Feedstuff	Pounds:Day
Corn silage	52.5
Corn gluten feed	6.4
Limestone	0.07
Rumensin Premix[b]	0.20
TMS	0.10

[a] Provides 11.6% crude protein
[b] Provides 200 mg:cow:day
[c] Wet wt. basis

Table 18. Replacement Heifer Diet[a]

Feedstuff	Diet %[b]
Soybean bean meal	15.0
DDGS	25.0
Corn silage	56.5
TMS	0.5
Limestone	1.5
Rumensin Premix[c]	1.5

[a] Provides 15.5% crude protein
[b] Expressed on wet weight basis
[c] Provides 200 mg:cow:day

Table 19. Creep Diet[ac]

Feedstuff	Diet %[b]
34% protein supplement[c]	20
Whole oats	50
Soyhull pellets	30

[a] Provides 16.0% crude protein, 74.7% TDN and 48.4% ADF
[b] Expressed on wet weight basis
[c] Contains 240 grams Bovatec:ton:no urea

Table 20. Dry Cow Diet[ab]

Feedstuff	Pounds:Day
Wheat straw	20.0
DDGS	12.0
Soyhulls	3.0
Limestone	0.2
Rumensin Premix[c]	0.2

[a] Provides 10.3% crude protein and 52.4% TDN
[b] Expressed on wet weight basis
[c] Provides 200 mg:cow:day

Table 21. Feedlot Diets Formulated to Include Low Fat Modified Wet Distiller's Grains with Solubles

Item	0 LWDGS	25 LWDGS	40 LWDGS	70 LWDGS	LWDGS
Ingredient, % of DM					
Corn Silage	15.00	15.00	15.00	15.00	
SBM	9.60	–	–	–	
WDGS	–	25.00	40.00	70.00	
Corn	73.16	57.04	42.69	12.49	
Limestone	1.44	1.63	1.74	1.94	
Premix[a]	0.80	1.33	0.57	0.57	
Chemical Composition, %					
DM	76.60	73.06	66.30	64.22	52.95
NDF	14.47	20.20	23.51	29.09	38.68
ADF	3.98	5.31	6.27	8.17	8.87
Wet Ash	4.08	5.75	5.45	7.31	5.25
Protein	11.80	12.84	15.08	19.34	23.00
Ether Extract	3.45	5.11	5.83	6.54	6.92
Sulfur	0.14	0.31	0.38	0.53	0.65
Calcium	0.64	0.86	1.08	1.44	0.12
Phosphorous	0.35	0.49	0.56	0.68	0.79
Ca:P ratio	1.8:1	1.8:1	1.9:1	2.1:1	

A Premix formulated to provide 200 mg:steer:day Thiamin and 200mg: steer:day Rumensin

Table 22. Feedlot Diets Formulated to Include High Fat Modified Wet Distiller's Grains with Solubles

Item	0 HWDGS	25 HWDGS	40 HWDGS	70 HWDGS	HWDGS
Ingredient, % of DM					
Corn Silage	15.00	15.00	15.00	15.00	
SBM	6.40	–	–	–	
HWDGS	–	25.00	40.00	70.00	
Corn	76.52	57.70	42.24	11.80	
Limestone	1.50	1.60	2.06	2.50	
Trace Mineral Salt	0.50	0.50	0.50	0.50	
Premix[a]	0.20	0.20	0.20	0.20	
Chemical Composition, %					
DM	82.28	70.47	63.53	53.76	48.40
NDF	22.48	28.41	32.42	36.70	41.59
ADF	9.19	9.73	10.42	11.44	10.33
Wet Ash	5.57	5.91	6.37	6.43	4.22
CP	13.28	16.04	19.58	24.86	28.40
Ether Extract	2.60	6.11	7.53	9.47	10.36
S	0.12	0.16	0.19	0.26	0.29
Ca	0.51	0.46	0.56	0.54	0.063
P	0.29	0.39	0.42	0.47	0.76
Ca:P ratio	1.8:1	1.2:1	1.3:1	1.2:1	

A Premix formulated to provide 200 mg:steer:day Thiamin and 200mg: steer:day Rumensin

Table 23. Late Gestation and Early Lactation Beef Cow Diets Formulated to Include Low Fat Modified Wet Distiller's Grains With Solubles

Item	D1	D2	D3	D4	WDGS[3]
Ingredient, % of DM					
Whole Shelled corn	21.52.	–	–	–	
Soybean meal	11.79	–	–	–	–
WDGS	–	24.77	43.05	58.31	
Corn Silage	63.76	71.57	53.15	37.54	
Dicalcium Phosphorus	0.04	–	–	–	
Limestone	1.31	1.76	2.05	2.43	
Premix[a]	1.92	1.90	1.75	1.72	
Analyzed Nutrient Composition, %					
DM	41.58	41.03	42.67	44.73	52.67
CP	12.0	12.50	15.70	19.0	24.17
NDF	42.52	45.50	44.00	42.87	52.30
ADF	16.69	17.27	16.22	15.24	13.10
Ether Extract	3.44	4.40	5.24	6.55	6.98
Sulfur	0.12	0.21	0.30	0.42	0.48
Calcium	0.50	0.65	0.87	1.07	0.14
Phosphorus	0.26	0.31	0.40	0.50	0.55
Ca:P ratio	1.9:1	2.1:1	2.1:1	2.1:1	

A Premix formulated to provide 200 mg:steer:day Thiamin and 200mg: steer:day Rumensin

We are at an opportune time in the beef industry regarding the use of distiller's grains in beef cattle diets. The rapid expansion of ethanol production has produced record tonnages of wet and dry distiller's grains (DGS). This increased DGS production has provided a feedstuff feedlot operators can take advantage of to replace shelled corn, soybean meal and even to some extent portions of forage in cattle diets.

As a reminder, distiller's grains contains 25.0-29.0% crude protein, around 88.0% TDN (3.18 Mcal of metabolizable energy) and 19.7% ADF. This high nutrient content in DGS is a result of the current fermentation process during dry milling that does not separate the germ from the bran fraction. The germ contains corn oil and a larger part of the corn protein. The inability of the dry milling process to separate the germ and bran fractions results in potential lost revenue for the dry milling plant. Therefore, we should expect scientists to develop manufacturing processes in the near future (within the next 5-7 years) that will separate the germ portion of the corn kernel from the starch prior to fermentation. In fact, chemists are actively developing technology to fractionate the germs from the starch and to separate the germ into corn oil and protein prior to fermentation. This technology will result in DGS with a much lower protein and energy value. The point – the cattle industry has only a few years to capitalize on the use of DGS as a value-added co-product feedstuff. Once DGS contains primarily the bran fraction only, its feeding value will be greatly reduced in cattle diets. Currently many ethanol plants are removing a major portion of oil from the CDS fraction. Consequently, when this lower fat CDS is added to the distiller's grains fraction the resulting distiller's grains with solubles is lower in fat content comparing 5-7% fat to 10-12% fat. The lower fat DGS has less energy value. This White Paper will address this issue later.

When discussing alternative feedstuff choices the question when defining or choosing an alternative feedstuff is, alternative to what? Alternative can be defined "as opposed to shelled corn, corn silage, local hays or soybean meal" i.e. feeds considered as traditional feedstuffs. Three alternative feedstuff choices that have been around for 2 or 3 decades but that receive variable interest are urea, anhydrous ammonia and a product called Mix 30.

Urea has been added to feedlot diets for over 40 years. However, many smaller Midwest feedlots have not considered urea as a protein equivalency source because its use necessitates a TMR approach. Major feed companies frequently add urea to protein supplements as a lower cost mechanism to increase the percent protein in the supplement. Even when priced at $800:ton (July, 2008) the cost per pound of crude protein equivalency for urea was only 0.14¢:lb compared to soybean meal at 44.44¢:lb., DDGS at 40.0¢:lb or wet DGS at 27.65¢:lb of protein. Adding urea to finishing diets should be considered by more Midwest feedlots, but be sure to adhere to the previously cited rules-of-thumb.

As hay supplies become more limited and/or more expensive due to increased hay acres converted to corn and soybean production, many cow-calf producers and yearling steer backgrounders should reconsider treating low quality forages (corn stalks, soybean stubble, wheat or oat straws, etc.) with anhydrous ammonia (AA) to increase the roughages crude protein and TDN composition. At $830:ton (Table 24) AA has a cost of only 0.08¢:lb of crude protein equivalency. Ron Lemenager (Purdue University) as did others, conducted a considerable amount of research treating low-quality forages with AA during the 1980's. Adding 3.0% AA to the dry matter weight of the forage can increase the TDN content by 10% and can double the crude protein concentration. For example, adding 3.0% AA to big round bales of corn stalks or to corn stalks harvested with a stacker can raise the crude protein value from 3 - 4% up to 6 - 8% and the TDN value from 45% to 55%.

Treating low quality roughages with AA may allow the forage to fully meet a dry cows or a yearling steers crude protein and TDN requirements with little or no supplemental protein or energy. Treating roughages with AA requires an accurate estimate of forage dry matter, a plastic cover sufficiently large to cover the bales/stacks of forage and a replaceable 100 gallon tank to capture the AA as it volatilizes under the plastic cover. It takes 3 – 4 weeks for the AA to stabilize within the forage prior to uncovering and feeding. Treatment with AA should be accomplished while daytime temperatures still reach at least 40°F.

Table 24 compares two diets fed at ISU to beef cows in past years. The difference in feed cost between the two diets allowed for a value of up to $33:1000 lb. round bale of corn stalks. The DGS in the diet was low fat modified wet distiller's grains with solubles (50% moisture). Treating cornstalks with A.A. saved $1.12:d in feed costs using current commodity prices at the time of the feeding trial ($7.00:bu shelled corn). This $1.12 in feed savings allows producers to value cornstalks based on cost of harvest, transport and storage.

Table 24. CS • SC • SBM Cow Diet/Lacation

	TRADITIONAL				A.A. + STALKS		
Feedstuff	As Fed (lb)		Cost (¢ lb)	Total (¢:d)	As Fed (lb)	Cost (¢ lb)	Total (¢:d)
SC	5.0	x	12.5	62.5			
SBM	3.1	x	20.0	62.0			
CS	32.2	x	2.63	84.7	0.4	22.0	8.8
CCC	0.2	x	22.0	4.4			
TMS	0.2	x	20.0	4.0			
DGS					16.8	3.25	54.6
Stalks					33.9	3.3	?[a]
A.A.					1.02	41.5	42.3
Total				$2.18			$1.06

[a]$1.12 difference; stalks value = 3.3¢:pound or $33:1000 lb. round bale

Another feedstuff that has been around for a number of years is Mix 30 sold by Timberlake Sales, Springfield, IL. Historically, sales of Mix 30 have been limited to volume orders (semi-trailer loads) and Mix 30 has been promoted as a feedstuff for feedlot cattle. More recently, local distributors for Mix 30 have been contracted and Mix 30 may now be available in smaller quantities at a location (feed dealer) near your operation. Mix 30 is considered a protein- energy supplement (16% crude protein, 10% fat) that has 130% the digestible energy (DE) value of shelled corn. It contains condensed distiller's solubles (CDS), vegetable fat and a product referred to as ProtaFerm. Mix 30 has a lower cost if purchased in quantities of 6000 gallons or more (FOB Springfield, Illinois) and a higher cost if purchased in smaller quantities.

Recommendations for feeding Mix 30 in cow diets is forage plus 15 – 20% Mix 30 or feed 2 – 5 lbs. of Mix 30:day and free choice forage. General recommendations for including Mix 30 into feedlot diets is 5 – 12% of the total diet on an as fed (moisture included) basis. Mix 30 and other commercial supplements composed of alternative feedstuffs may help larger and smaller size operations lower feed costs.

Feeding Value of Corn Distiller's Grains at High and Low Relative Corn Prices

High and low are relative or comparative terms. These words do not represent absolute values as so many people seem to think they do. On June 27, 2011 shelled corn was \$6.44:bushel on the Board and \$6.17 at my local elevator. On September 6, 2011 shelled corn was \$7.46:bushel on the Board. Table 25 shows the average farm price for shelled corn since 1970. While I am not an economist, it is my perception that the corn blight of the early 1970's combined with higher oil costs ushered in a new era of relatively high corn prices (\$3.00:bu plus), up from the previous

$1.25:bu era. Today, it seems that the new relatively high oil prices combined with a variety of new markets for shelled corn/corn products has ushered in another new and yet higher era of corn prices (the $6-7:00:bu era). And, when shelled corn is priced above $7.00:bushel (12.50¢:lb), shelled corn may be too expensive to continue as the primary feedstuff in finishing cattle diets. As most feeders have discovered, corn distiller's grains (DGS) may be the new primary feedstuff substitute for shelled corn.

This discussion will use the actual prices for feedstuffs on June 27, 2011 as an example. On June 27, Jessica (one of my most talented graduate students) contacted all the ethanol plants operating within Illinois and in the states bordering Illinois within 50 miles of the state line. The average selling price for high fat modified wet distiller's grains with solubles (HWDGS) was $72:ton FOB (ranging from $40 to $97:ton). At 40 – 60% moisture that translates to 7.20¢: lb of dry matter (DM) for HWDGS. Dried distiller's grains with solubles (DDGS) was priced at $196:ton FOB, ranging from $160 – $210:ton, (at 10% moisture that is 10.89¢:lb of DM). The short story is that HWDGS is less expensive to feed than is DDGS, and the three most important factors related to buying DGS are location, location, location. Our guideline regarding HWDGS, is that it is too expensive to haul water more than 50 miles if HWDGS is to compete with DDGS or shelled corn on a cost per pound of DM basis. At ISU we routinely feed either LWDGS or HWDGS, even during the warmer summer months. We economically store the WDGS in bunker silos with minimal storage loss. The storage process we use is to level the top of the piled WDGS, sprinkle the top with salt at the rate of one pound per square foot and cover the top with a plastic tarp.

Previously conducted research at Illinois State University has found that feeding diets containing 25, 40 and 70% low fat or high fat WDGS have returned more gross dollars over feed cost than diets containing whole shelled corn and 0% WDGS. While the total return over feed cost increases as percent WDGS in the diet increases, the rate of return over feed cost decreases as the percent WDGS increases over 25% of the diet DM. The average increase in return over feed cost was 13% for 25% WDGS inclusion compared to 0% WDGS. The average increase for 40% WDGS was 15% and for 70% WDGS it was 18%. Table 26 shows that if the return over feed cost for adding WDGS was linear, including 70% WDGS into finishing diets would increase return over feed cost by 64% compared to shelled corn based diets. The increase is not linear but rather increases at a decreasing rate. When adding WDGS to finishing diets, the return over feed cost rate of increase maximizes around 25% WDGS inclusion and the rate of increase decreases at higher inclusion levels.

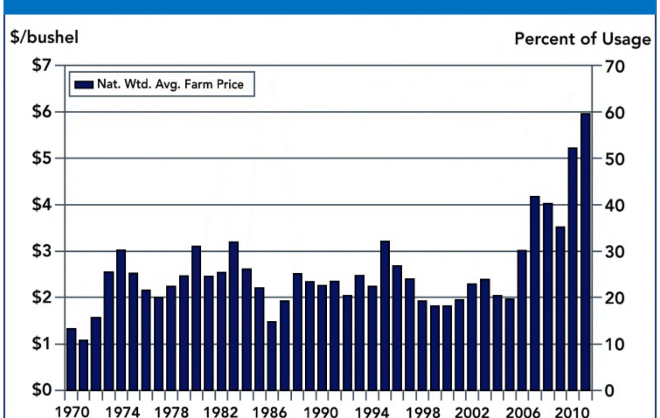
Another important factor to watch regarding whether or not, and how much WDGS to feed is the cost:lb of DM for shelled corn compared to WDGS. When shelled corn was \$3.50:bu., and 7.10¢:lb of DM, WDGS was priced at \$35:wet ton or 3.18¢:lb of DM. When shelled corn was priced \$6.64:bu and 13.47¢:lb of DM, WDGS was priced at \$72:wet ton or 7.20¢:lb of DM. At \$3.50: bu., shelled corn was 2.23 times as expensive as WDGS. At \$6.64: bu, shelled corn is 1.87 times as expensive as WDGS. Cattle feeders must watch the shelled corn/WDGS price spread. As the shelled corn price increases, the WDGS price is following corn up and the price differential is becoming less attractive. When shelled corn was priced at \$7.46:bushel, the price differential for shelled corn compared to DDGS, was only 1.24:1. And, on occasion, at some ethanol plants with a high demand for DDGS the price differential between shelled corn and

DDGS is 1:1 or negative. Day in and day out, both low fat and high fat WDGS compared to DDGS is usually the more economical feedstuff for finishing cattle.

Beef cow-calf producers and feedlot operators should carefully follow local shelled corn price and WDGS cost on a plant by plant basis. Given how volatile corn prices are, dietary inclusion rate of WDGS that insures the most return over feed cost can greatly fluctuate. Generally, the greatest biological efficiency or pounds of gain: pound of feed (G:F) occurs at around a 25% WDGS inclusion rate (DM basis). Maximum return over feed cost usually occurs around 45% WDGS dietary inclusion (DM basis). Our research has shown that up to 70% WDGS inclusion (DM basis) always returns more dollars over feed cost than shelled corn based diets; and, depending on the relative cost between shelled corn and WDGS, higher WDGS inclusion levels may be the most economical. However, as shelled corn price increases and as WDGS follows DDGS and corn price up, the current economic advantage for WDGS may not always be present.

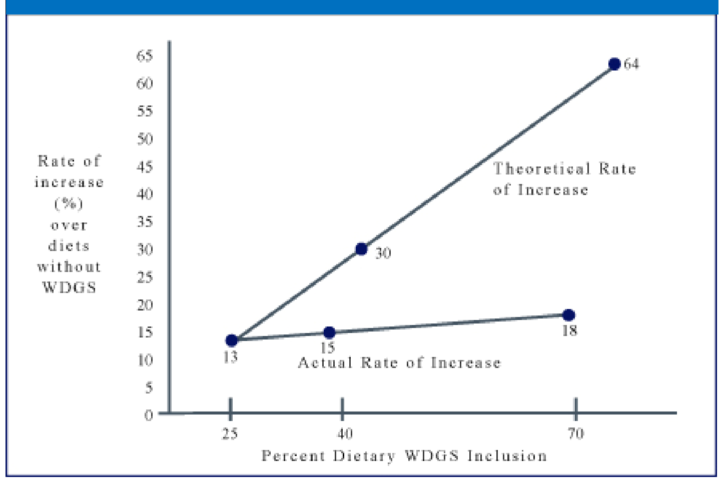
We have entered a new era of finishing cattle where corn is no longer king. Shelled corns by-product, DGS, is the new primary feedstuff in finishing diets for progressive feedlot managers. Tom Peters may be correct, we may actually live within the ethanol belt and not in the corn belt.

Table 25. U.S. Corn Price



* Edited table from article in the pork checkoff® REPORT - Summer 2011 Vol 30 No 2
Production Costs Still PINCH, But Profits Continue by Steve Meyer

Table 26. Percent Return Over Feed Cost Compared To Shelled Corn Diets



Collectively nutritionists have inferred that by- or co-products are generally less expensive than shelled corn. This is not always true, as was the case during the fall of 2011. On November 28, 2011, shelled corn was priced at $5.82:bushel or 11.80¢:lb. of dry matter (DM). Soybean hulls were $240:ton or 13.33¢:lb of DM, which was down from $270:ton three weeks earlier.

High fat DDGS was $215:ton or 11.94¢:lb. of DM. This was down from $267:ton 30 days before. Modified wet high fat DGS was selling for $75 to $95:ton or 6.25¢ to 7.92¢:lb. of DM. In short, shelled corn was less expensive as an energy source than soyhulls for beef cows. Shelled corn was also, less expensive as an energy source than DDGS for feedlot cattle assuming DDGS was fed above 20% of the diet DM.

If DDGS is fed primarily for its protein value (DDGS makes up less than 20% of diet DM), then as a replacement for shelled corn and soybean meal DDGS is the most economical buy. The really bright spot of this information is that modified wet DGS (60% DM) is as usual, a more economical replacement for shelled corn as energy and as a protein feedstuff than soybean meal.

As we are finding out, the co-product and by-product feeds are not immediately responsive to increases in the price of shelled corn. However, producers may pay close attention to changes in the comparative prices of shelled corn and the co- or by-products. The price changes in this volatile shelled corn market must be continually monitored to know when the by-products are an economical purchase. This is particularly true because forage is in short supply.

Corn silage that is generally considered the most economical forage for beef cows looked more attractive as a feedstuff in late November, 2011 at 3.03¢:lb. ($\$5.^{\underline{82}}$:bu for shelled corn at 250 bu:acre or 24 tons corn silage:acre) compared to corn silage back in early September, 2011 (3.65¢:lb.) when corn was $\$7:^{\underline{00}}$:bu.

Soyhulls are usually a more economical energy feedstuff for yearling steers or cows on grass or legume hay than shelled corn, but this co-product now has so many alternative uses in feeds that soyhulls are not always more economical than shelled corn. However, as a highly digestible fiber source, soyhulls have several intrinsic factors that make them a more desirable feedstuff for cows and backgrounding yearling steers than shelled corn.

Distiller's grains still should be considered a by-product feedstuff and not a co-product such as soyhulls. The nutrient composition of soyhulls is very consistent from plant to plant and from week to week, therefore, soyhulls are a true co-product. Distiller's grains are still a by-product feedstuff because their nutrient composition (crude protein, crude fat, phosphorous and sulfur especially) varies so much from plant to plant and from month to month.

<u>Low Fat Modified Wet Distiller's Grains for Finishing Steers</u>

In a study conducted at Illinois State University evaluating low fat modified wet distiller's grains with solubles (LWDGS) three feeding trials were conducted. These trials will be referred to as Trials 4, 5 and 6. Table 27 shows the composition of the diets used in these feeding trials. Each of these diets included the ionophore Rumensin fed at the rate of 200 mg:cattle:day to improve feed efficiency and included thiamine (Vit.B$_1$) fed at the rate of 200 mg:cattle:day to help prevent PEM (polio encephalomalacia). We believe it is important to always include an ionphore of your choosing to help prevent coccidiosis and to improve feed efficiency. We, also, believe it is important to include thiamine whenever the dietary inclusion of DGS exceeds 25% of diet DM. We recommend the addition of 100 mg:cattle:day of thiamine when DGS is less than 40% of diet DM and 200 mg:cattle:day whenever DGS exceeds 40% of diet DM. These are just responsible BMP's (best management practices). The cattle in Trials 4 and 6 were weaned steer calves and the cattle in Trial 5 were yearling steers. All cattle were Angus X Continental crosses.

Table 28 shows the analytical composition of the DGS and the diets. It is important to note that the fat content of the DGS fed in these trials was only 6.5 – 7.5% fat (mean = 7.08%). Most dry grind (new generation) ethanol plants produce higher fat DGS containing 11.5 to 12.5% fat. One of the reasons why the cattle of these trials performed as well as they did on the 70% DGS diets may be do to the lower fat content of the DGS that was fed. As total dietary crude fat approaches 9% of DM intake cattle performance usually decreases. Whether or not cattle will perform as well as they did in these trials when cattle are fed diets containing 70% DGS containing higher fat levels (11.0 – 12.5% fat) has not been fully determined. This white paper, also, addresses feeding cattle higher fat WDGS to evaluate the efficacy of feeding diets containing up to 70% "higher fat" DGS.

The 70% LWDGS diet fed in Trials 4, 5 and 6 contained 0.53% sulfur and whenever the dietary sulfur concentration approaches and/or exceeds 0.45% of the diet DM, sulfur toxicity may occur. Only one steer in Trial 6 expressed symptoms of PEM and died of sulfur toxicity. Never-the-less as previously noted, sulfur toxicity always should be a concern when feeding higher levels of DGS.

Tables 29 – 34 show the performance and economic analyses of the three trials. Within these tables, numbers within a row with different superscripts are considered significantly different. All other numbers within rows without superscripts are considered similar. In Trial 4 (Tables 29 and 30) the steers fed the 70/40 LWDGS diet were fed 70 LWDGS for the first 84 days on feed and 40% LWDGS from day 84 until harvest. Generally, these trials suggest that 25% LWDGS inclusion results in the greatest biological cattle performance i.e. less average daily feed intake (ADFI) and improved feed efficiency as measured by average daily gain over average daily dry matter intake (G:F); and, that 70% LWDGS inclusion results in greater ADFI and usually, but not always increased average daily DMI (dry matter intake). In these trials there was little difference in marbling scores (MS) and yield grades (YG) of the cattle regardless of the dietary inclusion level of DGS, but there was a non-significant trend for cattle fed the 70% LWDGS diets to have lower numerical MS (i.e. lower quality grades), and perhaps a few more days on feed.

Economic efficiency data contained within these tables is the real story. While cattle fed the 70% LWDGS diets returned similar to lower dollars per hundred weight of carcass at harvest and fewer gross dollars were returned per steer, because of significantly less total feed cost per steer, the 70% LWDGS fed steers always returned more dollars over feed cost per steer than control fed or 25% LWDGS fed steers. However, from an economic perspective steers fed 40%

LWDGS diets always returned the most gross dollars over feed cost compared to control (O% LWDGS), 25% LWDGS or 70% LWDGS fed steers.

Table 35 is an interesting table as it compares the relative cost and economic value of feeding LWDGS. From the spring of 2010 through the fall of 2010 (the time period of these trials), the price of wet DGS in Illinois did not vary much but was closely priced around $35:wet ton, regardless of how the price of corn fluctuated from $3.50:bushel up to $6.00:bu and back to $5.25:bushel. The data of this table shows that the greatest percent economic improvement when feeding LWDGS occurs with 25% LWDGS inclusion and increases as the percent LWDGS inclusion increases but increases at a decreasing rate. Cost of gain decreases 24.7% at 25% LWDGS inclusion, 32.5% for 40% LWDGS inclusion but at only 36.5% for 70% LWDGS. All things evaluated, 40% LWDGS inclusion may be the most efficacious inclusion level, but depending on feedlot performance, total feed cost and degree of management expertise, 70% LWDGS may return the most dollars over feed cost if the price is right. The ultimate factor determining whether or not DGS should be included in finishing cattle diets may be the effect of DGS on consumer acceptability of the beef produced. Therefore, we have evaluated several characteristics of the beef produced from the carcasses of the steers fed in these trials. Accordingly, we have evaluated the percent moisture, percent fat, tenderness as measured by the Warner-Bratzler shear force method and the percent product lost during cooking of rib steaks (Table 36). We also, evaluated the shelf life of rib steaks by observing color changes on day 1, 3 and 7 of chilled storage (Table 37). Color values for lightness (L), redness (a) and yellowness (b) were made using a Minolta Colorimeter**.** No significant differences in the carcass quality traits such as percent, moisture, percent fat, cooking loss percentage or tenderness scores were observed between rib steaks collected from carcasses of steers fed 0 LWDGS, 25% LWDGS, 40% LWDGS or 70% LWDGS. The average shear force value for all the steaks was 2.45kg (5.41 lbs.), which is considered very tender, and which we expected because nearly 90% of the steers in these trials graded low choice or higher with no significant differences between LWDGS treatment.

Significant differences do to LWDGS treatment were observed in the Minolta color values, however (Table 38), steers fed 70 LWDGS diets produced rib steaks with significantly lower a and b values compared to rib steaks from steers fed 0, 25 or 40 LWDGS. Lower redness scores (a) are associated with higher unsaturated fatty acid values in beef fat and lower yellowness scores(b) are correlated with lower marbling scores. Reduced redness (a) values could be expected if more unsaturated fatty acids escaped rumen fermentation; and since distiller's grains are high in corn oil and corn oil is approximately 50% linoleic acid (a polyunsaturated fatty acid) it is likely that steers fed the 70 LWDGS diets had sufficient amounts of corn oil escaping the rumen to substantially alter the composition of the beef fat. While there were no significant differences in quality grades of the carcasses between treatments, the steers fed 70 LWDGS did tend to have lower numerical quality grade (marbling scores). Therefore, lower yellowness (b) values could be expected.

Minolta color was evaluated on day 1, day 3 and day 7 of chilled storage for rib steaks collected from carcasses of steers fed each of the four LWDGS treatments (Table 38). No significant changes were observed for degree of lightness (L), redness (a) or yellowness (b) across the seven days of shelf life for steers fed shelled corn diets without LWDGS inclusion (O% LWDGS).

Both a and b values decreased progressively from day 1 to day 3 to day 7 for rib steaks collected from steers fed 25, 40 or 70 LWDGS diets. It is important to note that while the declines in their quality characteristics were significant, all Minolta color scores were still within value ranges considered acceptable to consumers and should not represent any decreased acceptability. These observations do suggest that beef from steers fed diets containing low fat distiller's grains could have shorter effective shelf life when presented for retail sale as fresh meat over an extended period of time. However, these declines in color scores may be of practical importance in terms of consumer acceptability only for beef presented for sale over an extended number of days and only realistically for beef produced by steers fed diets containing 70 LWDGS.

Rib steaks obtained from steers were analyzed for fatty acid composition and a linear increase ($P < 0.005$) in saturated fatty acids - SFA (44.85% vs. 48.84% for 0 and 70 LWDGS, respectively) at the expense of mono-unsaturated fatty acids - MUFA (50.32% vs. 42.71% for 0 and 70 LWDGS, respectively) was observed (Table 39). Linear increases ($P = 0.001$) were observed in polyunsaturated fatty acid/saturated fatty acid - PUFA/SFA, conjugated linoleic acid - CLA, and and ω6 fats, with increasing LWDGS level. Since wet DGS can have 3-12% corn oil (in this study crude fat of the WDGS was 6.92%) and corn oil has a high percentage of linoleic acid, it appears that increasing dietary LWDGS resulted in increased rumen bypass or incomplete rumen biohydrogenation of corn oil, thus shifting fatty acid profiles of the intramuscular fat (marbling).

TABLE 27. Mean Diet Composition (%DM Basis)

Feedstuff	25 LWDGS	40 LWDGS	70 LWDGS	Control
Corn Silage	15.00	15.00	15.00	15.00
DGS	25.00	40.00	70.00	
SBM				9.01
Shelled Corn	57.44	42.31	12.12	73.70
TMS	0.48	0.48	0.48	0.48
Limestone	1.60	1.73	1.92	1.33
Rum/B1	0.48	0.48	0.48	0.48

TABLE 28. Mean Diet Analysis (%DM Basis)

Treatment	DM	NDF	ADF	Wet Ash	Protein	Fat	Ca	P	S
Control	79.60	14.47	3.98	4.08	11.80	3.45	0.64	0.35	0.14
25 LWDGS	69.30	20.12	5.00	5.72	12.73	5.14	0.91	0.49	0.32
40 LWDGS	65.03	24.55	6.10	5.41	15.21	5.88	1.13	0.57	0.38
70 LWDGS	59.87	29.92	7.92	7.18	19.45	6.74	1.41	0.69	0.53
LWDGS	52.17	38.94	8.88	5.28	22.18	7.08	0.10	0.79	0.64

TABLE 29. Trial 4 Performance

Item	25 LWDGS	40 LWDGS	70 LWDGS	70/40 LWDGS
Harvest wt (lbs.)	1414	1407	1413	1430
ADFI (lbs.)	29.4[a]	32.5[b]	34.4[b]	38.3
DMI (lbs.)	20.0	21.1	20.8	21.1
G:F	0.18	0.16	0.18	0.16
MS	7.02	6.78	6.92	7.10
YG	3.65	3.46	3.91	3.55

TABLE 30. Trial 4 Economic Analysis ($)

Item	25 LWDGS	40 LWDGS	70 LWDGS	70/40
Return:cwt carcass	140.46	140.44	141.23	141.02
Gross return:steer	1213.57	1223.23	1219.82	1219.82
Feed cost:steer	245.11	251.77	218.22	229.70
Return over feed cost:steer	968.46	971.46	1030.25[a]	990.12
Days on feed	172	172	172	172

TABLE 31. Trial 5 Performance

Item	0 LWDGS	25 LWDGS	40 LWDGS	70 LWDGS
Harvest wt (lbs.)	1462	1450	1458	1408[a]
ADFI (lbs.)	27.9[a]	31.2	34.3	42.6[b]
DMI (lbs.)	18.8[a]	21.8[a]	23.4[ab]	26.1[b]
G:F	0.16	0.16	0.15	0.12
MS	7.21	7.66	7.35	6.73 (P=0.07)
YG	3.84[a]	3.96[a]	3.70	3.72

TABLE 32. Trial 5 Economic Analysis ($)

Item	0 LWDGS	25 LWDGS	40 LWDGS	70 LWDGS
Return:cwt carcass	141.66	143.14[a]	141.64	139.50[b]
Gross return:steer	1269.67	1290.71	1283.79	1192.25[a]
Feed cost:steer	386.85[a]	293.30[b]	276.76[c]	247.77[d]
Return over feed cost:steer	882.82[a]	997.41	1007.03	944.48[b]
Days on feed	180	181	180	187

TABLE 33. Trial 6 Performance

Item	25 LWDGS	40 LWDGS	70 LWDGS
Harvest wt (lbs.)	1395	1424	1401
ADFI (lbs.)	29.7	29.3	34.9[a]
DMI (lbs.)	19.9	18.7	19.4
G:F	0.16[a]	0.12	0.12
MS	6.25	6.25	6.05
YG	3.42	3.39	3.44

TABLE 34. Trial 6 Economic Analysis ($)

Item	25 LWDGS	40 LWDGS	70 LWDGS
Return:cwt carcass	153.75	153.75	152.75[a]
Gross return:steer	1357.61	1400.66[a]	1335.04[b]
Feed cost:steer	324.00	321.81	170.96[a]
Return over feed cost:steer	1033.61	1078.85[a]	1164.08[b]
Days on feed	224	232	225

TABLE 35. Comparative Cost/Value

Treatment	Diet		Live Wt. Gain		Cost of Gain	
	(¢/lb.)		(¢/lb.)		(% Improvement over 0 DGS)	
0 LWDGS	5.73	9.00	43.82	68.80	–	–
25 LWDGS	3.75[a]	5.90[a]	33.01[a]	51.83[a]	13.0[d]	17.7[e]
40 LWDGS	3.11[b]	4.89[b]	29.59[b]	46.46[b]	14.9[d]	20.2[e]
70 LWDGS	2.10[c]	3.30[c]	27.85[c]	43.73[c]	13.1[d]	17.8[e]

[abc]Means within a column with different superscripts differ ($p < 0.05$)
[d] Column two and column four are equivalent to $3.50:bu corn and $35:wet ton DGS (Aug., 2010)
[e] Column three and column five are equivalent to $5.50:bu corn and $35:wet ton DGS (Nov., 2010)

TABLE 36. Meat Quality

Treatment	0 LWDGS	25 LWDGS	40 LWDGS	70 LWDGS	p-value
% moisture	69.146	68.306	68.404	68.16	0.131
% fat	20.432	22.221	22.204	20.058	0.284
Shear force	2.3436	2.5895	2.4393	2.473	0.235
Cooking loss	16.999	16.262	15.465	16.878	0.234
n =	14	39	41	40	

TABLE 37. Minolta Color Of Rib Steak

Treatment		0 LWDGS	25 LWDGS	40 LWDGS	70 LWDGS	p-value
Day1	L	44.71	45.45	45.4	44.49	0.22
	A	21.07	21.61	21.68	20.73	0.185
	B	8.73	9.12	9.24	8.63	0.067
Day 3	L	45.72	45.83	45.95	45.16	0.431
	A	18.42	19.16	18.87	18.04	0.085
	B	7.67	8.07	8.03	7.58	0.141
Day 7	L	46.32	46.14	46.08	45.33	0.268
	A	16.75	16.99	16.8	14.89[a]	0.000
	B	7.43	7.65	7.62	7.08	0.071
n =		14	39	40	40	

TABLE 38. Minolta Color By Days

		Day 1	Day 3	Day 7	p-value
0 LWDGS	L	44.71	45.72	46.32	0.996
	A	21.07	18.42	16.75	0.689
	B	8.73	7.67	7.43	0.774
25 LWDGS	L	45.45	45.83	46.14	0.792
	A	21.61[a]	19.16[b]	16.99[c]	0.000
	B	9.12[a]	8.07[b]	7.65[c]	0.001
40 LWDGS	L	45.4	45.95	46.08	0.158
	A	21.68[a]	18.87[b]	16.8[c]	0.000
	B	9.24[a]	8.03[bc]	7.62[b]	0.000
70 LWDGS	L	44.49	45.16	45.33	0.720
	A	20.73[a]	18.04[b]	14.89[c]	0.000
	B	8.63[a]	7.58[b]	7.08[c]	0.000

TABLE 39. Fatty Acid Composition As A Percent Of Total Fatty Acids Of Steaks					
	Treatment				
Fatty Acid	0 LWDGS	25 LWDGS	40 LWDGS	70 LWDGS	*P*-value
C_12:0	0.06	0.05	0.06	0.07	0.09
C_14:0	3.00[ab]	2.79[b]	3.17[a]	3.22[a]	0.02
C_14:1	0.52	0.41	0.39	0.38	0.69
C_16:0	27.71	27.26	28.08	28.24	0.52
C_16:1	3.44	3.20	2.99	2.84	0.09
C_18:0	12.04	12.29	12.87	15.28[a]	0.001
C_18:1n9c	43.08	42.74	40.34	35.35[b]	0.001
C_18:2n6t	0.14	0.15	0.18	0.20	0.44
C_18:2n6c	3.52[a]	4.49[b]	5.24[c]	6.71[d]	0.001
C_20:0	0.08	0.07	0.08	0.07	0.81
C_18:3n6	0.01	0.01	0.01	0.02	0.32
C_20:1	0.09	0.07	0.07	0.06	0.58
C_18:3n3	0.12	0.13	0.14	0.13	0.95
C_21:0	0.07	0.06	0.06	0.08	0.52
C_18:9c11t	0.13[a]	0.16[a]	0.21[ab]	0.23[b]	0.05
C_18:10t12c	0.08	0.13	0.14	0.17	0.37
C_18:9c11c	0.01	0.01	0.01	0.04[a]	0.001
C_18:9t11t	0.01	0.01	0.01	0.01	0.20
SFA	44.85	44.21	46.21	48.84[a]	0.005
MUFA	50.32[a]	49.95[ab]	47.05[b]	42.71[c]	0.001
PUFA	4.82	5.84[a]	6.72[b]	8.45[c]	0.001
PUFA:SFA	0.09[a]	0.11[a]	0.12[b]	0.15[c]	0.001
O6	4.38	5.32[a]	6.13[b]	7.75[c]	0.001
O3	0.19	0.19	0.19	0.20	0.98
CLA	0.22	0.29[a]	0.37[b]	0.46[c]	0.001
IV	46.80	47.98	47.02	45.13	1.18

In addition to feedlot performance, economic analyses and carcass acceptability, we evaluated selected characteristics of feces collected from the steers fed various levels of LWDGS. No significant differences in nitrogen, phosphorous or sulfur concentrations of fecal samples collected from steers fed 0% LWDGS, 25% LWDGS or 40% LWDGS diets were found (Table 40.). However, steers fed 70% LWDGS diets had significantly higher nitrogen, phosphorous and sulfur concentrations in fecal samples analyzed. This suggests that when land applying manure according to a nutrient management plan (NMP) no more acres are required for the manure produced by steers fed diets containing up to 40% LWDGS diets than for steers fed high concentrate diets containing shelled corn and 0% LWDGS. But, manure produced by steers fed 70% LWDGS, when applied to nutrient rich soils, may require more acres for land application for the same dry weight of manure than the manure produced by 0%, 25% or 40% LWDGS fed steers. The manure produced by steers fed 70% LWDGS diets produced 14.5% more nitrogen, 30.8% more phosphorous and 60.9% more sulfur than the average manure concentrations of the steers fed the 0%, 25% and 40% LWDGS diets.

By contrast, increased nutrient concentration of the manure produced by steers fed 70% LWDGS diets may have increased economic value. Because of the increased nutrient (N, P, S) concentration, the manure produced by steers fed diets containing 70% LWDGS may have increased value per ton of dry matter as a soil fertilizer requiring either fewer tons:acre to meet crop production requirements or by providing more nutrients per acre with similar application rates. Recently soil scientists and agronomists have identified some midwest and northeast soils as becoming sulfur deficient and that some crops (alfalfa and corn grain) may respond to sulfur fertilization. The elevated S values of the manure produced by steers fed the 70% LWDGS diets may be able to satisfy the increasing soil/crop sulfur requirements.

It is important to note that no significant differences in *E coli* concentrations were found in the fecal samples collected within a season regardless of whether the steers were fed 0, 25, 40 or 70 LWDGS diets (Table 41). There were, however, significant differences in *E coli* concentrations between seasons of the year (Table 42) when the fecal samples collected from the steers were combined for all dietary treatments. *E coli* concentrations were higher during summer than they were during the winter and fall months. Any fecal samples identified to contain *E coli* were further analyzed to determine if the *E coli* included the 0157:H7 strain of *E coli*. Only two fecal samples were found to contain *E coli* 0157:H7. Both samples were from steers fed 70% LWDGS. One sample was collected in October and the other sample was collected in December. This data suggests dietary inclusion of LWDGS probably has less effect on *E coli* concentration than do environmental factors such as temperature and moisture conditions, and other management factors such as type of feed yard, numbers of cattle per pen, etc.

These results were obtained when cattle were fed diets containing low fat modified wet (50 – 60% moisture) distiller's grains that contained 24 – 26% crude protein and 6.5 – 7.0% crude fat, i.e. a lower fat concentration DGS.

TABLE 40. Percent Element Composition In Manure

Dietary Treatment					
Element	0 LWDGS	25 LWDGS	40 LWDGS	70 LWDGS	p-value
Nitrogen	2.61	2.55	2.49	2.92*	0.000
Phosphorous	0.70	0.60	0.66	0.85*	0.035
Sulfur	0.25	0.20	0.25	0.37*	0.05

*Means in a row with different superscripts differ significantly.

TABLE 41. Fecal *E Coli* Comparisons By Treatment Within Seasons (CFU:Gram)

Dietary Treatment					
Season	0 LWDGS	25 LWDGS	40 LWDGS	70 LWDGS	p-value
Winter	5.03e+6	3.62e+6	1.85e+6	2.48e+6	0.218
Summer	7.63e+6	1.07e+7	1.14e+7	1.14e+7	0.968
Fall	6.09e+6	4.35e+6	4.79e+6	3.59e+6	0.769

TABLE 42. Fecal *E Coli* Comparisons By Seasons For All Dietary Treatments Combined (CFU:Gram)

Winter	Summer	Fall	p - value
2.94e+6	1.08e+7*	4.45e+6	0.000

High Fat Modified Wet Distiller's Grains for Finishing Steers

In this study 240 steer calves went on feed in the fall and were harvested in two groups the following June and August. Cattle were fed one of four diets containing higher fat (10 – 12%) modified wet distiller's grains with solubles (HWDGS). The diets are shown in Table 43. As a reminder, whenever DGS are fed as an energy feedstuff protein is overfed. This generally is not a problem from a cattle performance perspective but the manure can have higher nitrogen, as well as higher phosphorous concentrations that can affect nutrient management plans (NMP) regarding increased acres required for land application of the resulting manure.

This was an exceptional group of steers from a quality grade perspective as 118 of 120 steers harvested in June, after 161 days on feed graded low choice or higher and 110 of 117 steers harvested in August, after 244 days on feed graded low choice or higher. Anytime 96% of the steers sent to harvest grade low choice or higher and the average yield grade is 3.01, it is a good day in the world of feeding cattle. This study demonstrates that acceptable quality grades can be achieved when feeding HWDGS.

All the previous feedlot studies conducted at ISU prior to this study evaluating WDGS used distiller's grains that were lower in percent fat (6-8%). In this study, steers were fed a higher fat (10-12%) distiller's grains (HWDGS). The same treatments were included as in the previous low fat studies, i.e. a high concentrate control diet containing whole shelled corn (SC) and soybean meal (SBM) with no distiller's grains (O), control diet containing 25% HWDGS replacing SMB and SC (25), control diet containing 40% HWDGS replacing SC and SBM (40), and control diet containing 70% HWDGS replacing SBM and SC (70). Table 44 shows the nutrient composition of the diets and of the HWDGS fed. Table 45 shows the feedlot performance data and Table 46 shows the carcass data. No statistical differences were observed between the treatments regarding average daily gain and feed efficiency as measured by pounds of gain to pounds of dry matter feed intake (G:F). Average daily gain (ADG) ranged between 2.88 and 2.99 lbs. Feed efficiency was similar between treatments ranging from 0.14 to 0.16. As has been the case in all of our feeding trials, steers fed HWDGS consume higher average daily feed intakes (ADFI) than steers fed whole shelled corn diets due to higher moisture contents of the diets containing HWDGS. However, as is normally observed, steers consuming HWDGS diets at 40% and 70% HWDGS have lower daily dry matter intakes (DMI). Even though the higher fat HWDGS contains a higher percent crude protein (28.4 vs. 25.0), a higher percent crude fat (10.4 vs. 6.75) and presumably more energy per unit weight than lower fat WDGS, the cattle feedlot performance of steers fed either high or low fat WDGS has been similar to controls. Our initial concern was that at higher intake levels (HWDGS fed at 70% of diet DM), steers fed higher fat WDGS may not perform as well as steers fed lower fat WDGS when compared to control fed steers because of the higher fat level. In this study the steers fed higher fat WDGS performed similarly to controls regarding ADG and G:F.

Steers fed the whole shelled corn diets and the higher fat WDGS, also, had similar carcass characteristics. No significant differences in any of the carcass parameters evaluated were observed. Yield grades were similar ranging between 2.8 and 3.1. The average rib fat thickness, regardless of dietary treatment was around 0.5 inches. There was a non-significant numerical tendency for steers fed 70% HWDGS to have lower carcass weights, smaller rib eye areas and lower quality grades than steers fed control, 25% HWDGS or 40% HWDGS diets. These three observations have been fairly consistent across all our feeding trials whether the WDGS was higher or lower fat WDGS.

The take home message from these data is that whether modified wet distiller's grains contain higher fat (10-12%) or lower fat (6-8%) contents we can successfully feed finishing steers up to 70% of the diet dry matter as WDGS without compromising the outcomes. How much WDGS is fed may depend on the amount of roughage included in the diets. All of our diets have included 15% corn silage or ground grass hay on a dry matter basis. The secret to facilitating the dietary inclusion of WDGS above 50% of the diet dry matter may be maintaining at least 15% roughage on a dry matter basis within the diet. The appropriate amount of WDGS to include in finishing diets is dependent upon the price of the WDGS (purchase cost plus transportation cost from the ethanol plant to the feedlot). Most of our work at ISU suggests that biological efficiency (ADG, G:F) for WDGS inclusion maxes out around 25% of the diet DM. Economic efficiency (return over feed cost) generally maxes out around 40 – 45% of the diet DM. Including WDGS in finishing diets above 45% of the diet DM is a function of cost of WDGS. During those opportune times when the cost of WDGS is substantially lower than shelled corn operators have the option of feeding up to 70% WDGS to obtain the greatest return over feed cost.

Table 43. Mean Diet Composition (% DM Basis)

Item	0 HWDGS	25 HWDGS	40 HWDGS	70 HWDGS
Corn Silage	15.00	15.00	15.00	15.00
SBM	6.40	-	-	-
HWDGS	-	25.00	40.00	70.00
Corn	76.52	57.70	42.24	11.80
Limestone	1.50	1.60	2.06	2.50
Trace Mineral Salt	0.50	0.50	0.50	0.50
Premix[a]	0.20	0.20	0.20	0.20

[a]Premix provided 200 mg:cattle:day of Thiamin and 200 mg: cattle: chemical composition, %

Table 44. Mean Diet Analysis (% DM Basis)

Nutrient	0 HWDGS	25 HWDGS	40 HWDGS	70 HWDGS	HWDGS
DM	82.28	70.47	63.53	53.76	48.40
NDF	22.48	28.41	32.42	36.70	41.59
ADF	9.19	9.73	10.42	11.44	10.33
Wet Ash	5.57	5.91	6.37	6.43	4.22
CP	13.28	16.04	19.58	24.86	28.40
Ether Extract	2.60	6.11	7.53	9.47	10.36
S	0.12	0.16	0.19	0.26	0.29
Ca	0.51	0.46	0.56	0.54	0.063
P	0.29	0.39	0.42	0.47	0.76
Ca:P ratio	1.8:1	1.2:1	1.3:1	1.2:1	

TABLE 45 –Feedlot Performance

Treatment	ADG	ADFI	DMI	G:F	Days on Feed
Control	2.92	28.89[a]	21.03	0.15	
SD	0.46	4.57	6.04	0.04	194
25% HWDGS	2.99	34.12	22.32	0.14	
SD	0.29	4.04	5.00	0.03	194
40% HWDGS	2.86	34.01	19.65	0.14	
SD	0.31	2.66	3.71	0.03	191
70% HWDGS	2.88	34.84	17.39[b]	0.16	
SD	0.32	2.90	2.75	0.03	193
[a,b]: Means within a column with different superscripts differ significantly.					

TABLE 46 – Carcass Data

Treatment	Liver Score	Lung Lesions	Harvest Wt.	Carcass Wt.	Dressing Percent
Control	1.52	0.47	1374	847	61.80
SD	1.02	0.60	110.2	71.9	3.59
25% HWDGS	1.39	0.25	1372	854	62.27
SD	0.97	0.51	95.8	66.94	2.19
40% HWDGS	1.47	0.36	1375	866	63.11
SD	1.13	0.61	86.7	56.9	3.15
70% HWDGS	1.31	0.22	1344	836	62.37
SD	0.73	0.46	89.2	61.5	4.58

TABLE 47 – Carcass Data Continued

Treatment	Rib Fat Thickness (in)	Rib Eye Area (sq. in)	Quality Grade[a]	Yield Grade	KPH Percent
Control	0.53	14.53	7.3	2.8	2.27
SD	0.24	1.24	1.2	0.8	0.31
25% HWDGS	0.60	14.58	7.6	3.1	2.31
SD	0.18	1.41	1.2	0.7	0.35
40% HWDGS	0.59	14.28	7.3	3.1	2.21
SD	0.23	2.08	1.4	1.0	0.31
70% HWDGS	0.53	13.87	7.0	3.0	2.28
SD	0.20	1.47	1.1	0.8	0.28

[a]Quality grade scores: 7= low choice 8= average choice

Table 48. Meat Quality

Meat Quality Measurements	0 HWDGS	25 HWDGS	40 HWDGS	70 HWDGS	P-value
% Cooking loss	5.05	4.72	4.55	4.71	0.63
WBSF	3.74	3.59	3.67	3.51	0.73

Table 49. Minolta Color Of Rib Steaks

Minolta color, day		0 HWDGS	25 HWDGS	40 HWDGS	70 HWDGS	P-value
# of observations, animals		14	39	40	40	
Day 1	L*	45.29	45.18	43.64	45.15	0.28
	a*	20.51	20.85	21.38	21.97	0.79
	b*	7.74	7.96	8.06	8.05	0.91
Day 7	L*	47.65	48.10	47.83	48.25	0.94
	a*	17.99	17.42	15.76	18.21	0.44
	b*	7.27^{a}	6.88^{a}	6.10^{b}	6.78^{ab}	0.04

Table 50. Fatty Acid Composition As A Percent of Total Fatty Acids Of Steaks

	Treatment[1]				
Fatty Acid	0 HWDGS	25 HWDGS	40 HWDGS	70 HWDGS	*P*-value[2]
C_12:0	0.004	0.009	0.008	0.01	0.67
C_14:0	2.58[a]	2.39[ab]	2.26[b]	2.24[b]	0.04
C_14:1	0.63	0.58	0.43[a]	0.43[a]	0.01
C_15:0	0.46	0.21[a]	0.21[a]	0.31[b]	0.001
C_15:1	0.60	0.92	0.90	1.69	0.32
C_16:0	27.71	25.92[a]	25.89[a]	24.01[b]	0.001
C_16:1	3.49	3.09[a]	2.82[a]	2.52[b]	0.001
C_18:0	13.77	14.48	13.61	15.69[a]	0.001
C_18:1n9t	1.26	2.38[a]	2.24[a]	4.20[b]	0.001
C_18:1n9c	38.98	37.40[a]	36.46[ab]	35.19[b]	0.001
C_18:1n7	1.76	1.66	1.89[†]	1.62	0.06
C_18:2n6t	0.05	0.08	0.05	0.12[a]	0.004
C_18:2n6c	4.31	6.22[a]	8.53[b]	6.86[a]	0.001
C_20:0	0.001	0.008	0.02	0.05[a]	0.001
C_18:3n6	0.03	0.04	0.02	0.05	0.27
C_20:1	0.08[a]	0.04[ab]	0.03[ab]	0.07[b]	0.04
C_18:3n3	0.07	0.06	0.18[a]	0.09	0.003
C_18:9c11t	0.08	0.14	0.13	0.43[a]	0.001
C_18:9c11c	0.02	0.05	0.03	0.04	0.33
C_20:2	0.002	-	0.12[a]	0.006	0.001
SFA	45.33[†]	43.74	42.71	43.19	0.06
MUFA	47.35	46.54	45.15[†]	46.13	0.08
PUFA	5.72	8.16[a]	10.60[b]	9.06[a]	0.001
PUFA/SFA	0.09	0.15[a]	0.22[b]	0.17[a]	0.001
O6	5.73	7.88[a]	10.46[b]	8.46[a]	0.001
O3	0.08[a]	0.08[a]	0.19[b]	0.13[ab]	0.04
CLA	0.10	0.19	0.16	0.47[a]	0.001
IV	44.54	46.05	49.29[a]	44.83	0.001

[2]*P* – values: TRT = main effect of treatment.

Meat Quality Analysis. No significant differences were found in % cooking loss or Warner-Bratzler Shear Force (WBSF) (Table 48). The WBSF measures the pounds of force required to cut the muscle fibers. The lower the WBSF value, the more tender the meat cut.

In regards to indicators of shelf life, no significant differences were observed in Minolta Color (Table 49) with the exception of b* values on day seven, where a decrease was observed as HWDGS increased from 0 to 40% inclusion. A decrease in redness (a*) and in yellowness (b*) can indicate a decreased shelf life of steaks. The Minolta scores observed in the study reported here indicate that dietary concentration of HWDGS has little to no effect on shelf life of the beef.

Fatty acid analysis (Table 50) showed no significant difference in either saturated fatty acid (SFA) or monounsaturated fatty acid (MUFA) across treatments. There was a trend (P= 0.06) for lower SFA concentration in steaks from steers fed HWDGS compared to controls. Concentrations of MUFA were not significantly different between dietary treatments but percent MUFA were numerically lower for steaks from HWDGS fed steers with a trend (P = 0.08) for lower MUFA concentrations when steers were fed 40 HWDGS. Steaks from steers fed HWDGS had significantly higher polyunsaturated fatty acid (PUFA), PUFA/SFA and omega 6 fatty acid concentrations compared to steaks from steers fed 0 HWDGS with 40 HWDGS fed steers producing steaks with significantly higher PUFA, PUFA/SFA and O6 concentrations than 25 or 70 HWDGS fed steers. Steaks from the 40 and 70 HWDGS fed steers had significantly higher O3 fatty acid concentrations than steaks from the 0 and 25 HWDGS fed steers. Conjugated linoleic acid (CLA) concentrations were not significantly different between 0, 25, and 40 HWDGS fed steers but were higher for 70 HWDGS fed steers with a numeric trend for 25 and

40 HWDGS fed steers to have higher CLA concentration than 0 HWDGS fed steers. An increase in unsaturated fatty acid **(USFA)** concentrations was expected because it has been suggested that some of the oil in DGS is protected from rumen hydrolysis/hydrogenation. Increasing dietary HWDGS within the diet could have increased rumen bypass of fat or have resulted in incomplete rumen biohydrogenation of fat, thus shifting fatty acid profiles of the intramuscular fat (marbling).

Implications of High Sulfur and Phosphorous Concentrations in Distiller's Grains on Cattle Health

The NRC estimated requirements for sulfur in cattle rations is 0.08 – 0.15% of the diet dry matter (DM). The maximum tolerable limit (MTL) is estimated at 0.40% of the diet DM. Concentrations above 0.4% are often, though not always toxic. The NRC estimates may be, in reality, low. We at ISU and investigators at the University of Nebraska both have finished a lot of cattle on DGS diets containing 0.40 to 0.55% sulfur without toxicity issues. Most of the NRC estimates are based on the sulfur concentration of water and, therefore, may not truly be representative of sulfur MTL as related to toxicity in cattle. It may be that the sulfur content of DGS is not degradable in the rumen and therefore, passes through to the feces. Inclusion of additional roughage (corn silage, hay, straw, etc.) in DGS diets may decrease the incidence of sulfur toxicity or Polioencephalomalacia (PEM) symptoms. The Nebraska work has observed that as the amount of dietary sulfur increases with no additional roughage, the cases of PEM have increased. When the diets have contained normal (7 – 15%) amounts of roughage, few cases of sulfur toxicity have been observed.

The sulfur concentration in corn gluten feed (CGF) ranges between 0.23 and 0.72% of the DM. The sulfur concentration in distiller's grains (DGS) ranges between 0.33 and 0.95% of the DM. Regarding DGS, the historical range for sulfur concentration was 0.31 – 0.55% (DM basis) until recently (since the early 2000's). Currently, at many (though not all) ethanol plants the sulfur concentration for DGS has increased and has been ranging between 0.7 and 0.95% (DM basis).

There are perhaps two reasons for the increase in sulfur concentration of DGS. One reason may be the result of more condensed distiller's solubles (CDS), also, referred to as "syrup" being added to the DGS fraction. Condensed distiller's soluble is sometimes marketed as a separate co-product. At other times, when the demand for CDS is limited, CDS is added to the DGS fraction. The CDS component normally has a higher concentration of sulfur than the DGS fraction. Therefore, the more CDS added, the higher the sulfur concentration of DGS. A second reason for higher relative sulfur concentrations in DGS may be linked to the use of sulfur dioxide (SO_2) and/or sulfuric acid (H_2SO_4) during the production of ethanol. To adjust the pH during fermentation, ethanol plants add either SO_2 or H_2SO_4. Because of improved enzyme changes, some ethanol plants have had to add more SO_2 or H_2SO_4 to increase ethanol production. Consequently, the left-over sulfur is concentrated in the CDS and DGS.

Higher dietary sulfur concentrations generally pose little concern when balancing diets that include DGS. In the past, DGS inclusion into cattle diets was limited to 25% or less. More recently, DGS inclusion levels have reached 30 – 35% of the diet DM. At inclusion levels of 35% or less, sulfur concentration has not been of much concern. Most recently, scientists and feedlot operators have been including higher levels of DGS into cattle diets, as high as 40 – 45%

of the diet DM. These higher inclusion levels (above 35% of the diet DM) may place the cattle into the borderline toxicity zone for sulfur. When cattle diets are in the borderline sulfur toxicity zone, cattle as a group may suffer from reduced feed intake, lower average daily grains and "going-off-feed". Individual cattle may exhibit PEM. Excess sulfur intake may manifest itself in reduced thiamine (vitamin B_1) production or B_1 deficiency. Cattle with B_1 deficiency become lethargic and lose the ability to stand and be mobile. Intravenous injection of 2.2 mg: kg of body weight of thiamine will reverse the PEM symptoms if PEM is not too severe. To prevent PEM, thiamine concentrate can be added to the diet at levels between 100 – 200 mg B_1: head:day. If the cattle are being fed via a total mixed ration (TMR) the herdsman can develop a thiamine premix and include the premix into the TMR to provide the thiamine. If the thiamine must be top-dressed, several feed companies offer DGS and CGF supplements that include appropriate levels of thiamine.

If the DGS inclusion rate places the dietary sulfur concentration into the toxicity zone (equal to or greater than 0.40% of the diet DM) then thiamine supplementation of 200 mg:cattle:day is an absolute necessity. Even at 200 mg: cattle: day thiamine may not prevent PEM or sulfur toxicity. Cattle exhibiting sulfur toxicity are often referred to as "brainers". In addition to going off feed, cattle will develop abnormal behavior, including pushing their heads against fence posts, feed bunks etc. Sulfur toxicity can result in death. Therefore, if sulfur concentrations in DGS are relatively high (0.65 – 0.95%), DGS should be limited to 35% or less of the diet DM.

High sulfur concentrations of DGS can be compounded by high water sulfur concentrations. Sulfur is not an EPA regulated contaminant in drinking water. Therefore, if the cattle drinking water has a sulfur odor, and DGS is going to be fed at higher inclusion levels (above 35% of diet DM); the water should be tested for sulfur concentration. Often times the analytical laboratory will report the water analysis in terms of sulfate concentration, either as ppm or % (sulfate at 38 ppm = .0038%). Producers should not be interested in the sulfate concentration. Of real concern is the sulfur concentration. On a molecular weight basis sulfate is 33% sulfur. Therefore, a sulfate concentration of 99 ppm (.0099%) contains 33.2 ppm (.0033%) sulfur. If the cattle's' drinking water is relatively high in sulfur concentration, then DGS inclusion should be reduced if the sulfur concentration in the DGS is relatively high (perhaps greater than 0.65% S). Part of the dilemma in suggesting fixed recommendations regarding DGS inclusion rates relative to sulfur concentration is that several factors affect how the cattle will react. Potential for sulfur toxicity is just one more issue of concern regarding the feeding of DGS.

Distiller's grains by-products also, contain relatively high concentrations of phosphorous (0.71 – 0.82%). For reference corn grain contains 0.35% phosphorous. The phosphorous concentrations of shelled corn are concentrated during the ethanol fermentation/extraction process into the condensed distiller's solubles fraction (CDS) sometimes referred to as "syrup". The amount of CDS added to the distiller's grains portion to produce distiller's grains with solubles affects the sulfur and phosphorous concentration of the DDGS and WDGS. Therefore, nutrient management plans may be affected by higher manure concentrations of sulfur and phosphorous if distiller's grains represents substantial portions of the diet dry matter. Several studies have suggested that the phosphorous in the DGS is more biologically available, even in ruminants, which suggests the feces from DGS fed cattle may contain less phosphorous than cattle fed traditional diets. However, at high dietary DGS inclusion levels (45 to 70% of the diet DM) the manure phosphorous concentration may be high enough to affect NMP's. Formulating mineral mixtures for beef cattle with lower phosphorous and higher calcium concentrations is warranted. A second phosphorous concern relates to urinary calculi (water belly). When diets contain 25% or more of the dry matter as CGF or DGS, an unfavorable calcium to phosphorous ratio may develop. Recommended Ca:P are between 1.2:1 and 2:1. When phosphorous concentration exceeds these levels diets should contain added calcium upwards to 0.75 – 1.0% of the diet dry matter in the form of calcium carbonate or ground limestone.

High dietary phosphorous for prolonged feed periods (calf feds from weaning to harvest, for example) can result in urinary calculi. To prevent urinary calculi, diets should include 0.5% ammonium chloride. The ammonium chloride dissolves the phosphate stones or prevents their build-up and accumulation in the bladder. Urinary calculi results when the phosphate stones are dislodged from the bladder and the stones block the flow of urine down the urethra. Treatment of steers with urinary calculi requires surgery and economically is usually not worth the cost. Steers with urinary calculi generally should be euthanized. (Heifers do not get urinary calculi.) In addition to adding 0.5% ammonium chloride to the diet, salt can be added from 1 to 3% of the diet DM, but only if plenty of water is readily available. Salt addition increases water intake that increases urine flow, thereby, diluting the urine phosphorous concentration that reduces phosphate stone formation.

Sulfur toxicity and urinary calculi are generally not a problem when feeding DGS. However, at high dietary DGS inclusion levels these two problems can occur and feedlot operators should be prepared. Prevention is more satisfactory than treating the symptoms.

CHAPTER 5: USING CORN BY-PRODUCTS AND SOYBEAN CO-PRODUCTS FOR BEEF COWS

Replacement Heifers

There are many factors to consider when determining whether or not to include, CGF, SH and DGS in beef cattle diets for a given cow-calf operation. In addition to nutritive value, factors such as product turnover (rate of co-product usage), type of storage facility, roughage supply (availability and cost), type of corn processing, nutrient management plan considerations (phosphorous load and fiber volume), and anticipated or expected cattle performance all play a role in deciding how much CGF, SH and/or DGS to include.

So, what is the best choice? Should cow-calf producers feed soyhulls, corn glutten feed or distiller's grains. My first response is what is the roughage source? Is it grass hay or corn silage? If it is high quality alfalfa or other legume hay, the cows probably do not require any co-product supplementation. My rule-of-thumb is if cows are being fed average to high quality grass hay, supplement with soyhulls (SH). If cows are being fed corn silage, supplement with CGF or DGS. Whether the cow is supplemented with SH or CGF/DGS is a function of her protein (CP) and metabolizable energy (ME) needs. A 1,400 pound cow in late gestation/early lactation requires a 11-12% CP diet and 22-27 Mcal of ME per day. In short, grass hay (11-14% CP: 2 Mcal of ME per kg) will meet her CP needs but not her energy requirement. Accordingly, she needs about 3 pounds of SH (9-11% CP, 2.31 Mcal ME) to meet her ME requirement. Feeding GCF/DGS will over supply CP. If the cow is eating 3-4% of her body weight as corn silage her ME requirements are either met or only 2-3 Mcal's short. The cow fed corn silage is short on CP. Therefore, supplement her with 4-5 pounds of dry CG or DGS to fulfill her CP requirement. Feeding SH to a cow consuming corn silage will not meet the CP requirement. These suggestions assume cows are in optimum body condition with a body condition score between 5 and 7. Body condition score (BCS) will effect the level of co-product supplementation required and cows with less than a 5 BCS will require more co-product intake per day.

Coming two-year old heifers in late gestation weighing 900-1,100 pounds require a 10.5 – 12.0% CP diet (this is actually a little higher than the NRC tables recommend) and 20 – 21 Mcal of ME per day. On corn silage and most low quality forage diets SH will not meet the replacement heifers CP needs. Accordingly, supplementation with either CGF or DGS (wet or dry) could be a more correct option. Higher quality grass and/or legume mixed hay is a different situation. In this case SH are an effective energy replacement for shelled corn. Some University of Missouri work has found cows supplemented with SH as a replacement for shelled corn on a pound for pound basis when fed fescue hay outperformed the cows supplemented with shelled corn. The SH fed cows had greater weight gains and higher conception rates post-partum compared to the shelled corn fed cows. In two feeding trials, conducted at Illinois State University, cows during late gestation and lactation fed corn silage based diets supplemented with either shelled corn and soybean meal or DDGS or CGF had similar changes in body weight and body condition score, and similar reproductive performance.

Co-products, also, can be utilized in growing replacement heifer diets. An 84 day feeding trial conducted at Illinois State University found similar ADG for calves fed either a shelled corn, SH, or DDGS based pelleted supplement at 2% of body weight and *ad libitum* grass hay. The calves fed the SH and shelled corn based supplements has higher daily dry matter intakes and gain:feed ratios than calves fed the DDGS based supplement. Two interesting observations were noted in this trial: 1) fewer of the cattle (actually none of the cattle) fed the SH supplement required treatment for respiratory illness during the first 28 days on feed and 2) calves fed the SH based diets at 2% body weight had higher ADG and G:F ratios during the first 12 days on feed.

Another similar 53 day receiving trial conducted at Illinois State University compared wheat midd (WM)-SH, CGF-Shelled corn, CGF-SH and CGF based supplements fed at 1% of body weight to calves consuming grass hay libitum. No significant differences between dietary treatments was observed in ADG, average daily feed intake or gain:feed ratio. It appears growing calves fed co-product based supplements can perform equally as well or better than calves fed shelled corn based supplements.

Table 13 to 20 provide example diets containing either CGF, SH or DGS, singularly or in combination. Each of these diets has been successfully fed to the beef herd at Illinois State University. These diets are shown as examples regarding how co-products can be included into heifer calf, replacement heifer and beef cow diets. All those factors mentioned in the opening paragraph will determine which co-product and how much should be fed.

Another question producers can ask is whether to feed wet or dry CGF/DGS? My response is simple: calculate cost per pound of dry matter delivered to the farm. For example, wet DGS at $15: wet ton at the plant seems cheap compared to $50: dry ton DGS but realized cost is a function of mileage and moisture. Wet DGS at 60% moisture is $37.50: ton dry, and if trucking is $2: loaded mile and the plant is 60 miles away; then the cost is $12: dry ton hauling or $49.50 delivered to the farm assuming the truck hauls 40,000 pounds of product – very comparable to $50 dry DGS. Actual cost per ton of feed can be very similar or very different depending on distance hauled and moisture content.

It is extremely interesting that "in-the-country" there are tremendous variations in the price of the co-products. The true definition for a co-product implies that the co-product has a uniform market value based on the co-products own market demand with an established trading value. In reality the co-products (CGF, DGS and SH) still behave very much like by-products; their market value is largely based on local demand near the processing plant, or a specific companies export market and access to transport to the Gulf. As example, on one day I called several processing plants in Illinois, New York, Iowa, Indiana and Wisconsin to obtain the current days trading values. Soyhulls ranged in value from $70: ton FOB to $100: ton FOB. Wet CGF ranged from $15: ton to $35: ton. Dry CGF varied from $55 to $75 depending on the location and owner of the production plant. The prices for wet DGS ranged from $22 to $38: ton FOB. Dry DGS prices varied from $75 to $92: ton FOB. The point is, co-product prices vary substantially depending on a variety of factors and cattle producers should contact a variety of sources to obtain the best buy. The time of year; also, has a bearing on the price of DGS, CGF and SH. Generally, co-products are higher from November through May than they are during the summer months. If on-farm storage is an option, producers should consider volume-time of year purchases. Feeding co-products is a good thing but it's not always the easiest.

Certainly wet CGF or wet DGS can be the most economical purchase FOB at the manufacturing plant for local cow-calf producers where higher trucking costs are not an issue. However, herd sizes of small scale beef cow-calf producers can be too few in number of cows to utilize high moisture DGS or CGF as a protein-energy supplement on a fresh basis prior to spoiling. Because these feedstuffs typically range in dry matter content between 40% and 60%, the length of storage time until feeding without spoilage is limited to 3-4 days in summer and one week in winter to minimize spoilage. Consequently, cattle producers with smaller herd sizes and limited daily consumption of wet CGF and DGS have had few choices for utilizing this feedstuff. The options have included: 1) hauling smaller loads from the plant to the farm to minimize spoilage that ultimately have resulted in higher transportation costs offsetting the lower purchase cost of DGS or CGF, or 2) ensiling wet DGS or CGF with another feedstuff such as dry corn silage or small grain straws. Scientists at South Dakota State University have evaluated the anaerobic fermentation characteristics of ensiling wet DGS alone or mixed with SH. Combining DGS with SH resulted in immediate acidic conditions in silage mass as a result of the initial low pH of the DGS rather than from fermentation. Ensiling DGS by itself has proven problematic in both upright and horizontal silos. With a modified bagger, DGS can be stored in a silage bag; but the consistency of DGS does not lend itself to all bagging equipment. In Illinois, there is at least one custom bagger capable of placing wet CGF/DGS in a traditional silage bag. Producers may contact Dan Foley, Foley Brothers Trucking, Lena, IL; telephone number (815) 369-5168. In addition, bagging equipment may be too costly or custom bagging may not be available. Storing high moisture CGF or DGS in vertical silos as the sole ingredient is often undesirable for a variety of reasons (poor quality ensiling, difficult to unload, etc.). High moisture CGF and DGS can be mixed with forages and stored successfully in either bunker or column silos. As an alternative option Illinois State University conducted a trial to evaluate a vacuum ensiling method for longer term storage of high moisture distiller's grain. Freshly produced DGS (36.53 ± 0.43% DM) were placed on .24mm thick white plastic silo covers in two rows containing either 49mt or 63.3mt. Each row was either 10 feet or 15 feet wide at the base and 75 feet long. Prior to covering each row with plastic and sealing the plastic at the base with ground limestone a 2 inch diameter x 50 feet perforated tube was laid on each side of each DG row and connected to a 5 HP, 45.4 1, 120 volt Shop Vac® (Williamsport, PA) vacuum. Each vacuum was turned on 3x:d for a 5 minute duration at 8:00 a.m., noon and 4:00 p.m. Bag one was opened at78d post-sealing and fed for 112d. Of the 63.3mt DGS stored in bag one, 19.8% was considered spoiled and unfit for feeding. Bag two was opened on day 190 post-sealing and fed for 67d. Of the 49.0mt DG stored in bag two 27.6% was considered spoiled and unfit for feeding. This trial suggests vacuum storing can preserve DGS for prolonged periods but the vacuum procedure used did not ensile DGS. This particular trial began in November and ended in July the following year.

While including SH, CGF and/or DGS into replacement heifer and beef cow diets is warranted, producers should be aware of several nutritional concerns regarding co-product inclusion. Sulfur can be relatively high in CGF and DGS compared to other feedstuffs such as corn, oats and SH. High sulfate concentrations can lead to low thiamin production by bacteria in rumen. Low thiamin concentrations can result in Polioencephalomalacia (PEM) which can be a fatal tetany. Polioencephalomalacia can be treated with immediate thiamin injections and can be prevented with thiamin supplementation at a rate of 100 mg – 200 mg:head:day. The greater the dry matter portion of the diet composed of DGS or CGF, the higher rate of thiamin supplementation.

Generally unless DGS or CGF represent more than 30% upwards to 40% of the diet dry matter thiamin supplementation is not necessary. Most beef cow diets will contain less than 25% of the diet dry matter as CGF or DGS, therefore, thiamin supplementation should not be required. Replacement heifer diets may require additional thiamin, especially if CGF or DGS approach 40% of the diet dry matter. It is recommended the sulfur content be no greater than 0.4% of the diet dry matter from all sources (including water).

Another concern is the sodium concentration in DGS and CGF. Sodium can range as high as 0.57% - 1.05%. In itself high sodium concentration is not necessarily detrimental High relative sodium concentration suggest producers may want to limit the salt concentration in mineral mixtures by requesting low salt mineral mixes. Corn gluten feed products tend to contain the highest concentrations of sulfur (upwards to 0.72%) and sodium (upwards 1.05%) and are of the most concern of the three co-products. Soyhulls are the least concern regarding high sodium and sulfur concentrations.

<u>The Cost of Feeding Cows During The Winter</u>

In a previous keynote address I discussed the issue of hay value and hays relative cost:lb of TDN (total digestible nutrients) compared to other feedstuffs for beef cows. This information can be seen in Table 51. The calculations in this table assume hay at 90% dry matter (DM) (most hay is probably 85-88% DM) and 55% TDN (grass hay may range between 50 and 53% TDN and legume hay can range between 53 and 59% TDN). The table, also, assumes shelled corn was 12% moisture, and 90% TDN on a DM basis. To calculate corn silage values it was assumed shelled corn yielded 200 bu:ac or 24 tons of corn silage @ 60% moisture and 70% TDN.

An average 1,400 pound cow in late gestation requires 5.9% crude protein and 52% TDN and in early lactation requires 10.9% crude protein and 55% TDN most hay (grass or legume) will satisfy the cows requirements in gestation and high quality grass/legume hay will meet her requirements without supplementation during lactation. Meeting the cows CP (crude protein) and TDN requirements with hay is really not the problem (unless we are dealing with sub-quality hay). The problem is hay is simply too expensive to feed to cows, if one has an alternative market for the hay. Even at $7.50:bu shelled corn costs less per pound of TDN than hay priced at $200:ton. If corn is $7.50, hay must be valued no higher than $170.80:ton so as not to be more expensive than shelled corn. Of course cows can't eat just shelled corn without digestive upset and founder, so either an alternative roughage (corn stalks, soybean stubble, etc.) or limited amounts of hay must be included in the diet. A quick calculation finds the cost of big round bales of corn stalks average 2.35 to 3.53₵:lb of TDN if baling is $10 - $15:bale and no value is given to the corn stalk for nutritive content other than filler or loss in organic matter as a soil amendment caused by removal of the corn stalks. Therefore, a diet containing shelled corn and corn stalks is less expensive than hay.

A recent study completed at Illinois State University compared the cost of feeding late gestation/early lactation beef cows corn silage based diets with either shelled corn and soybean meal (SBM), or low fat modified wet distiller's grains (LWDGS). Table 52 shows that feeding LWDGS to meet similar CP and ME (metabolizable energy) requirements is less expensive than corn silage, shelled corn and soybean meal by 52.86¢:day:cow or $95.15 over a 180 day feeding period. Over feeding LWDGS that results in over feeding CP costs less per day than supplementing corn silage with shelled corn and SBM but is more expensive than feeding

LWDGS to meet just CP and ME requirements. Using LWDGS to replace shelled corn and SBM as a supplemental CP and TDN replacement, cost wise is the most efficacious strategy. Using LWDGS as a replacement for corn silage in addition to shelled corn and SBM is more economical than supplementing corn silage based diets with just shelled corn and SBM. But, as LWDGS replaces corn silage in the diet the cost advantage decreases. However, if corn silage or hay is in short supply, increasing LWDGS in the diet can still be a more economical alternative than purchasing hay. In this study, corn silage made up 64% of the diet DM when shelled and SBM were fed (T1); 72% when LWDGS was 25% of the diet DM (T2); 53% when LWDGS was 43% of diet DM (T3); and 38% when WLDGS was 58% of the diet DM (T4).

When hay is in short supply or when hay has a high relative value, low fat modified wet distiller's grains with solubles are an attractive replacement. However, the price advantages for LWDGS can be reduced if LWDGS is overfed.

Table 51. Hay Value vs. Cost:lb TDN

Hay*	\$100:Ton	\$200:Ton	\$300:Ton
	10.10¢:TDN	20.20¢:TDN	30.30¢:TDN
Shelled Corn	\$2.50:bu	\$5.50:bu	7.50:bu
	5.64¢:TDN	12.40¢:TDN	16.91¢:TDN
Corn Silage	3.71¢:TDN	8.18¢:TDN	11.16¢:TDN

*Hay must be \$56:Ton to = 5.64¢:TDN

Table 52. Feed Cost (Cents:Day) Per Cow Fed Corn Silage And Either Varying Amounts Of LWDGS, Or Shelled Corn And SBM

	Treatments			
Feedstuff	T1	T2	T3	T4
Whole shelled corn	54.27	—	—	—
Soybean meal	42.02	—	—	—
WDGS	—	31.90	60.53	83.04
Corn silage	82.43	93.16	75.56	54.10
Dicalcium Phosphate	0.07	—	—	—
Limestone	2.43	3.30	4.14	5.04
Pre-mix	1.20	1.20	1.20	1.20
Daily feed costs[3]	182.42	129.56	141.43	143.38

[1] All calculations based on DMI per day and cost per unit weight of feeds.

[2] Treatments: T1 = control diet balanced to provide 12.0% CP; T2 = replacement of corn:soybean in T1 diet with LWDGS to provide approximately 12.0% CP; T3 = replacement of corn:soybean:some corn silage with LWDGS to provide approximately 16% CP; and T4 = replacement of corn:soybean:some corn silage with LWDGS to provide approximately 20% CP.

[3] [4] Calculated with the following prices on a DM basis: whole shelled corn = \$6.00:bu; SBM = \$310:ton; LWDGS = \$65; corn silage = 2.25¢:lb; dicalcium phosphate = 9¢:lb; limestone = 9¢:lb; pre-mix \$13.80:lb.

SUMMARY

The take home message from these data is that whether modified wet distiller's grains (WDGS) contain higher fat (10-12%) or lower fat (6-8%) contents we can successfully feed finishing steers up to 70% of the diet dry matter without greatly compromising the outcomes. How much WDGS is fed may depend on the amount of roughage included in the diets. All of our diets have included 15% corn silage or ground grass hay on a dry matter basis. The secret to facilitating the dietary inclusion of WDGS above 50% of the diet dry matter may be maintaining at least 15% roughage on dry matter basis within the diet. All things evaluated, 40 to 45% DGS inclusion may be the most efficacious inclusion level, but depending on feedlot performance, total feed cost and degree of management expertise, 70% DGS may return the most dollars over feed cost if the price is right. Modified wet DGS is more efficacious than DDGS.

Bullet points include:

- Increase of lower fat WDGS in diet at 70% inclusion increases average daily feed intake (ADFI) and dry matter intake (DMI)
- Increase of higher fat WDGS in diet decreases DMI
- Greatest biological efficiency = 25% WDGS
- Greatest economic efficiency = 40-45% WDGS
- High WDGS inclusion (70%) = greater economic efficiency than 0% WDGS
- Lower fat WDGS performance differs from higher fat WDGS, especially at 70% DM inclusion
- Lower and higher fat 70% WDGS have tendency for lower quality grade
- Lower and higher fat WDGS fed at 25 or 40% results in similar to higher quality grade to 0% DGS

- Lower fat WDGS and high fat WDGS inclusion rates have little effect on meat shelf life
- Both lower fat WDGS and higher fat WDGS increase PUFA, PUFA/SFA and 06 fatty acids in beef tallow
- Higher fat WDGS increases PUFA, PUFA/SFA and 06 fatty acids more than lower fat WDGS