Utilizing the Growing Supply of Distillers Grains

Robert M. Kaiser
University of Wisconsin-Extension

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 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 percent 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. Energy legislation before the Senate and the House contains a Renewable Fuels Standard which, if approved, will further accelerate the growth of ethanol 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 2.85 gallons of ethanol, 18 pounds of distillers dried 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). Compared to 2000, distillers grains production again doubled in 2004 at over 7.3 million metric tons and it remains the fastest growing commodity feed for livestock.

An illustration may help to put the present volume of distillers grains into perspective. The national dairy herd of approximately 9 million cows would need to consume 6 pounds of distillers grains per day over a 305 day lactation to balance the supply. Distillers grains are also utilized in the rations of dairy replacements, in the diets of other classes of livestock such as beef, swine and poultry, and are an important export commodity. While our national livestock base is sufficient to make use of all available distillers grains, other feed ingredients now included in diets, must be displaced. Currently there are 83 ethanol plants in operation and 15 new plants under construction. Ethanol production is expected to top 4 billion gallons this year. Most ethanol plants built in the last ten years employ dry mill technology and dry mills generate about seventy-five percent of the total ethanol volume. With increasing supplies and relatively stable exports (about 1 million metric tons) it is evident U.S. dairy and livestock producers are supplementing animal diets with distillers grains.

Various cereal grains (corn, sorghum, wheat, rye, etc.) are used to produce grain alcohol or ethanol. In the Midwest where most plants generate fuel vs. beverage ethanol, the predominant grain used is corn. 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 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. After removal of ethanol through distillation processes, the whole stillage is run through centrifuges where grain particles are separated from 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. At most plants the solubles are added to the spent grain or cake to become distillers wet grain with solubles (DWGS) or DDGS and the combined product reaches equilibrium dry matter. Distillers grains are then offered for sale to feed manufactures/handlers or directly to livestock producers. Marketing of DWGS usually occurs 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 distillers byproducts represents a significant energy cost savings. Assuming these savings are 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 dairy rations are nutrient composition and variability. The nutrient composition of distillers grains as with many byproduct feeds, is influenced by multiple variables including type of grain used, grain quality, grinding procedures, extent of fermentation, drying conditions, quantity of solubles blended back with the cake and particle separation. Depending on the plant and whether DWGS or DDGS is being produced, the relative proportions of cake to solubles varies. Personal communications with industry experts indicate the composition of DWGS ranges from 65 percent cake and 35 percent solubles to 45 percent cake and 55 percent solubles on a dry matter basis. Nutrient means and standard deviations of dried (Robinson, 2005; Hardy et al., 1998; DePeters et al., 2000; Belyea et al., 1989; Spiehs et al., 2002) and wet (Kaiser, 2005) distillers grains from six surveys are included in Table 1. These values compare favorably with DDGS analyses reported in the National Research Council's 2001 Nutrient Requirements of Dairy Cattle.

An approximate 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. The ethanol production process also enhances the digestibility of the fiber fraction. Highly digestible fiber and moderate fat content classify corn 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 which are inherently low in lysine. DDGS and DWGS are excellent sources of ruminally undegraded protein (RUP). 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). Cromwell found that elevated drying temperatures resulting in acid detergent insoluble nitrogen (ADIN) levels greater than 13 percent are negatively correlated with apparent N digestibility. Heat damaged protein is usually of greater concern with DDGS than DWGS. 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, distillers dried grains (DDG), DDGS and DWGS 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. Meta-analyses of literature data (Kaiser et al., 2005 - reviewed 21 trials with 53 control vs. distillers grains comparisons from 1980 to 2005; Kalscheur, 2005 - reviewed 24 studies with 98 treatment comparisons from 1982 to 2005) confirm lactation performance responses to inclusion of distillers grains in the diets of lactating cows. DDGS has become a common component of commercial dairy protein supplements, often comprising 25-35 percent of the blend on a dry matter basis (DM 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.

Work by Nebraska researchers (Al-Suwaiegh et al., 2002) allowed direct comparison of wet and dried distillers grains from corn or sorghum. Diets of lactating dairy cows included 25 percent corn silage, 25 percent alfalfa haylage and 15 percent distillers grains with solubles (DM basis). Treatments were corn DDGS, corn DWGS, sorghum DDGS and sorghum DWGS. Milk production was similar (71 vs. 72 pounds) comparing wet to dried with a slight advantage of corn over sorghum. Milk protein and milk fat values were similar across treatments with a slight advantage of DDGS compared to DWGS. Dry matter intake was similar across treatments suggesting the higher moisture content of the DWGS diets did not limit intake. Water per se does not limit dry matter intake and because low pH and elevated organic acids are not characteristics of DWGS, it does not seem likely that feeding wet distillers will adversely affect intake. However, intake may be depressed if the inventory of DWGS is not turned fast enough to prevent spoilage.

Feeding Guidelines

As rations are formulated, each ingredient is examined for its nutritional contribution and interactions (physical form; rumen dynamics; effect on amino acid profile; etc.) with other feeds. DWGS and DDGS are very palatable feeds and will frequently comprise 5 to 20 percent of the dietary dry matter of lactating dairy cows. Studies reviewed in meta-analyses cited above report successful dietary inclusion rates of over 30 percent distillers grains (DM basis). 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. Dependent upon protein characteristics of other ration ingredients, feeding high levels of distillers grains may increase RUP above dietary recommendations and may depress rumen ammonia levels. When this occurs, rumen microorganisms are starved for nitrogen reducing microbial protein production, and depressing fiber digestion and dry matter intake. Maximizing the quantity and quality of protein available to the intestine is vital to achieving high levels of milk production. A costly error of any dairy diet is to limit microbial protein synthesis.

A discussion by Linn and Chase (1996) recommended limiting the amount of crude protein coming from corn sources in dairy rations to 60 percent 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 appeared to be a prudent recommendation. With the introduction of the 2001 Nutrient Requirements of Dairy Cattle a valuable tool for evaluating dairy diets became available. After diet ingredients and cow data are entered the ration evaluation program predicts nutrient requirements of the animal, nutrients supplied by ration ingredients and positive or negative balances. The model predicts dietary ruminally degraded protein (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 of 60 percent from corn sources 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 percent and 25-30 percent (DM basis), 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 however present additional nutritional challenges. 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 percent. 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 DWGS offers some challenges. Fresh DWGS typically has a dry matter content ranging from 30 to 40 percent. Some ethanol plant managers, seeking to gain competitive advantage are further drying their DWGS. Higher dry matter DWGS (40 to 50% DM) may improve the handling characteristics of the product making it more attractive to dairy operators and expand the distance from the plant where it is economically feasible to market DWGS. 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 responsible for spoilage. When exposed to air the product typically has a shelf life of two to seven days depending on the weather. On large dairies, DWGS is often delivered via end dump or live floor trailers and stored on bunker silo floors or in-ground pits and utilized before spoilage occurs. The DWGS 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 DWGS possible 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 feedstuffs currently included in dairy rations. As ethanol production ramps up to meet demand, the supply of distillers grains will significantly increase. DWGS 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. 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

Belyea, R. L., B. J. Steevens, R. J. Restrepo, and A. P. Clubb. 1989. Variation in composition of by-product feeds. J. Dairy Sci. 72:2339

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

DePeters, E. J., J. G. Fadel, M. J. Arana, N. Ohanesian, M. A. Etchebarne, C. A. Hamilton, R. G. Hinders, M. D. Maloney, C. A. Old, T. J. Riordan, H. Perez-Monti, and J. W. Pareas. 2000. Variability in chemical composition of seventeen selected by-product feedstuffs used by the California dairy industry. Prof. Animal Sci. 16:69

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

Kaiser, R. M., E. C. Schwab, R. D. Shaver, and L. E. Armentano. 2005. Using ethanol industry co-products in dairy rations. ASAS Midwest Meeting, Des Moines, IA

Kaiser, R. M. 2005. Variation in composition of distillers wet grains with solubles. Proc. 4-State Dairy Nutrition and Management Conference. Dubuque, IA

Kalscheur, K. F. 2005. Impacts of feeding distillers grains on milk fat, protein and yield. Distillers Grains Technology Council, Louisville, KY.

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

National Research Council. 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed., Natl. Acad. Press, Washington DC.

Robinson, P. H. 2005. Ethanol industry co-products: milling process, nutrient content and variation. ASAS Midwest Meeting, Des Moines, IA.

Spiehs, M. J., M. H. Whitney, and G. C. Shurson. 2002. Nutrient database for distiller's dried grains with solubles produced from new ethanol plants in Minnesota and South Dakota. J. Anim. Sci. 80:2639

Table 1. Nutrient means and standard deviations of distillers grains with solubles from seven data sets.

	DM	SD	CP	SD	EE	SD	EE UW	SD	NDF	SD	NDF-D	SD
NRC, DDGS	**90.2**	**1.8**	**29.7**	**3.3**	**10.0**	**3.4**			**38.8**	**7.8**		
Kaiser, DWGS	35.8	1.5	26.6	1.6	10.5	1.0	16.4	1.2	30.1	3.0	59.0	6.4
Robinson, DDGS	90.1	1.6	30.1	2.6	11.5	3.5			33.7	4.7	76.2	7.6
Robinson, Dakota Gold™	88.2	0.9	30.7	1.2	11.9	0.7			28.1	2.4	77.5	1.5
Hardy, DDGS	92.7	1.0	30.1	1.5	10.5	1.2			48.8	3.2		
DePeters, DDGS			31.2	0.6	13.0	1.3			35.6	8.2		
Belyea, DDGS			30.6	1.4	7.4	0.9			33.0	1.5		
Spiehs, DDGS	89.0	1.1	30.2	1.0	10.9	0.5			42.0	4.3		

	P	SD	Ca	SD	K	SD	Mg	SD	Ash	SD	Ash UW	SD
NRC, DDGS	**0.8**	**0.1**	**0.2**	**0.1**	**1.1**	**0.2**	**0.3**	**0.1**	**5.2**	**1.1**		
Kaiser, DWGS	0.9	0.2	0.1	0.1	1.2	0.1	0.4	0.0	5.6	1.5	4.5	0.4
Robinson, DDGS	0.9	0.1	0.1	0.0	1.0	0.2	0.3	0.1	4.9	0.8		
Robinson, Dakota Gold™	0.7	0.1	0.0	0.0	0.9	0.1	0.3	0.0	4.6	0.2		
Hardy, DDGS									4.3	0.6		
DePeters, DDGS	0.8	0.0	0.1	0.0	1.0	0.1	0.4	0.0	4.7	0.3		
Belyea, DDGS	0.7	0.0	0.0	0.0	0.9	0.1	0.3	0.0	3.1	0.3		
Spiehs, DDGS	0.9	0.1	0.1	0.0	0.9	0.1	0.3	0.0	5.8	0.5		

DM = dry matter, SD = standard deviation, CP = crude protein, EE = ether extract – acid hydrolysis, EE UW = ether extract University of Wisconsin-Madison – Soxhlet, NDF = neutral detergent fiber, NDF-D = NDF digestibility, P = phosphorous, Ca = calcium, K = potassium, Mg = magnesium.