The Interaction Between Ethanol and Cattle Feeding: Economics and Issues

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By-products have long been a feed source for livestock. From the time cattlemen started "cattle feeding", by-products have been utilized to reduce the cost of gain, especially in the finishing ration. With the current expansion of the ethanol industry, another by-product feed, or co-product of ethanol production, distiller's grains, is becoming more available to livestock feeders.

Over the years, the cattle feeding industry has spread from the Corn Belt with each area having its own specific competitive advantages. The top four cattle feeding states are Texas, Nebraska, Kansas, and Colorado. Nebraska and Kansas grow surplus grain while Texas and Colorado are corn deficit states. Texas and Colorado use the railroad system to secure corn supplies from the Midwest to meet their feed demands. Regional differences in feeding technologies, location to feed sources, and market infrastructure are prime determinants in the impact of distiller's grains feeding.

This research evaluates the potential impact of increasing ethanol and distiller's grains production on the beef cattle feeding industry. Geographic differences and specific regional implications for beef cattle feedlots in the top four cattle feeding states are analyzed. Implications for the feed deficit states, Texas and Colorado, are compared with Nebraska and Kansas that have abundant ethanol production. Regional differences in feedlot equipment and ration composition that are affected by the feedlot's proximity to ethanol production are included in the analysis. Feedlot distance to distiller's grains production is included.

Literature Review

Economic implications of the potential tradeoff between corn and ethanol co-products in feedlot rations have not been extensively analyzed. Feed is the single most costly component of finishing cattle, often representing 70 to 80 percent of the total cost of gain. It takes approximately 55 bushels of corn to raise a feeder calf to harvest, where every pound of beef produced requires 5.6 pounds of corn (USMEF, 2006). Distiller's grains replace a portion of the corn, as well as supplemental protein, like soybean meal, potentially reducing ration costs (Erickson, 2005).

There have been numerous studies on the nutritional aspects of distiller's grains (DG), but for the most part, specific regional economic aspects of feeding DG have not been considered. Nutritional research has shown optimum inclusion rates for WDGS ranging between 25 and 35 percent of ration dry matter (Vander Pol et al., 2006b) in Eastern Nebraska, while Daubert et al. (2006) found optimal levels between 8 and 16 percent for cattle fed in Kansas**.** Texas studies have shown less favorable results from including DG in steam-flaked corn (SFC) based feedlot rations (Cole et al., 2006). Differences in cattle performance are generally attributed to variations in co-product quality and nutrient content and varying energy values of corn from different processing methods in the base ration.

Although variability of fed cattle and feeder cattle prices have greater impacts on cattle feeding profitability than corn prices; corn price, feed conversion, and average daily gain explained 65, 27, and 2 percent of cost-of-gain variability (Albright, Schroeder, and Langemeier, 1994). In general, as placement weight increases, feeder cattle prices impact profitability relatively more than corn prices, interest rates, and animal performance. Feed conversion influences profitability more for winter placements while ADG has a greater impact on profits for late winter/early spring placements (Mark, Schroeder, and Jones, 2000).

The co-products from wet and dry mill ethanol processing plants have substantially different nutrient contents and feeding characteristics requiring separate economic consideration. Ethanol expansion is primarily occurring in the dry mill industry generating wet or dry distiller's grains (WDGS or DDGS).

WDGS has a short useful life and spoils quickly due to its high water and fat content. The minimal 3 to 6 day shelf life of WDGS limits its use and can add extra preservation and storage costs to the feed product. The excess water weight (up to 70 percent water) adds significantly to transportation costs, limiting the profitable feeding radius around the ethanol plant. A ton of WDGS may contain up to 1,300 pounds of water, which must be hauled to and handled at the feedlot. Although the extra moisture in the ration has a positive effect on cattle performance, the increased handling and transportation costs are significant considerations (Erickson, 2006).

Wet-mill ethanol plants produce a variety of co-products, but cattle feeders primarily use wet corn gluten feed (WCGF). WCGF is lower in protein and fat than distiller's grains and its energy is primarily derived from highly digestible fiber.

Perrin and Klopfenstein's (2001) research at the University of Nebraska used a combination of experimental results, survey data, and market prices to compare the average value of feeding wet corn gluten feed to the dried product. The average calculated value of the WCGF was $130 per ton of dry matter during the 1990's, compared to the alternative value as dried feed of $93 per ton. One ton of WDGS on a dry matter basis primarily replaced 0.03 tons of alfalfa hay and 49.8 bushels of dry rolled corn and had a total value of $140.03 per ton.

Haugen and Hughes (1997) analyzed the economic implications of feeding different levels of wet corn gluten feed in a 1,000-head capacity North Dakota beef feedlot by integrating feeding trial data with input and output prices. The different percentages of WCGF in the feedlot rations resulted in significantly different net returns due to changes in gross margin (based on pounds gained per animal), feed costs, operating margin, hauling costs, shrink, and death loss. Many factors influenced the net return, including biological effects of the ration measured as gain per day and feed efficiency. The 56 percent ration (as compared to 0, 28, and 85 percent WCGF) showed the highest economic return per head for each corn price and the best biological effect.

Vander Pol et al. (2006b) conducted an economic comparison for cattle fed 0, 10, 20, 30, 40, and 50 percent WDGS in DRC/HMC-based rations. Corn was evaluated using a 10-year average price, with either a $0.05 or $0.10 increase in price per bushel to represent the higher basis on corn near an ethanol plant. WDGS prices were estimated at 95 percent of the price of corn at the ethanol plant. Scenarios were compared for feedlots surrounding the plant, and within 30, 60, and 100 miles of the plant at $2.50 per loaded mile.

The results showed the optimum inclusion rate for feedlot producers is 30 to 40 percent of diet dry matter when feedlots are within 30 miles of the ethanol plant. As the distance increases from the plant to the feedlot, the optimum inclusion of WDGS decreases to between 20 and 30 percent. This comparison suggests that WDGS can be fed at higher levels than the current industry inclusion rate. However, the optimum inclusion is dependent on the WDGS energy value, price, cattle performance, distance from the plant, and corn price (Vander Pol et al., 2006b).

Feedlot rations and feed management are largely based on the corn processing method utilized. The most common corn processing methods, from least to most intensive, are dry rolling (DRC), early harvest high moisture (HMC) ensiling, and steam flaking (Macken, Erickson, and Klopfenstein, 2006). Steam flaking corn (SFC) results in the highest energy value relative to the other corn processing methods, but is also the most costly processing method (Macken, Erickson, and Klopfenstein, 2006; and Cooper et al., 2001). Steam flaking is primarily utilized in corn deficit areas, like the Texas panhandle (Cole et al., 2006) and Eastern Colorado to maximize the feed energy value of corn. Where corn is available at lower prices, i.e. Eastern Nebraska, feedlots use the less expensive, less intensive processing methods (dry rolling and high moisture ensiling).

Galyean and Lemon (2006) conducted a study to determine the optimal dietary concentration of WDGS in SFC based finishing diets. They also compared the feeding value of sorghum-based wet distiller's grains, or WSDG with corn-based wet distiller's grains, or WCDG. The importance of the SFC ration for this research is that the Texas cattle feeding industry predominately feeds SFC. Galyean and Lemon found a linear decrease in ADG as the dietary concentration of WSDG increased. Unlike previous studies (Larson et al., 1993; Ham et al., 1994; and Lodge et al., 1997) which reported improved feed efficiency in cattle fed distiller's grain, they found a linear increase in the feed to gain ratio, meaning poorer feed conversion, with increasing WSDG concentrations. These results also differ from those of Daubert et al. (2005), who fed steam-flaked corn based diets containing WSDG to heifers. Peak performance occurred at the 8 and 16 percent inclusion rates and performance decreased significantly with higher distiller's grains concentrations. Lodge et al. (1997) also found a decrease in ADG and feed efficiency for cattle fed a higher concentration of dried sorghum distiller's grains.

Drouillard et al. (2006) compared the feeding value of wet and dry distiller's grains in SFC based diets and also evaluated the roughage value of distiller's grains. The trial rations included 15 percent (DM basis) wet or dry sorghum distiller's grain with solubles (WDSG or DSDG) and wet and dry corn-based distiller's grains. Roughage value was evaluated by feeding wet sorghum distiller's grain with 0 and 6 percent alfalfa hay (where steam flaked corn replaced alfalfa in the 0 percent hay ration). Drouillard et al. found wet and dry distiller's grains with solubles derived from sorghum and corn have comparable nutritional values. Removal of alfalfa hay from wet and dry sorghum-based distiller's grains rations adversely affected dry matter intake, average daily gain, and final body weight.

Feeding equipment used for processing and feeding dry rations (using steam-flaked corn) are significantly different from equipment used to handle Nebraska's wet rations. In Nebraska ration ingredients are placed in Roto-mix® mixer-delivery box trucks using front end loaders and rations are then mixed in the trucks on the way to the feed bunks. When feed mills are used to produce SFC based rations, the dry ingredients are mixed in the feed mill and then loaded directly onto the feed trucks. Therefore, no mixing occurs on the feed trucks. If WDGS were incorporated into these types of rations, it could not be mixed in the feed mill because of its high water content requiring new truck purchases (Erickson, 2006).

For cattle feeders located further from ethanol production, DDGS could be an economical feed source, where handling, storage, and transportation costs are lower than for WDGS. The dry co-product could be mixed in the feed mills and therefore requires less extra handling costs and equipment changes for Texas feeders. Feedlot nutrition studies have shown that DDGS should be fed at lower inclusion rates than WDGS, and generally limited to 15 percent of the ration on a dry matter basis (Drouillard et al., 2006). At inclusion rates greater than 15 percent, ration mixing problems can occur because the high fat content of DDGS can inhibit flow-ability. Also, at the 15 percent inclusion rate, DDGS replaces dietary protein sources, but at higher inclusion rates it would compete with cheaper energy sources (Erickson, 2006).

The nutritional attributes of DDGS for dairy and beef cattle include high levels of bypass protein and a highly digestible combination of fiber and fat, making DDGS a highly desirable ingredient for ruminant diets. DDGS can be a substitute for corn or SBM in ruminant rations, but DDGS protein is of lower quality than SBM. Because ethanol is produced from the starch in corn, the energy in DG comes from digestible fiber and fat instead of starch. Ruminal starch fermentation is more likely to result in acidosis, laminitis, and fatty liver, so the removal of starch results in a valuable feed product (Schroeder, 2003).

The limitations of DDGS are its low level of amino acid content, especially lysine and tryptophan, giving SBM the advantage in protein quality. At a higher percentage of the diet (>50 percent), additional fat limits the inclusion of DG in feedlot rations. The high phosphorus content of DDGS can also be a concern due to manure phosphorus levels. The cost of supplementing calcium (CA) must also be considered. Beef cattle rations need a calcium to phosphorus ratio of 1:1 to 1.5:1 otherwise the negative effects include a potential for water belly steers as well as increased phosphorus levels in manure (Shurson and Noll, 2005). High sulphur levels are another concern when feeding large amounts of DDGS. If DDGS has a high sulphur content, thiamin should be supplemented, especially if water sources also contain sulphur (Erickson, 2006).

In summary, the existing feeding research sets a base for comparison to current used feed rations. It is clear that cattle performance is key to feeding distiller's grains. Performance gains can partially offset the high costs of corn. In addition, there are some challenges in terms of feeding infrastructure that must be incorporated into any analysis.

Methods

Historical data was used to develop a partial budget model for beef feedlots. The partial budget includes ration costs and feeding (yardage) costs representing feedlots in Colorado, Kansas, Nebraska, and Texas. Ration costs are a function of ingredient prices, ration composition, and cattle performance (dry matter intake). Historical price data from *Feedstuffs* was used to estimate ration ingredient prices. Feedlot data from the Professional Cattle Consultants (PCC), a private feedlot consulting company, was used to estimate feed efficiency, average daily gain, dry feed conversion, daily dry matter intake, veterinary/medical expenses, and other key variables for each region.

Changes in cattle performance resulting from feeding two different levels of WDGS and one level of DDGS were estimated by adjusting historical average daily gain, feed efficiency, and dry matter intake (from PCC data) by the results found in feedlot nutrition studies reviewed above. Nutrition research results account for the regional changes in cattle performance with the corresponding ration composition incorporating distiller's grains. Manure management costs correlated with feeding WDGS (and corresponding increases in dietary phosphorus levels) were estimated from Kissinger et al.'s (2006) results.

Feed costs are estimated for a base ration without DGs, and both wet and dry distiller's grains at two dietary inclusion rates in a total of four rations for Kansas and Nebraska, and seven rations for Colorado and Texas, where steam-flaked corn based rations are compared to dry-rolled corn based rations. Steam flaking and dry rolling corn processing costs are estimated from Macken, Erickson, and Klopfenstein's (2006) results. Natural gas and electricity price data were obtained from the Department of Energy (USDOE, 2006). Trucking costs obtained from the Agricultural Marketing Service Grain Transportation 1st Quarter 2006 Report, were used to estimate WDGS hauling costs (USDA/AMS).

A stochastic partial budget simulation model, using Simetar®, was developed for each feedlot region, with cost of gain as the key output variable. Stochastic simulation adds risk to a deterministic model by estimating a variable's probability distribution which can be used by a decision maker in a risky environment. The deterministic and stochastic variables are contained in Table 1.

Two cattle on feed placement months, May and October, were analyzed to capture any differing effects caused by calf feds and heavier feeder cattle placements. The two weight groups and corresponding months were used to account for seasonal cattle performance and feed cost differences when determining whether changing ration costs and compositions have different implications for lighter (fall) versus heavier weight (spring) placements.

WDGS prices were estimated as a percentage of the local corn basis at the ethanol plant. To estimate the ethanol plant's corn basis, a $0.15 per bushel premium was assumed for corn within 25 miles of an ethanol plant, representing the increased demand for corn (Vander Pol et al., 2006b). WDGS prices were estimated as 95 percent of corn price, on an equal dry matter basis.

Alternative Ration Scenarios

Base regional ration ingredients were adjusted to incorporate DDGS at 15 percent of the diet dry matter and WDGS at 15 and 30 percent of the diet dry matter. DDGS and WDGS primarily replace corn and the protein supplement (soybean meal, cottonseed meal, or urea). Previous feedlot nutrition studies were used to determine ration adjustments for the incorporation of distiller's grains.

If steam-flaked corn (SFC) is used in the base ration, an alternative scenario replaces steam-flaked corn with dry rolled corn (DRC) and WDGS at the two inclusion rates. Corn processing costs were adjusted, reflecting the elimination of natural gas costs with use of the dry-rolling process.

Potential costs for changes in infrastructure or equipment were accounted for to more adequately determine whether cost savings exist for feeding DRC with WDGS. Additional costs include investment in Roto-Mix® mixer/delivery box trucks, labor costs for Roto-Mix® drivers and front end loader operators, as well as fuel, insurance, and maintenance costs. The costs are correlated with the WDGS inclusion rate, where a 15 percent inclusion rate would require half the labor and fuel of the 30 percent WDGS inclusion rate. One Roto-Mix® truck is included in the investment costs for both the 15 and 30 percent WDGS scenarios. These costs were estimated based on personal communication with cattle feeders in the Texas Panhandle.

Increased feeding time and handling costs were also estimated based on the increasing amount of weight hauled to the feedlot and fed each day when incorporating WDGS. The feed cost equation estimated by Vander Pol et al. (2006b) was used to determine the percentage increase in feeding costs for each inclusion rate of WDGS. The percentage increase in feeding costs is calculated from the change in as-fed feed when incorporating WDGS as compared to the base ration. An industry average feeding cost of $0.085 per head per day is used as the basis feeding cost.

Cattle performance was also adjusted for the DDGS and WDGS inclusion rates. The regional average daily gain, dry matter intake, and feed efficiency from the PCC data was adjusted by the percentage change found in feedlot nutrition studies. The feedlot nutrition studies utilized have ration components comparable to those in the model scenarios, ensuring an accurate performance adjustment.

SFC is fed in the base scenario, the 15 percent DDGS scenario, and the 15 percent WSDGS TTU scenario for the Texas feedlot model (Table 3). DRC is fed in the 15 and 30 percent WDGS scenarios. The 15 percent WSDGS TTU ration and corresponding cattle performance are estimated from research by Galyean and Lemon (2006). The 15 and 30 percent WDGS rations were estimated by primarily substituting DRC for SFC in the base scenario and replacing a portion of the DRC with WDGS. Cattle performance, specifically ADG, for the 15 and 30 percent WDGS rations was estimated from Vander Pol et al. (2006a).

Nebraska ration scenarios (Table 4) were estimated from Vander Pol et al. (2006a,c). All Nebraska rations contain DRC, and the 30 percent WDGS DRC:HMC contains a combination of DRC and HMC. A DDGS scenario was not included for the Nebraska analysis, as it was assumed that all feedlots will have access to WDGS.

RESULTS

Colorado Model Results

Cost of gain is lowest for the ration scenario including 15 percent WDGS fed with DRC. Thirty percent WDGS/DRC was the next lowest cost of gain alternative ration.

Three model specifications should also be noted for these results. First, in this case the feedlot is located at the ethanol plant, where no transportation costs are included for WDGS. Second, the corn price basis is a positive $0.15 per bushel to account for the increase in corn demanded by the ethanol plant. The $0.15 per bushel premium for corn also increases the cost of WDGS because the WDGS is priced at 95 percent of the price of corn (on an equal dry matter basis).

The rations with the highest cost of gain are those where 30 percent WDGS is fed in a steam-flaked corn based ration. These rations are based on studies from the University of Nebraska (Vander Pol et al., 2006a) and Kansas State University (Daubert et al., 2005). The major cost difference between the 30 percent WDGS/DRC and 30 percent WDGS/SFC scenarios is cattle performance, specifically ADG, where the total pounds gained are lower for the cattle fed WDGS/SFC than those fed WDGS/DRC based rations. Steam-flaking costs are also much higher than dry-rolling costs, increasing the cost of gain in the WDGS/SFC rations.

When feedlots are located further from ethanol production, WDGS transportation costs are included in the cost of gain. At a distance of 25 miles from an ethanol plant, the 15 percent WDGS/DRC ration still has the lowest cost of gain, $0.04, but the 15 percent DDGS/SFC is the second lowest cost of gain scenario.

Feedlots located 300 miles from ethanol production could still lower their cost of gain by feeding 15 percent WDGS/DRC. The next best alternatives are 15 percent DDGS/SFC and the base ration scenario. The 30 percent WDGS/DRC ration is now clearly not preferred as a cost-minimizing scenario. Those rations combining SFC with WDGS remain the highest cost of gain alternatives.

The increased cost of transportation for the feedlot 300 miles from the ethanol plant when compared to the feedlot located 25 miles from an ethanol plant is approximately $0.02 and $0.05 more per pound of gain for 15 and 30 percent WDGS inclusion rates, respectively. The 15 percent WDGS/DRC ration still has the lowest cost of gain at a distance of 300 miles from ethanol production, where total WDGS transportation costs per head for the feeding period are approximately $14.73, compared with $3.58 for feedlots located 25 miles from the WDGS source. WDGS transportation costs for the 30 percent WDGS inclusion rates are about twice as much as those for the 15 percent inclusion rates, on a per head basis.

Kansas Model Results

Kansas results are similar to those from the Colorado model, with the same ration scenarios used in the analysis. The 15 percent WDGS/DRC, followed by the 30 percent WDGS/DRC were the least cost of gain ration scenarios. These results are for feedlots located at an ethanol plant, including a $0.15 corn basis and WDGS investment costs.

The results for a feedlot located 25 miles from ethanol production are nearly the same as those for the feedlot located at an ethanol plant. When WDGS must be hauled 100 miles to the feedlot the 15 percent WDGS/DRC ration still had the lowest cost of gain, but the 30 percent WDGS/DRC scenario became less feasible.

Even when a feedlot is located 200 to 300 miles from ethanol production, the 15 percent WDGS ration can be fed cheapest. The 15 percent DDGS/SFC ration is the next least cost of gain alternative, followed by the base ration for both the 200 and 300 mile locations. Depending on the distance from ethanol production, Kansas cattle feeders can likely lower their cost of gain by incorporating WDGS or DDGS at the 15 percent inclusion rate (dry matter basis).

Nebraska Model Results

Although only four ration scenarios are compared in the Nebraska model, the 15 percent WDGS/DRC ration still has the lowest cost of gain in most cases. Nebraska ration composition and corresponding cattle performance are estimated from University of Nebraska feedlot nutrition research (Vander Pol et al., 2006a,c). The 15 followed by the 30 percent WDGS/DRC ration are the lowest cost scenarios.

At a distance of 25 miles from ethanol production, Nebraska cattle feeders can still feed 15 percent WDGS/DRC at the lowest cost of gain, and the 30 percent WDGS/DRC has a similar cost of gain to the base scenario. The increasing costs of transportation for WDGS are evident, as the 30 percent WDGS/DRC ration becomes less optimal when the feedlot is located 25 miles from an ethanol plant.

When transporting WDGS 60 miles, the 30 percent WDGS/DRC scenario is no longer preferred over the base scenario, but the 15 percent WDGS/DRC remains the least cost of gain option. The results for Nebraska feedlots located 60, 100, and 200 miles from ethanol production are similar. At each distance from ethanol production, WDGS can be fed at 15 percent dry matter to obtain the lowest cost of gain. The base ration of DRC has the second lowest cost of gain at all three distances.

It is important to note that cattle feeders in eastern Nebraska are feeding WDGS at inclusion rates greater than 15 percent of ration dry matter (Erickson, 2006). The Nebraska model could be adjusted to value WDGS at less than 95 percent the price of corn, and more WDGS inclusion rates could be evaluated in addition to the 15 and 30 percent scenarios. Changing these variables and adding scenarios could provide a more accurate estimate of the cost of gain for eastern Nebraska cattle feeders.

Texas Model Results

When located at an ethanol plant, 15 or 30 percent WDGS can be fed with DRC to decrease cost of gain when compared to the base, 15 percent DDGS/SFC, and 15 percent WDGS/SFC rations. It is important to note that the Texas base scenario and the 15 percent WSDGS TTU scenario include SFC, while the 15 and 30 percent WDGS rations include DRC instead of SFC. The 15 percent WSDGS TTU ration is based on feedlot nutrition research by Galyean and Lemon (2006) from Texas Tech University.

SFC costs more to process than DRC, due to the use of natural gas, which increases total costs for both the base and 15 percent WSDGS TTU scenarios. In addition, ADG for cattle fed 15 percent WDGS with SFC is lower than for cattle fed 15 percent WDGS with DRC. Even when feedlots are located at an ethanol plant, the highest cost of gain scenario occurs when WDGS is fed in SFC-based rations instead of DRC-based rations. The WDGS/SFC results are similar to those discussed previously in the Colorado and Kansas models.

When WDGS must be hauled 300 miles from an ethanol plant to a feedlot, it can still be fed at 15 percent of the ration dry matter. The 15 percent WDGS ration has a similar cost of gain as the base ration and the 15 percent DDGS ration. At distances greater than 100 miles from ethanol production, the 30 percent WDGS ration would no longer be preferred as a least cost of gain ration.

Ethanol production and the resulting co-products provide cattle feeders an alternative feed ingredient which could lower their cost of gain. When WDGS is fed with DRC at 15 percent of the ration dry matter, primarily replacing a portion of the DRC, cost of gain savings can range from $7.30 to $2.73 per 100 pounds of gain for cattle feeders located at an ethanol plant (no WDGS transportation costs). Even when transporting WDGS 100 miles, costs per 100 pounds of gain can be decreased by $5.93 to $1.42 depending on which state the feedlot is located.

Table 5 contains the cost savings from feeding 15 percent WDGS/DRC instead of the base ration in each state, when located at the plant and 100 miles from the ethanol plant. The cost savings are also listed by placement month because those placed on feed in May are on feed for fewer days (fewer total pounds of gain) than those placed at a lighter in-weight in October. Generally cost savings per pound of gain are greater for the October placements as a result of more days on feed and more total pounds of gain per head.

The least cost and second least cost alternatives for each state and placement date are included in Table 6. The least-cost scenarios for each distance from ethanol production are included to show the impact of increasing transportation costs for WDGS, as it contains only 35 percent dry matter. The 15 percent WDGS/DRC ration is preferred in all cases. Again the major difference between the 15 percent WDGS/DRC ration and the 15 percent WDGS/SFC rations is the higher ADG when cattle are fed WDGS with DRC. The cost savings from dry-rolling corn instead of using natural gas to steam-flake corn is another significant cost saving aspect of the 15 percent WDGS/DRC scenario.

The next best alternative is either the 30 percent WDGS/DRC ration or the 15 percent DDGS/SFC ration, in most cases. If feedlots are located within 200-300 miles of ethanol production, and WDGS is priced at 95 percent the price of corn (on an equal dry matter basis) the co-product is a cost-saving feed ingredient. Feedlot nutrition research has also shown that WDGS improves cattle performance when fed with DRC, so it has benefits on both the cost saving and total gain sides of the cost of gain equation.

Summary and Conclusions

The 15 percent WDGS/DRC ration consistently had the lowest cost of gain when compared to the other scenarios when feedlots were located within 200 miles of ethanol production. On the other hand, the 15 percent and 30 percent WDGS/SFC rations consistently had the highest costs of gain, even when feedlots were located at the ethanol plant. The primary difference between these ration scenarios is the lower ADG when cattle are fed WDGS with SFC instead of DRC. The increased cost of corn processing when steam-flaking corn also results in higher costs for the WDGS/SFC rations. It is important to note the differences in ADG for each ration. The current feeding infrastructure in areas further from the Corn Belt is a disadvantage. SFC is a more costly investment that has already been made. The benefits of feeding DGs are largely lost if SFC feeding continues. The areas feeding SFC also rail in the corn. While the rail infrastructure is in place any impacts of substituting loads of distiller's grains for corn are not explored in this work. However, transportation costs will be an important issue in the regional economics of cattle feeding.

WDGS and DDGS can improve cattle performance, and through increased ADG decrease the total cost of gain. The partial budget model shows that these co-products will help offset the higher corn prices, as co-products can be fed at a lower cost of gain than the base ration, even for feedlots located 200 to 300 miles from ethanol production. The gain in cattle performance is critical to the success of these rations.

This research relies on limited animal science feedlot nutrition studies regarding the use of ethanol co-products in feedlot rations. As seen in the analysis, cattle performance differences can make the difference between alternative scenarios including WDGS as the least and the highest cost rations. More feeding research and practical application and experience may change the current base of knowledge.

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Table 1. Exogenous and Endogenous Variables in Colorado, Kansas, Nebraska, and Texas Feedlot Models Incorporating Ethanol By-Products.

Exogenous Stochastic	**Exogenous Deterministic**
PCC Data	Steers Placed
Average Daily Gain	Purchase Weight
Feed:Gain	Days on Feed
Dry Matter Intake	Yardage
Vet/Med Costs	Manure hauling
Feedstuffs Data	**Endogenous Stochastic**
Corn	Total feed
Soybean Meal	Total Gain
Cottonseed Meal	Out-weight
Cottonseed Hulls	Total cost of feeding
Corn Gluten Feed	Corn Processing Costs
DDGS	Transportation of WDGS
WDGS	WDGS Feeding Costs
Alfalfa pellets	**WDGS Investment Costs**
Corn Silage	Roto-mix
Urea	Front end loader operator salary
Yellow Grease	Roto-mix driver salary
Molasses	Repair, Maintenance, Insurance
	Fuel

Table 2. Scenarios for Colorado and Kansas Models.

As is feed lbs/day	Base	15% DDGS/SFC KSU	15% WDGS/SFC KSU	30% WDGS/SFC KSU	30% WDGS/SFC NE	15% WDGS/DRC	30% WDGS/DR NE
Total Corn	**20.15**	**17.47**	**17.22**	**13.87**	**15.34**	**16.92**	**15.0**
Flaked corn	**20.15**	**17.47**	**17.22**	**13.87**	**15.19**	**0.00**	**0.0**
Dry Rolled corn	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**16.92**	**15.4**
HM Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Ground Corn	0.00	0.00	0.00	0.00	0.15	0.00	0.1
Corn silage	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Alfalfa hay	**1.41**	**1.42**	**1.40**	**1.64**	**1.31**	**1.86**	**1.3**
DDGS	**0.00**	**3.51**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**
WDGS	**0.00**	**0.00**	**8.99**	**19.22**	**18.02**	**8.99**	**18.9**
Corn Gluten Feed	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Soybean meal	0.97	0.00	0.00	0.00	0.00	0.00	0.0
Fat	0.00	0.00	0.00	0.00	0.02	0.03	0.0
Rumensin/Tylan	0.00	0.00	0.00	0.53	0.00	0.00	0.0
Limestone	0.41	0.64	0.64	0.32	0.30	0.00	0.3
Urea	0.30	0.11	0.11	0.00	0.00	0.00	0.0
KCl	0.00	0.00	0.00	0.12	0.10	0.00	0.1
Salt	0.00	0.00	0.00	0.07	0.06	0.00	0.0
Vitamin/min	0.00	0.00	0.00	0.03	0.01	0.00	0.0
Premix	0.00	0.00	0.00	0.00	0.64	1.27	0.0
Premix total	0.41	0.64	0.64	1.06	1.12	1.27	1.1
Total Feed/head/day	**23.24**	**23.14**	**28.35**	**35.79**	**35.80**	**29.07**	**37.1**
ADG	**3.18**	**3.19**	**3.11**	**3.00**	**3.59**	**4.07**	**4.0**
DMI	20.60	20.90	20.30	18.80	20.40	19.50	22.0
Adj DMI May	21.12	21.27	20.97	20.22	21.02	20.57	22.1
Adj DMI Oct	19.52	19.67	19.37	18.62	19.42	18.97	20.5
Feed:Gain (DM)	6.49	6.54	6.53	6.96	5.76	6.53	5.0

Table 3. Scenarios for Texas Model, Expected Value					
As is feed lbs/day	**0% WDGS**	**15% DDGS**	**15% WDGS**	**30% WDGS**	**15% WSDGS TTU**
Total Corn	16.81	14.73	14.48	12.60	14.26
Flaked corn	**16.81**	**14.73**	**0.00**	**0.00**	**14.26**
Dry Rolled corn	**0.00**	**0.00**	**14.48**	**12.60**	**0.00**
HM Corn	0.00	0.00	0.00	0.00	0.00
Ground Corn	0.00	0.00	0.00	0.00	0.00
Corn silage	**2.27**	**2.27**	**2.31**	**1.73**	**0.00**
Alfalfa hay	0.33	0.33	0.34	0.22	0.00
DDGS	**0.00**	**3.28**	**0.00**	**0.00**	**0.00**
WDGS	**0.00**	**0.00**	**8.67**	**17.31**	**8.42**
Corn Gluten Feed	**2.32**	**1.99**	**2.02**	**2.02**	**0.00**
Soybean meal	0.00	0.00	0.00	0.00	0.00
Cottonseed hulls	0.83	0.66	0.67	0.00	1.54
Cottonseed meal	0.00	0.00	0.00	0.00	0.00
Molasses	0.91	0.00	0.00	0.00	1.02
Fat (yellow grease or tallow)	0.50	0.50	0.51	0.31	0.56
Rumensin/Tylan/MGA premix	0.00	0.00	0.00	0.00	0.56
Limestone	0.35	0.35	0.35	0.35	0.15
Urea	0.36	0.30	0.30	0.12	0.05
KCl	0.06	0.06	0.06	0.06	0.00
Salt	0.00	0.00	0.00	0.00	0.00
Vitamin/mineral premix	0.00	0.00	0.00	0.00	0.00
Premix	0.40	0.30	0.31	0.20	0.47
Premix total	1.11	0.94	0.96	0.68	1.18
Total Feed/head/day	**25.14**	**24.76**	**30.03**	**34.93**	**27.03**
ADG	**3.68**	**3.70**	**4.07**	**4.05**	**3.09**
DMI	20.09	20.10	20.82	20.75	17.25
Adj DMI May	19.87	19.87	20.23	20.20	18.45
Adj DMI Oct	18.68	18.68	19.04	19.01	17.26
Feed:Gain (dry matter basis)	4.63	4.60	4.72	4.75	5.64

Table 4. Scenarios for Nebraska Model.				
As is feed lbs/day	**CON**	**15% WDGS/DRC**	**30% WDGS/DRC**	**30WDGS DRC:HMC**
Total Corn	**23.94**	**19.61**	**15.82**	**16.88**
Flaked corn	0.00	0.00	0.00	0.00
Dry Rolled corn	**23.67**	**19.13**	**15.66**	**7.64**
HM Corn	0.00	0.00	0.00	9.08
Ground Corn	0.27	0.48	0.16	0.16
Corn silage	0.00	0.00	0.00	0.00
Alfalfa hay	**1.29**	**1.25**	**1.40**	**1.36**
DDGS	0.00	0.00	0.00	0.00
WDGS	**0.00**	**9.62**	**19.24**	**18.77**
Sweet Bran	0.00	0.00	0.00	0.00
Soybean meal	0.00	0.00	0.00	0.00
Cottonseed hulls	0.00	0.00	0.00	0.00
Cottonseed meal	0.00	0.00	0.00	0.00
Molasses	0.00	0.00	0.00	0.00
Fat	0.03	0.03	0.02	0.02
Rumensin/Tylan	0.00	0.00	0.00	0.00
Limestone	0.34	0.35	0.32	0.31
Urea	0.30	0.12	0.00	0.00
KCl	0.11	0.09	0.11	0.10
Salt	0.07	0.07	0.07	0.07
Vitamin/min	0.00	0.00	0.02	0.02
Premix	0.08	0.03	0.68	0.66
Premix total	0.79	0.58	1.09	1.06
Total Feed/head/day	**26.15**	**31.17**	**37.67**	**38.19**
ADG	**3.65**	**4.09**	**4.05**	**3.91**
DMI	24.00	24.85	22.60	21.50
Adj DMI May	23.14	23.57	22.44	21.89
Adj DMI Oct		0.12	0.11	0.07
Feed:Gain (DM)	6.52	6.08	5.68	5.61

Table 5. Average Cost Savings per 100 Pounds of Gain When Feeding 15 Percent WDGS/DRC

	Placements	At Plant	100 miles
CO	May	$5.46	$3.51
	October	$6.22	$4.43
KS	May	$6.33	$5.05
	October	$7.30	$5.93
NE	May	$4.16	$2.80
	October	$4.44	$3.08
TX	May	$2.73	$1.42
	October	$3.41	$2.24

Note: Cost savings=Average(Base COG-15%WDGS/DRC COG)*100 using the average of 500 iterations
COG=Cost of gain including WDGS investment costs for CO,KS, and TX
At plant costs include $0.15 corn basis

Table 6. Least Cost of Gain Rations for Each State at Various Distances from Ethanol Production

Nebraska May & Oct		At plant, $0.15 corn basis	25 Miles, $0.15 corn basis	60 Miles	100 miles	200-300 miles
	1	15% WDGS	15% WDGS	15% WDGS	15% WDGS	15% WDGS
	2	30% WDGS	30% WDGS; Base	Base; 30% WDGS	Base	Base
Texas						
May	1	15% WDGS	15% WDGS	15% WDGS	15% WDGS	15% WDGS; 15% DDGS
	2	30% WDGS	30% WDGS	30% WDGS	30% WDGS, 15% DDGS; Base	Base
Oct	1	15% and30% WDGS	15% WDGS	15% WDGS	15% WDGS	15% WDGS
	2		30% WDGS	30% WDGS	30% WDGS	15% DDGS; Base
Kansas						
May	1	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC
	2	30% WDGS/DRC	30% WDGS/DRC; 15% DDGS	15% DDGS	15% DDGS/SFC	15% DDGS
Oct	1	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC
	2	30% WDGS/DRC	30% WDGS/DRC	30% WDGS/DRC; 15% DDGS	30% WDGS/DRC; 15% DDGS; Base	15% DDGS
Colorado						
May	1	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC
	2	30% WDGS/DRC	15% DDGS/SFC	15% DDGS	15% DDGS/SFC	15% DDGS
Oct	1	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC
	2	30% WDGS/DRC	30%WDGS/DRC; Base; 15% DDGS	Base; 15% DDGS	15% DDGS; Base	15% DDGS; Base

Note: WDGS is fed with DRC in all the above scenarios and DDGS is fed with SFC.