FEEDING THE NEXT GENERATION OF CORN ETHANOL BYPRODUCTS TO BEEF CATTLE

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INTRODUCTION

Over the last ten years, no topic has received more ruminant nutrition research attention than the utilization of byproducts from the ethanol industry. The rapid increase in ethanol production capacity in the United States has resulted in abundant quantities of corn-based ethanol byproducts. According to the Renewable Fuels Association (RFA), ethanol production in the United States has increased from 1.6 billion gallons and 54 operational ethanol plants in the year 2000 to 10.6 billion gallons of ethanol and 187 operational ethanol plants in 2009 (RFA, 2010; Figure 1).

Two primary byproducts have come from the rapid increase in ethanol production: distillers grains with solubles (DGS) from the dry grinding industry and corn gluten feed from the wet milling industry. In 2009-10, the RFA estimates that approximately 34 million metric ton of byproduct feedstuffs will be produced from ethanol production (RFA, 2010; Figure 2). Of this total production, DGS comprises the vast majority of ethanol byproducts, with approximately 30 million metric ton, while corn gluten feed accounts for approximately 3 million metric ton. Ruminants are by far the largest users of DGS, with dairy cattle consuming 39% of DGS produced, followed by beef cattle at 38%, swine at 15%, and poultry at 7% (RFA, 2010).

Though ethanol production continues to increase, the magnitude of the increase has slowed, and new and existing ethanol plants are looking for ways to become more efficient, extract more

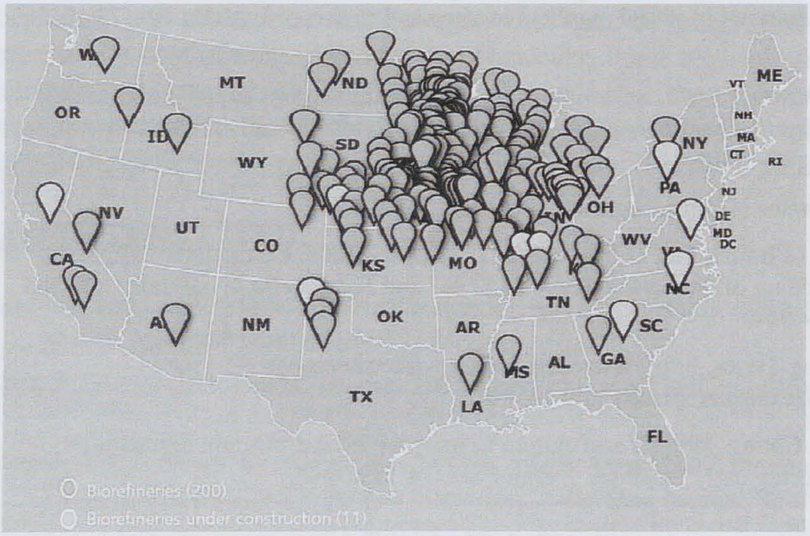

Figure 1. Location of ethanol biorefineries in the U.S.

Source: Renewable Fuels Association, January 2010.

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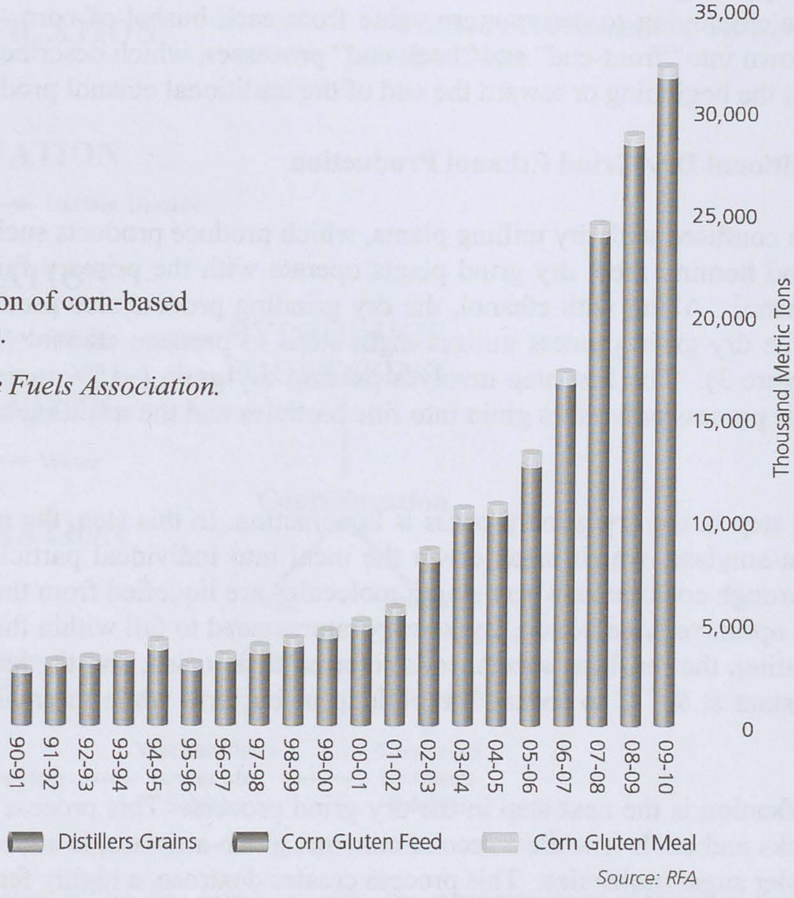
ethanol from each bushel of corn, and diversify their product portfolio. Traditional figures estimate that one bushel of corn in a dry grind ethanol plant will produce 2.7 gallons of ethanol, 18 pounds of carbon dioxide, and 18 pound of dry DGS (DDGS). Although DGS add value for dry grind ethanol plants, the value of ethanol fuel is greater. In addition, opportunities exist for dry grind ethanol plants to broaden their product portfolio to provide food-grade products, such as those produced by wet milling ethanol plants. Therefore, dry grind ethanol plants have undertaken processes, often broadly termed fractionation, to derive more ethanol, and in some cases new, higher-value products, from their feedstock supply. These advanced processes will affect the nutrient and feeding value of DGS and other byproducts that are produced.



Source: RFA

Figure 2. Production of corn-based ethanol byproducts.

Source: Renewable Fuels Association.

CORN-BASED ETHANOL PRODUCTION

Traditional corn-based ethanol production consists of either dry grinding or wet milling. Though these production processes are often grouped together, there are significant differences between the two types of mills and the products they produce. Dry grind plants produce three primary products: ethanol, carbon dioxide, and DGS. Wet mills also produce ethanol and carbon dioxide, with the primary feedstuffs resulting from wet mills being corn gluten feed and corn gluten meal. Wet mills also produce food grade products, such as high-fructose corn syrup, that add tremendous value to the wet milling process of these types of plants. As a result of the more complicated milling process, wet mills are much more expensive to build and operate, and are therefore much less common than dry grind ethanol plants. Wet mill ethanol plants are primarily owned and operated by large agribusiness corporations, such as Cargill and ADM, while dry grind plants vary widely in size and ownership groups, ranging from small farmer-owned cooperatives to large, corporate-owned plants. Because these new technologies apply almost exclusively to dry grind ethanol plants, wet milling will not be covered in detail. The Corn Refiners Association website (http://www.corn.org) contains a large amount of information on wet milling processes and products.

New technologies have brought about systems to improve the array of byproduct feedstuffs and the yield of ethanol from corn and other feedstocks in dry grind plants. These technologies are often grouped together as "fractionation". In reality, there are multiple processes that ethanol plants are employing to derive more value from each bushel of corn. In general, they can be broken down into "front-end" and "back-end" processes, which describe if the new technology is applied at the beginning or toward the end of the traditional ethanol production process.

I. Traditional Dry Grind Ethanol Production

Not to be confused with dry milling plants, which produce products such as corn meal, breakfast cereal, and hominy feed, dry grind plants operate with the primary function of producing fuel grade ethanol. Along with ethanol, the dry grinding process also produces carbon dioxide and DGS. The dry grind process utilizes eight steps to produce ethanol (ICM, 2009; Vander Pol, 2006; Figure 3). The first step involves passing dry grain (~15% moisture) through a hammer mill. This process pulverizes grain into fine particles and the resulting substance is referred to as meal.

The next step in the dry grind process is liquefaction. In this step, the meal is mixed with water and alpha-amylase, which break down the meal into individual particles. The mixture is then passed through cook tanks where starch molecules are liquefied from the actions of enzymes and heat. To optimize liquefaction, cook temperatures need to fall within the range of 121 to 148^{o} C. After heating, the resulting substance is referred to as mash, and the temperature of the mash is held constant at 93^{o} C to reduce the buildup of bacteria while the mash is in separate holding tanks.

Saccharification is the next step in the dry grind process. This process takes the mash from the 93^{o} C tanks and cools it while a second enzyme, gluco-amylase, is added to break down starches into simpler sugar molecules. This process creates dextrose, a highly fermentable sugar.

After the saccharification process, fermentation of the resulting dextrose can occur. There are two types of fermentation processes typically utilized in the industry, continual or batch (ICM, 2009). In a continuous fermentation process, the mash passes from one fermenter to another, piped together in series. By the time the mash enters the final fermenter, all the sugar has been fermented.

In a batch fermentation process, the mash stays in one fermentation tank for approximately 48 hours to allow for complete fermentation. After the fermentation process is complete, the resulting material is referred to as beer, and is stored in a beer well before transfer to the next process.

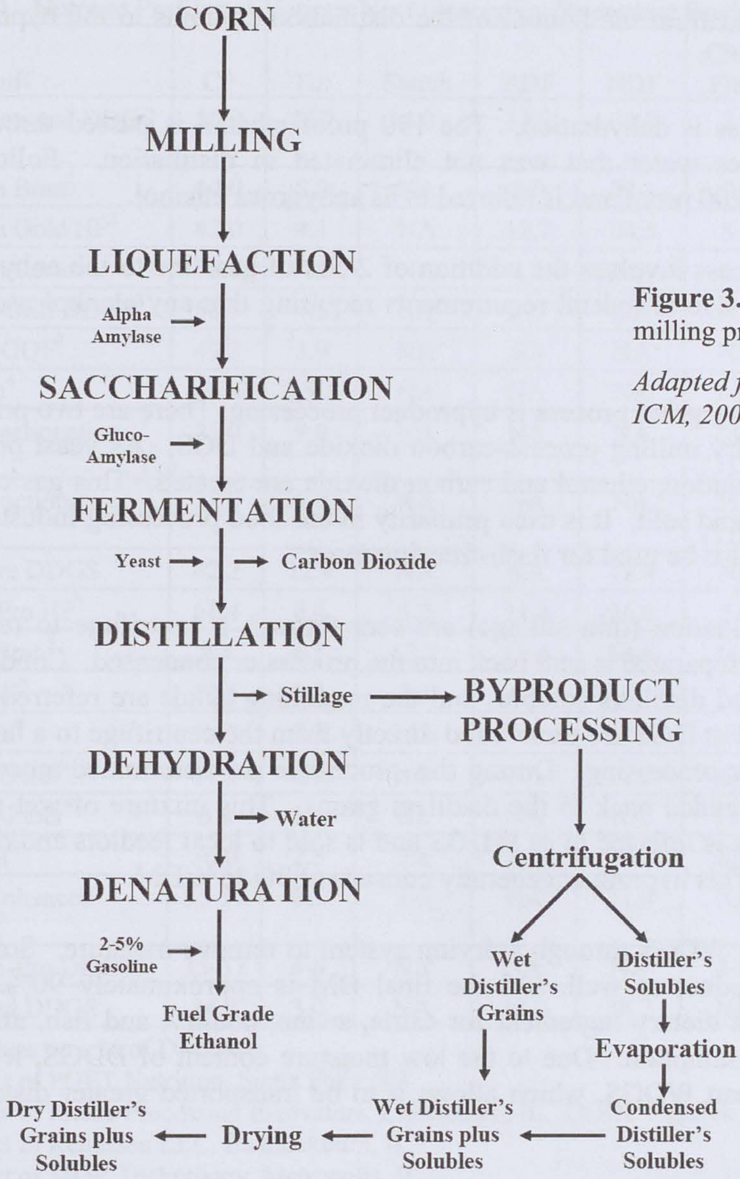


Figure 3. Diagram of the ethanol dry milling process.

Adapted from Vander Pol, 2006 and ICM, 2009.

Before reaching the next step in the dry grind process, the percentage of alcohol in the beer is roughly 10% and contains all of the solid material from the original substrate. The beer is pumped from the beer well into a multi-column distillation system that removes alcohol from beer through distillation. The distillation process uses the differences in the evaporating points of ethanol and water. The boiling or evaporation point of ethanol is 81° C; therefore, as long as the temperature in the columns remains between 81° C and 100° C (the boiling point of water), ethanol in a gaseous form will rise to the top of the distillation column, where the gas is later cooled below 81° C. This cooling allows the gas to condense back to liquid form and contains a much higher percentage of ethanol than the original beer. The liquid condensate is then passed to the next distillation column, where the process is repeated. By the time the product reaches the final distillation column it is 95% ethanol, or 190 proof. The residue from distillation, now referred to as stillage, is pumped from the bottom of the distillation columns to the byproduct processing area.

Step six in the dry grind process is dehydration. The 190 proof ethanol is passed through a molecular sieve, which removes water that was not eliminated in distillation. Following dehydration, the ethanol is now 200 proof and is referred to as anhydrous ethanol.

Step seven in the dry grind process involves the addition of 2-5% of gasoline to the anhydrous ethanol. This step in necessary due to federal requirements requiring that any alcohol used for fuel be denatured, or undrinkable.

Step eight, the final step in the dry grind process is byproduct processing. There are two primary byproducts created during the dry milling process-carbon dioxide and DGS. As yeast process the simple sugars during fermentation, ethanol and carbon dioxide are created. This gas can be captured, purified, compressed, and sold. It is used primarily in the food processing industry for carbonated beverages and may also be used for flash-freezing meat.

The solids remaining after distillation (thin stillage) are sent through a centrifuge to remove excess liquid. The liquid that is separated is sent back into the process or condensed. Condensed liquid is referred to as condensed distillers solubles and the remaining solids are referred to as distillers grains (no solubles). Wet DGS are transferred directly from the centrifuge to a holding pad for later transport or further processing. During this process, a pre-determined amount of condensed distillers solubles is added back to the distillers grains. This mixture of wet grains and condensed distillers solubles is referred to as WDGS and is sold to local feedlots and dairies for use as a dietary ingredient. This byproduct generally consists of 30-35% DM.

Dry DGS are a result of putting WDGS through a drying system to remove moisture. Solubles are generally added to this product as well, and the final DM is approximately 90%. This ingredient is currently used as a dietary ingredient for cattle, swine, poultry, and fish, and has been researched for human consumption. Due to the low moisture content of DDGS, it has a significantly longer shelf life than WDGS, which allows it to be transported greater distances, and stored longer than WDGS.

Modified DGS is a general term for DGS that have a DM content somewhere between WDGS and DDGS. Modified DGS are processed in two different ways: through partial drying to a pre-determined DM content, or through soluble addition to DDGS. With either process, MDGS generally contain between 45-55% DM, which allows for greater transport distances and increased shelf life compared with WDGS.

II. New Ethanol Production Systems

An excellent review of new ethanol production systems was recently published by Berger and Singh (2010). In this review, the authors outline four new ethanol production systems: front-end wet fractionation, front-end dry fractionation, back-end removal of fiber from distillers grains, and back-end oil extraction from syrup or distillers grains. The basic processes and the resulting byproducts are described here and in Table 1.

Table 1. Nutrient Profiles of Various Next Generation Byproduct Feedstuffs[1]

Feedstuff	CP	Fat	Starch	ADF	NDF	Crude Fiber	Source of Values
Conventional DDGS	30.9	10.7	4.0	11.8	30.3	7.2	Shurson and Alghamdi, 2008; field observations
Dakota Bran[2]	14.0	8.9	NA	8.0	38.1	7.0	www.dakotagold.com
Dakota Gold HP[2]	42.0	4.1	NA	12.7	24.5	8.3	www.dakotagold.com
Dakota Germ[2]	15.8	17.3	NA	8.1	24.7	6.6	www.dakotagold.com
MPI E-Mill DDGS[3]	58.5	4.5	NA	2.0	NA	NA	Singh et al., 2005
MPI QGQF[3]	49.3	3.9	NA	6.8	NA	NA	Singh et al., 2005
E-Corn[4]	40-50	2.5-5	NA	NA	NA	7-11	Shurson and Alghamdi, 2008
Dry Fractionation DDGS	25.0	9.0	NA	NA	NA	28.0 (TDF)	Martinez-Amezcua et al., 2007
Wet Fractionation DDGS	28.0	5.4	NA	NA	NA	25.0 (TDF)	Martinez-Amezcua et al., 2007
Elusieve DDGS	42.2	12.9	NA	NA	19.9	NA	Srinivasan et al., 2006
MOR-Pro HP[5]	61.4	0.4	5.7	24.8	26.6	5.0	www.mortechnology.com
MOR Bran[5]	9.3	4.3	13.2	15.4	64.6	NA	www.mortechnology.com
Glutenol[6]	50.5	3.8	7.3	6.7	34.1	3.8	www.qtitechnology.com
ProBran[6]	18.3	3.3	24.0	9.9	32.6	16.6	www.qtitechnology.com
NeutraGerm[6]	17.5	45.0	8.1	NA	NA	6.0	www.qtitechnology.com
Neutra-Fiber[6]	6.8	1.5	6.8	NA	NA	17.1	www.qtitechnology.com
Energia[6]	30.0	2.5	3.8	NA	NA	8.2	www.qtitechnology.com
FWS Enhanced DDGS[7]	35-37	6.5	3-5	NA	21.0	NA	www.fwstl.com
CPT Hi-Pro DDGS[8]	35-37	4-6	NA	NA	NA	4-6	Shurson and Alghamdi, 2008
De-oiled DDGS	34.9	3.0	NA	12.9	38.2	NA	Kalscheur and Garcia, 2010

[1] All values on a % of DM basis.
[2] Product of POET Nutrition, Sioux Falls, SD.
[3] Product of Maize Processing Innovators, Champaign, IL. QGQF = Quick germ, quick fiber.
[4] Product of Renessen LLC, Bannockburn, IL.
[5] Product of MOR Technology, Metropolis, IL.
[6] Product of Quality Technology International Inc., Elgin, IL.
[7] Product of FWS Technologies, Winnipeg, MB, Canada.
[8] Product of Cereal Process Technologies, Overland Park, KS.

A. Front-end wet fractionation

Wet fractionation prior to the traditional dry grind process involves soaking corn in an aqueous solution to allow for recovery of the germ, pericarp fiber, and endosperm fiber (Singh et al., 2005). This process is known as enzymatic dry milling, or E-Mill. In this system, corn is soaked for 6-12 hours, then ground and incubated with protease and starch degrading enzymes for 2-4 hours (Berger and Singh, 2010). The enzymes increase specific gravity of the slurry and allow for improved separation of the individual corn components. Germ and pericarp fiber are recovered by floatation in hydrocylones (Singh et al., 1999). Endosperm fiber can be recovered either before or after fermentation. The resulting byproduct from E-Milling contains approximately 58% CP, 4.5% fat, and 2% ADF (Berger and Singh, 2010, Table 1).

B. Front-end dry fractionation

Dry fractionation prior to traditional dry milling allows for recovery of germ and pericarp fiber. Unlike wet fractionation, however, endosperm fiber is not recovered in the dry fractionation process (Berger and Singh, 2010). The process, termed dry degerm defiber or 3D, involves an initial tempering of grain with hot water or steam for 5-10 minutes, followed by grinding in a degerminator to remove germ and pericarp from endosperm (Duensing et al., 2003). During grinding, endosperm is broken into smaller pieces, or grits. Germ is then separated from grits with gravity tables, and fiber is removed from grits by aspiration. The remaining grits then enter the traditional dry mill ethanol process. The resulting byproduct from 3D contains 23.8% crude protein, 8.7% fat, and 28% fiber (Berger and Singh, 2010). Another key difference between the nutrient content of 3D and conventional DGS is the reduction in phosphorus. Conventional DGS contain approximately 0.78% P, while 3D DGS contain 0.47% P (Berger and Singh, 2010). The reduction in P is due to the germ removal in the 3D process. Nearly 90% of the phytic acid in corn is present in corn germ (Ravindran et al., 1995)

C. Removal of fiber from distillers grains

This process, termed elusieve, involves back-end separation of fiber from distillers grains (Berger and Singh, 2010). The fiber recovered with this process can then be used for other value-added byproducts. As the elusieve name implies, this process consists of sieving and elutriation to separate fiber from distillers grains. Material that settles at the top of the elutriation column is the lighter fiber fraction, while the heavier material that settles at the bottom is the remaining distillers grains. The resulting byproduct is approximately 42% CP, 13% fat, and 20% NDF (Table 1), and the fiber portion contains 19.3% CP, 7% fat, and 53.3% NDF (Srinivasan et al., 2006).

D. Oil extraction from syrup

Through oil extraction from syrup, approximately 1/3 of the oil in syrup can be recovered, with the remaining oil usually added to distillers grains (Lüking and Funsch, 2009). This process involves centrifugation of the thin stillage to separate oil and syrup. The resulting byproduct contains approximately 8-9% fat and 30-35% CP, though further oil removal has resulted in byproducts that contain as little as 3% fat (Kalscheur and Garcia, 2010, Table 1).

RESULTS FROM BEEF CATTLE EXPERIMENTS

Because fractionation and extraction technologies are relatively new and only used at a small number of plants, very few data exist that measure beef cattle performance when next generation byproducts are included in the ration. However, numerous experiments comparing these byproducts are currently underway or in the planning process.

In one of the first experiments evaluating the feeding value of corn milling byproducts from new dry grind technology, Bremer et al. (2006) fed yearling steers dry-rolled and high-moisture corn-based diets containing 15, 30, and 45% (DM basis) of a byproduct from a partially fractionated process (Dakota Bran Cake, POET Nutrition, Sioux Falls, SD). The Dakota Bran replaced corn, and alfalfa hay was included in each diet at 5% as the roughage source. A conventional DDGS grain treatment was also included in this study, with DDGS replacing corn at 30% (DM basis) of the ration. Dakota Bran used in this study contained 52% DM, 27% starch, 39% NDF, 15% CP, and 10% fat. Results from this study indicated a linear increase in final live weight, hot carcass weight, ADG, and feed efficiency with increasing Dakota Bran inclusion. Dry matter intake responded quadratically to Dakota Bran inclusion, with the peak DMI occurring at 30% inclusion. A quadratic response was also present for 12th rib fat thickness, with the greatest fat thickness occurring with the 30% Dakota Bran inclusion. No other carcass characteristic responses were significant. When comparing dietary inclusion of either 30% Dakota Bran or 30% conventional DDGS, no differences were observed for any live or carcass characteristics. Results from this study indicate that Dakota Bran can replace corn up to 45% of the diet DM without negatively affecting feedlot steer performance. Live performance responses from this study also indicate that Dakota Bran has an energy value 100-108% that of corn grain. It is important to note that the Dakota Bran product used in this experiment was 52% DM and was compared against DDGS at approximately 90% DM. Numerous field observations and research data (Klopfenstein et al., 2008; Nuttelman et al., 2010) have reported decreased performance with DDGS compared with WDGS (and in some instances MDGS). Therefore, it is plausible to hypothesize that the results from the comparison of Dakota Bran with DDGS at 30% inclusion may have been different if WDGS (or possibly MDGS) were used in place of DDGS.

Buckner et al. (2007) included 15 and 30% (DM basis) Dakota Bran or 15 and 30% of conventional DDGS in growing steer diets containing alfalfa haylage, brome hay, and a dry supplement as the only other ingredients. Feed efficiency was 6% greater with DDGS inclusion than with Dakota Bran, and final body weight was also greater with DDGS inclusion. No other differences were present when comparing the two byproducts. The authors attribute the increase in feed efficiency with DDGS to its higher fat content when compared with Dakota Bran.

Depenbusch et al. (2008) fed feedlot heifers steam-flaked corn diets containing either no byproducts, 12.9% (DM basis) conventional DDGS, or 13.5% de-germed byproduct (Dakota Gold HP, POET Nutrition, Sioux Falls, SD). The Dakota Gold HP used in the experiment consisted of 91% DM, 43% CP, 4% fat, and 23% NDF. All diets contained approximately 6% alfalfa hay as the roughage source. No differences were observed for ADG, feed efficiency, or any carcass characteristics; however, DMI was 5% greater with the conventional DDGS than with Dakota Gold HP, with both treatments being equal to the control. Urea was included in the conventional DDGS diet at 0.7% of DM, while no urea was included in the Dakota Gold HP diet. The authors noted that this may be the reason for the difference in intake between the two treatments, suggesting that perhaps DIP was limited in the Dakota Gold HP treatment. To date, no follow-up research has been conducted to assess whether urea inclusion in this type of diet has an effect on DMI.

Our feedlot research group at the University of Minnesota recently concluded a feedlot steer experiment with treatments structured similarly to the Depenbusch et al. (2008) experiment

(Kelzer et al., 2010). In our experiment, steers were fed either a dry-rolled corn-based control diet or byproduct-containing diets with 35% (DM basis) conventional DDGS or 35% Dakota Gold HP. All diets contained 12% alfalfa haylage as the roughage source. Overall DMI was not different between the control treatment and the conventional DDGS treatment, but tended to be greater with the control treatment compared with the Dakota Gold HP treatment. From day 28 to the end of the trial (day 118), DMI was greater for the control treatment compared with the Dakota Gold HP treatment, with the conventional DDGS treatment being equal to both. No other live performance or carcass characteristic parameters were statistically different in this experiment.

Interestingly, in both of these experiments, the Dakota Gold HP treatment resulted in a decrease in DMI compared to either conventional DDGS (Depenbusch et al., 2008) or a dry-rolled corn control (Kelzer et al., 2010). In the Depenbusch et al. (2008) experiment, the conventional DDGS and Dakota Gold HP treatments were balanced for CP through the previously mentioned addition of urea to the conventional DDGS treatment. In the Kelzer et al. (2010) experiment, dietary CP concentrations were not balanced, and measured 12.1, 17.1, and 22% CP for the control, conventional DDGS, and Dakota Gold HP treatments, respectively. The high concentration of CP in the Dakota Gold HP experiment could perhaps partially explain the reduction in DMI, although the lack of response in ADG or feed efficiency in either experiment may confound this explanation. Data from these two experiments indicate that, at the inclusions evaluated, de-germed DGS can be included in finishing cattle diets as a replacement for either corn grain or conventional DDGS without affecting live performance or carcass characteristics.

Godsey et al. (2010) evaluated E-Corn (Renessen LLC, Bannockburn, IL), a new byproduct resulting from a front-end fractionation procedure. E-corn contains 40-50% CP, 2.5-4% crude fat, and 7-11% crude fiber (Shurson and Alghamdi, 2008). E-Corn replaced dry-rolled corn at 0, 20, 40, or 60% (DM basis) in finishing steer diets containing either 30% WDGS or 30% wet corn gluten feed. Corn stalks were included in each diet at 5% of DM as the roughage source. No E-corn inclusion x byproduct type interactions were observed. Dry matter intake increased quadratically to E-corn inclusion level, with the peak DMI occurring at 40% inclusion. Feed efficiency responded cubically with 20% and 60% E-corn inclusion having the highest feed efficiency. Linear decreases in marbling, fat depth, and calculated yield grade were observed with increasing inclusion of E-Corn. The carcass effects observed in this experiment were unexpected, and no clear reason exists to explain these results. Carcass responses aside, these data suggest that the optimal inclusion of E-corn is 20% of diet DM for finishing steers. At this inclusion, E-Corn had an energy value of 118% of corn.

In summary, the research conducted to date is extremely limited, but in general shows that next-generation byproducts have a feeding value similar to that of DDGS and dry-rolled corn, and can be included in finishing diets at varying levels without negatively affecting live performance. The lone experiment with next generation byproducts in growing diets indicates that the byproduct evaluated (Dakota Bran) had a lower energy value than conventional DDGS (Buckner et al., 2007). In finishing diets, the highest inclusion level tested was 60% inclusion in the Godsey et al. (2010) experiment. The E-Corn product used in that experiment was a wet byproduct. The highest inclusion of the dry next-generation byproducts evaluated was 35% in the Kelzer et al. (2010) experiment. Using these data, it appears that use and inclusion will depend largely on pricing and availability, which will be covered in the next section.

NEXT GENERATION BYPRODUCT PRICING AND AVAILABILITY

Many of the next-generation byproducts that are either on the market or being developed are branded as "value-added" DGS or "enhanced" DGS due to their comparatively high protein and low fat contents. For swine and poultry diets there may indeed be added value with these byproducts; however, for ruminants, and particularly for beef cattle, the nutrient composition of these byproducts is generally inferior to that of conventional DGS. As was shown in the previous section, the feeding value of the next-generation byproducts is generally equal to that of conventional DDGS, and quite possibly less than that of WDGS or MDGS. However, caution should be taken when grouping these next generation byproducts together as they are not all similar in nutrient profiles (Table 1), and many next generation byproducts have yet to be evaluated in performance experiments.

Due to the "enhanced" nature and marketing of these next generation byproducts, they are often priced higher than conventional DGS. The USDA Wisconsin Ethanol Plant Report (http://www.ams.usda.gov/mnreports/ms_gr116.txt, accessed August 16, 2010) listed conventional DDGS (90% DM) at $105-115/ton, MDGS (45-50% DM) at $40-52/ton, WDGS (30-35% DM) at $28-30/ton, and "corn protein concentrate" (90% DM) at $192.70/ton. We generally use a factor of 37x the price of corn grain to determine the opportunity price for DDGS, meaning that if DDGS can be purchased and delivered for less than 37 times the bushel price of corn grain, it is a better buy than corn grain. For example, August 16, 2010 cash corn price in Beaver Creek, MN was $3.51/bushel for new crop corn (http://news.ncgapremium.com). Using this figure, DDGS would have to be purchased and delivered for less than $130/ton to be a better value than feeding corn ($3.51 x 37 = $129.87). Most current price quotes for DDGS are less than this figure, meaning DDGS is generally a good value relative to corn at current prices. If we use futures prices to price corn, the advantage to DDGS becomes even greater, as the current basis is approximately $0.50 over the cash price. If we assume the next-generation byproducts to be an equal energy value to DDGS, then we can use the same factor there as well. This means that at current cash prices, the next generation byproducts shown in the Wisconsin report are overpriced for inclusion in beef cattle diets.

It is important to note, however, that the prices for next generation byproducts seem to be declining relative to conventional DGS, as the same Wisconsin USDA report would often list corn protein concentrate for well over $250/ton throughout 2009 when DDGS prices were ranging from $130-150/ton.

In terms of availability, Shurson and Alghamdi (2008) listed 14 next generation byproducts from a relatively small number of suppliers. Berger and Singh (2010) estimate that six ethanol plants in the United States are using front-end fractionation technologies, while an unknown, but likely small, number of ethanol plants are utilizing back-end processes. However, the market is expected to continue to grow, with FDA estimates that by 2022, 20% of ethanol plants will employ front-end fractionation technologies, 22% will employ back-end oil extraction technologies, and 58% will remain as conventional ethanol dry milling plants (Shurson, 2009).

Shurson (2009) estimates that the actual implementation of these technologies will be much lower, and may measure 3-5% implementation of front-end technologies and 15% implementation of back-end technologies by 2022. Shurson (2009) reasons that front-end technologies will be adopted at a lower rate than the FDA predicts due to 1- the high capital investment required; 2- difficulty in starting up and keeping front-end technology functional; 3- greater emphasis on back-end oil extraction due to greater return on investment; and 4- undeveloped and uncertain market for the resulting byproducts.

Regardless of the magnitude of technology implementation, it is very safe to assume that next generation byproducts will be more available than they are currently. The increase in supply of the byproducts may push their price down to a point where they are consistently competitive with corn and/or conventional DGS. This, coupled with more research data becoming available, will allow for more widespread, and more accurate, inclusion of next generation byproducts in beef cattle diets.

TAKE HOME MESSAGES

- Ethanol plants are beginning to seize the opportunity to increase profits, improve efficiency, and diversify product portfolio through fractionation and extraction processes.
- These processes can be broken down into two general categories: Front-end fractionation and back-end extraction or separation.
- The byproducts resulting from these processes differ, but in general contain less fat and more protein than conventional distillers grains.
- Research results to date have generally shown next generation byproducts to have equal value to either conventional dry distillers grains with solubles or corn grain.
- At current prices, next generation byproducts do not compete well with corn grain and conventional dry distillers grains. Increases in supply and more research data may bring the pricing for these byproducts to a more appropriate level.

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