Utilizing the Growing Local Supply of Distillers Grains

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Introduction

Across the Midwest, ethanol plants (primarily dry mill vs. wet mill process) are being planned and built and existing plants expanded. Today over 98 percent of commercially produced ethanol is used to extend gasoline. The attributes of ethanol allow it to be utilized as an octane booster, replacing gasoline additives such as lead and benzene, and as the preferred oxygenate for gasoline replacing MTBE (methyl tertiary butyl ether). Ethanol maintains widespread support for its ability to improve the environment and public health by reducing harmful vehicle emissions. Ethanol contains 35% oxygen and adding ethanol to fossil fuels (gasoline and diesel) results in more complete fuel combustion, reducing tailpipe emissions. Ethanol is non-toxic and is rapidly biodegraded in surface water, ground water and soil. Current energy legislation before congress contains a Renewable Fuels Standard which, if approved, will further accelerate the growth of ethanol and biodiesel production.

Two methods used to produce ethanol from corn are wet milling and dry milling, and each process generates unique co-products. Primary products of wet milling corn include corn starch, corn syrup, sweeteners and corn oil in addition to feed co-products – corn steep liquor, corn germ meal, corn gluten feed and corn gluten meal. Dry mills are significantly less expensive to build and typically produce only three products, ethanol, distillers grains and carbon dioxide. A well-managed plant utilizing modern dry mill technology generates approximately 2.7 gallons of ethanol, 18 pounds of dried distillers grains with solubles (DDGS) and 18 pounds of CO_2 from each bushel of corn processed. A typical area plant processes 20 million bushels of corn annually. From 1980 to 2000 the tonnage of distillers grains increased ten fold from 320 thousand to 3.5 million metric tons (1 metric ton = 1000 kilograms = 2204.6 pounds). Distillers grains production is expected to again double by 2005, at an estimated 7 million metric tons (U.S. Grains Council; personal communication, Steve Markham, Commodity Specialists Company). An illustration may help to put the projected volume of distillers grains into perspective. The present national dairy herd of 9,147,000 cows would need to consume 5.5 pounds of distillers grains per day over a 305 day lactation to balance the 2005 projected supply. Distillers grains is also utilized in the rations of dairy replacements, in the diets of other classes of livestock such as beef, swine and poultry, and is an important export commodity.

While the U.S. clearly has the livestock base to absorb all of the distillers grains produced, it must do so by displacing other feed grains and oil seeds, primarily corn and soybean meal. It is interesting to note that despite increasing supplies of distillers grains its price has remained nearly flat the past 4 years. With increasing supplies and stable exports (average 770,000 metric tons or about 20% of current national production) it is evident U.S. dairy and livestock producers are supplementing animal diets with distillers grains. In several Midwestern states (Illinois, Iowa, Kansas, Minnesota, Nebraska, North Dakota and South Dakota) fuel ethanol plants have been in operation for several years. Two Wisconsin ethanol plants (Ace Ethanol, Stanley and Badger State Ethanol, Monroe) and a Michigan facility (Michigan Ethanol, Caro) initiated production during 2002. Currently, 68 ethanol plants nationwide have the capacity to produce

2.65 billion gallons annually (Renewable Fuels Association). There are presently 10 additional ethanol plants under construction.

Various cereal grains (corn, wheat, sorghum, rye, etc.) are used to produce grain alcohol or ethanol utilizing dry mill technology. In the Midwest where most plants generate fuel vs. beverage ethanol, the predominant grain used is corn or a combination of corn and sorghum. During processing, cleaned whole kernel grain is ground to increase the surface area, and then water is added to make a mash, which is cooked under pressure. Cooking serves to gelatinize the starch and greatly reduces undesirable microbial populations within the mixture. The mash or slurry is then cooled and enzymes are added to liquefy the mass and to convert the starch into sugar. Yeast is then added to ferment the sugar to alcohol and carbon dioxide. For thousands of years, this innovation in biotechnology, i.e., the conversion of fermentable substrate (fruits, grains, flowers) via a living agent (yeast) into alcohol has served to lift the human spirit. Initially this benefit to mankind was through the direct consumption of alcohol in the form of wine, and more recently, as a renewable energy source and oxygenating agent for fossil fuels.

The remainder of this paper will explore how best the dairy industry may utilize spent distillers grains and de-alcoholized fermentation residues from corn as it is the dominant feedstock used in Midwest ethanol plants. After removal of the ethanol through a distillation process, the whole stillage is run through a centrifuge or series of screens and presses where the solid undissolved grain particles are separated from the dissolved solids. The dissolved solids, which are carried in the thin stillage, are then concentrated into syrup through multiple effect evaporators. The syrup may then be marketed as condensed distillers solubles (CDS) or dried as such to become dried distillers solubles (DDS). However, very little CDS or DDS is presently produced. In most plants the solubles are added to the grain or cake (wet distillers grain with solubles – WDGS or dried distillers grain with solubles – DDGS) and the combined product reaches an equilibrium dry matter content. Distillers grains are then offered for sale to feed manufactures/handlers or directly to livestock producers. Marketing of wet distillers grains has developed near distilleries. The customer base is usually within 150 miles of the plant because of transportation costs associated with the movement of water. From a plant operations perspective, not having to dry all the spent distillers byproducts represents a significant energy cost savings. Assuming this cost savings is passed on to the customer, a win-win situation is created for both entities; ethanol plant management achieves more efficient energy production from each bushel of corn and dairy producers have the potential to realize greater income over feed costs.

Nutrient Composition of Distillers Grains with Solubles

Important factors to consider when evaluating any feedstuff for inclusion in a ration is its nutrient composition and variability. As with many byproduct feeds, the nutrient composition of distillers grains is influenced by several variables including type of grain used, grain quality, grinding procedures, extent of fermentation, drying conditions, quantity of solubles blended back with the spent grain and particle separation. Mean DDGS nutrient composition values from a recent survey of eight Midwestern fuel ethanol plants (Hardy et al. 1998) are as follows: 30% crude protein; 53% ruminally undegraded protein; 10.5% ether extract; 49% neutral detergent fiber; and 4.3% ash. These values compare favorably with analyses reported in the National Research Council's 2001 Nutrient Requirements of Dairy Cattle. However, the range in values across plants (and within plant) is greater than one would typically find with whole grains (slides 14 and 15).

Approximately a three-fold increase in the concentration of protein, fat and fiber is found in distillers grains compared to corn and unlike corn which is high in starch, distillers grains is practically devoid of starch (slide 12). The process also enhances the digestibility of the fiber fraction. Highly digestible fiber and moderate fat content classify distillers grains as a high energy feed. The fermentation residues contain yeast cells, B-complex vitamins and other unidentified nutrients formed during the fermentation-distillation process. The protein quality of corn distillers grains is similar to other corn products with inherently low lysine content. Wet and dried DGS are excellent sources of ruminally undegraded protein (RUP). However, heat damaged protein may occur during the drying of distillers grains or solubles, reducing the efficiency of protein utilization by animals (Cromwell et al. 1993). Heat damaged protein is of greater concern with dried vs. wet distillers grains. Elevated drying temperatures that result in acid detergent insoluble nitrogen (ADIN) levels greater than 13% are negatively correlated with apparent N digestibility. Compared to corn grain, phosphorous is also concentrated three-fold in distillers grains and must be taken into consideration when formulating dairy diets to minimize phosphorous excretion into the environment.

Nutritional Aspects - Dairy Diets

DDS, CDS, DDG, and DDGS have been successfully utilized in dairy rations for over a century. A great deal of research comparing these products to other protein and energy feeds has been conducted over the past 50 years with distillers byproducts proving their value. Some of the more recent trials utilizing "new generation" distillers grains include Armentano 1994 & 1996; Nichols et al. 1998; Schingoethe et al., 1999; Liu et al., 2000 and Al-Suwaiegh et al., 2002. DDGS has become a common component of commercial dairy protein supplements, often comprising 25-35% of the blend (dry matter basis) depending upon the price of other competing ingredients. A common comparison by dairy nutritionists is that one pound of DDGS is roughly equivalent to 0.6 pounds of shelled corn and 0.4 pounds of soybean meal.

Recent work by Nebraska researchers allowed direct comparison of wet versus dried distillers grains of corn or sorghum (slide 26). Diets of lactating dairy cows included 25% corn silage, 25% alfalfa haylage and 15 % distillers grains (dry matter basis). Treatments were corn DDGS, corn WDGS, sorghum DDGS and sorghum WDGS. Milk production was similar (71 vs. 72 pounds) comparing wet to dried DGS with a slight advantage of corn over sorghum. Milk protein and butterfat values were similar across treatments with a slight advantage of dried vs. wet DGS. Dry matter intake was similar across treatments, suggesting the higher moisture content of the wet DGS diets did not limit intake. Water per se does not limit dry matter intake and because low pH and elevated organic acids are not a concern in WDGS, it does not seem likely that feeding this product will adversely affect intake. However, dry matter intake may be depressed if the inventory of WDGS is not turned fast enough to prevent spoilage.

Feeding Guidelines

As rations are formulated, each ingredient is examined for its nutritional contribution and its interactions with other feeds (physical form; rumen dynamics; effect on amino acid profile; etc.). WDGS and DDGS are very palatable feeds and will frequently comprise 10 to 20% of the ration dry matter. The basic limit to the quantity of distillers grains in dairy diets is related to protein content and quality. Noted as an asset above, distillers grains are an excellent source of RUP. However, depending on the protein characteristics of other ration ingredients, feeding high levels of distillers grains decreases ruminally degraded protein (RDP), may depress rumen ammonia levels and increase RUP above dietary recommendations. When this happens, rumen microorganisms are starved for nitrogen reducing microbial protein production, fiber digestion is decreased and dry matter intake depressed. Maximizing the quantity and quality of protein available to the intestine is key to achieving high levels of milk production. A costly error of any dairy diet is to limit microbial protein synthesis.

An excellent discussion by Linn and Chase (1996) recommended limiting the amount of crude protein coming from corn sources in a ration to 60% of the total crude protein, and identified sources as corn silage, corn grain, corn distillers grains, corn gluten meal and corn gluten feed. As corn protein is deficient in lysine, this appears to be a prudent guideline. A valuable new tool for evaluating dairy diets is included in the National Research Council's 2001 Nutrient Requirements of Dairy Cattle. After diet ingredients and cow data are entered the ration evaluation program predicts nutrient requirements of the animal, nutrients supplied ration ingredients and positive or negative balances. The model predicts dietary RDP and RUP and also identifies, based on tabular values, when amino acids such as lysine or methionine may limit milk production. Use of the model suggests the crude protein limitation may be increased if feeds high in lysine content such as blood meal or ruminally protected lysine sources are included in multiple corn source diets.

The non-fiber carbohydrate (NFC) and starch content of dairy rations should usually not exceed 35-40% and 25-30%, respectively. Diets exceeding these levels of NFC and starch have the potential for causing ruminal acidosis. A characteristic of distillers grains is that its net energy of lactation equals that of corn without contributing to the starch load in the rumen. The low NFC as well as moderately high fat content of distillers grains may present additional nutritional concerns. Rumen microorganisms need readily available sources of energy and nitrogen to grow rapidly. This is where other ration ingredients need to compliment distillers grains. If whole oilseeds like soybean or cottonseed are fed, the maximum potential inclusion of distillers grains will likely be reduced to avoid dietary fat levels greater than 6%. Although the feeding guidelines outlined above may seem complex, nutritionists apply these principles to distillers grains as well as a plethora of other feedstuffs everyday in countless dairy diets. If suggested guidelines are followed, distillers grains can be used effectively in dairy cattle diets.

Handling and Storage Considerations

DDGS is relatively easy to handle and store on farm, whereas WDGS offers some challenges. Depending on the plant and whether wet or dried feed is being produced, the relative proportions of distillers grains to solubles varies. Personal communications with industry experts indicate WDGS composition ranges from 65% distillers grains and 35% solubles to 50% distillers grains and 50% solubles on a dry matter basis. Fresh WDGS typically has a dry matter content ranging from 30 to 40%. Some ethanol plant managers, seeking to gain a competitive advantage are further drying their WDGS. Higher dry matter WDGS (40 to 50% DM) may improve the handling characteristics (flowability, likelihood of freezing in cold weather, nutrient losses via leaching, etc.) of the product making it more attractive to dairy operators. As described above, cooking the mash greatly reduces microbial populations, especially those that may compete for substrate. The process therefore renders a product that is at least initially low in microorganisms, including those potentially responsible for spoilage. When exposed to air the product has a shelf life of 2 to 7 days depending on the weather. On large dairies, WDGS is often delivered via end dump or live floor trailers and stored in bunker silos or in-ground pits and utilized before spoilage occurs. The WDGS used in the Nebraska trial was stored in nine-foot diameter silo bags and researchers reported excellent keeping quality over the yearlong study. A logical conclusion for extended shelf life was exclusion of air provided by the plastic bag. It is unlikely there is sufficient residual fermentable substrate and lactic acid producing bacteria to facilitate fermentation processes similar to other ensiled crops. Silo bag storage may make feeding WDGS feasible for more dairies in close proximity to ethanol plants. Bagging expense is estimated at $6 per ton including the rental cost of a table-dump-bagging machine, plastic bag and fuel (personal communication, Lyle Lange, Lange Ag Systems).

Summary

Distillers grains with solubles are excellent feed resources for dairy cattle but must be competitively priced to displace feedsuffs currently included in dairy rations. As ethanol production ramps up to meet demand, the supply of distillers grains will significantly increase. WDGS is subject to biodegradation and must be handled properly at the plant as well as on farm. Diet inclusion rates and on farm storage strategies must be developed in order to capture its maximum feeding value. Enlisting a nutritionist who understands grouping strategies, facility limitations and feed inventories usually pays dividends as dairy operators consider adding distillers grains to their feedstuff arsenal. Savvy ethanol plant managers recognize the importance of product consistency and are beginning to provide additional services to dairy customers.

References

Al-Suwaiegh, S., K. C. Fanning, R. J. Grant, C. T. Milton, and T. J. Klopfenstein. 2002 Utilization of distillers grains from the fermentation of sorghum or corn in diets of finishing beef and lactating dairy cattle. J. Anim. Sci. 80:1105

Armentano, L. E. 1994. How we can optimize the protein quality delivered to lactating cows when feeding DDGS. Proc. Distillers Feeds Research Council, Vol. 49:63. New Orleans, LA.

Armentano, L. E. 1996. Addition of lysine improves lactation performance in cows fed high levels of DDGS. Proc. Distillers Feeds Research Council, Vol. 51:11. Orlando, FL.

Cromwell, G. L., K. L. Herkelman, and T. S. Stahly. 1993. Physical, chemical, and nutritional characteristics of distillers dried grains with solubles for chicks and pigs. J. Anim. Sci. 71:679

Harty, S. R., J-M Akayezu, J. G. Linn, and J. M. Cassady. 1998. Nutrient composition of distillers grains with added solubles. J. Dairy Sci. 81:1201

Linn, J. G. and Chase, L. 1996. Using distillers grains in dairy cattle rations. Proc. Professional Dairy Management Seminar. Dubuque, IA.

Liu, C., D. J. Schingoethe and G. A. Stegeman. 2000. Corn distillers grains versus a blend of protein supplements with or without ruminally protected amino acids for lactating cows. J. Dairy Sci. 83:2075.

Nichols, J. R, D. J. Schingoethe, H. A. Maiga, M. J. Brouk and M. S. Pipenbrink. 1998. Evaluation of corn distillers grains and ruminally protected lysine and methionine for lactating dairy cows. J. Dairy Sci. 81:482.
Schingoethe, D. J., M. J. Brouk and C. P. Berkelo. 1999. Milk production and composition from cows fed wet corn distillers grains. J. Dairy Sci. 82:574.