# Influence of Distillers Grains from a Cellulosic Ethanol Process Utilizing Corn Kernel Fiber on Nutrient Digestibility of Lambs and Steer Feedlot Performance

## A.S. Leaflet R2951

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### Summary and Implications

Two experiments were designed to evaluate the impact of traditional wet distillers grains (T-WDG) compared to wet distillers grains derived from a novel process for conversion of corn kernel fiber into cellulosic ethanol (C-WDG) on nutrient digestibility and animal performance. Experiment 1 utilized 10 wethers in a replicated 5 × 5 Latin square design to evaluate the digestibility of dry matter, fiber, fat, and crude protein in diets containing T-WDG or C-WDG. In experiment 2, 168 crossbred steers were used in a randomized complete block design to determine the impact of T-WDG or C-WDG in finishing diets on performance and carcass characteristics. Although digestibility of T-WDG and C-WDG slightly varied at moderate inclusions in the diet, performance and carcass characteristics of steers fed 30% T-WDG were similar to steers fed 30% C-WDG. Therefore, incorporation of a co-product from a novel, secondary fermentation process for conversion of corn kernel fiber into cellulosic ethanol maintained significant growth performance of cattle when replacing corn in finishing diets.

### Introduction

Recently, there has been a trend for ethanol plants to extract more value from the corn kernel, primarily through corn oil extraction. Oil extraction during ethanol production results in decreased fat content of distillers grains (DG), and it has been estimated that more than 85% of ethanol plants are currently extracting corn oil from DG. Although oil removal has been successful, due to costs and advancements in technology, the ethanol industry is moving beyond oil extraction towards fiber extraction by converting corn kernel fiber into cellulosic ethanol. One of the first fiber extraction processes (known as Cellerate™, Syngenta and Cellulosic Ethanol Technologies, LLC, Galva, IA) developed includes a pretreatment with cellulosic enzymes, yeast, and heat and results in a novel wet DG (C-WDG).

Limited research has been conducted regarding use of lower fat DG in finishing diets, and no previous research has been conducted with DG resulting from this new cellulosic ethanol process. Therefore, a series of experiments were designed to aid in determining the feeding value of wet DG (WDG) from a secondary fermentation process (C-WDG) in finishing cattle diets compared to traditional WDG (T-WDG).

### Materials and Methods

**Experiment 1: Lamb Digestibility Study.** Ten crossbred wethers (75 ± 1.6 lbs) were used in a replicated 5 x 5 Latin square design with 15 day periods, including ten days of diet adaptation and five days of total fecal and urine collection. During each period, lambs received one of five diets: a corn-based control diet containing 7.5% T-WDG and 7.5% C-WDG (**CORN**), diets containing 30% or 45% inclusion of T-WDG (**30% T-WDG** or **45% T-WDG**) or diets containing C-WDG (**30% C-WDG** or **45% C-WDG**) on a DM basis. Wet distillers grains were added at the expense of dry rolled corn in the diet. Total fecal and urine collections were collected over a period of five days. This process was repeated for a total of five periods with two lambs·treatment$^{-1}$·period$^{-1}$ allowing for ten lambs/treatment over the trial (*n* = 10/treatment).

Feed refusals, urine, and feces from the previous day were removed at the same time each day. Lambs were fed once daily in the morning and feed was offered at 105% of the average intake for the previous five days. Total feed refusals, fecal output and urine output for each individual lamb were recorded and a sample from each day was saved and composited for that period.

All TMR, feces, and feed refusals were dried in a 70°C convection oven for 96 hours for dry matter determination and ground for further analysis. Individual animal DM intake (DMI) and digestibility of dietary DM, fiber [neutral detergent fiber (NDF), acid detergent fiber (ADF), and hemicellulose], fat, and crude protein were determined. The equations used to calculate digestibility and nitrogen balance are as follows:

Digestibility (%) = (total intake – total output) / total intake × 100%

Nitrogen (N) balance = N intake – N excreted.

Data were analyzed using the mixed procedure of SAS (SAS Institute, Inc., Cary, NC) with lamb as the experimental unit (*n* = 10/treatment). The model included the fixed effects of treatment, period, and lamb nested within square. Four *a priori* single degree of freedom contrast statements were constructed: 1) linear and 2) quadratic effects of increasing inclusion of T-WDG (7.5, 30, and 45% DM of T-WDG), 3) linear and 4) quadratic effects of increasing inclusion of C-WDG (7.5, 30, and 45% DM of C-WDG).

**Experiment 2: Feedlot Performance Study.** One hundred sixty-eight crossbred Angus steers (928 ± 10.9 lbs) were blocked by weight, stratified by source, and randomly assigned to one of four dietary treatments (6 steers/pen, 7 pens/treatment): corn-based control with 13% T-WDG (**CON**), 30% T-WDG (**TRAD**), 30% C-WDG (**CEL**), and 18% C-WDG plus 12% corn condensed distillers solubles (**CEL+CCDS**) on a DM basis . At the initiation of the study, weights were collected on two consecutive days. Steers were implanted with Component TE-IS on day 28 of the trial and were started on Optaflexx at a rate of 300 $mg \cdot steer^{-1} \cdot day^{-1}$ on day 66 (fed for a total of 28 days). Single day weights were taken every 28 days and at the start of the Optaflexx period. Consecutive day weights were taken again at the end of the study (day 93 and 94). Steers were harvested on day 95 and individual carcass data were collected after a 24 hour chill by representatives of Tri County Steer Futurity (Lewis, IA). A four percent pencil shrink was applied to all live weights, and carcass-adjusted performance was determined by calculating final body weights (FBW) from hot carcass weights (HCW) using the average dressing percentage of cattle in this trial (63.55%). Pen feed delivery was recorded daily, and pen average DMI, average daily gain (ADG), and feed conversion were calculated.

Performance data and carcass characteristics were analyzed using the mixed procedure of SAS (SAS Institute, Inc.) as a randomized complete block design with pen as the experimental unit ($n$ = 7/treatment). The model included the fixed effects of treatment and block. Yield grade and quality grade distribution data were analyzed using the glimmix procedure of SAS. Three *a priori* single degree of freedom contrast statements were constructed: 1) CON vs. TRAD, 2) TRAD vs. CEL, and 3) CEL vs. CEL+CCDS.

## Results and Discussion

**Experiment 1: Lamb Digestibility Study.** Dry matter intake and organic matter intake (OMI) did not differ ($P$ = 0.25) due to increasing concentrations of T-WDG in the diet. However, DMI and OMI were quadratically affected ($P$ = 0.02) by increasing concentrations of C-WDG which was primarily driven by decreased intake of lambs fed 30% C-WDG. Dry matter digestibility of T-WDG tended to decrease quadratically ($P \leq 0.09$) due to decreased digestibility at 45% T-WDG. As inclusions of C-WDG increased, there was a linear decrease ($P \leq 0.01$) in DM digestibility.

As expected, increasing WDG in the diet, regardless of source, resulted in an increase ($P \leq 0.05$) in NDF, ADF, fat, and crude protein (CP) concentrations. In the T-WDG−fed lambs, fiber digestibility was linearly increased ($P \leq 0.05$) with increased inclusions of T-WDG. This effect was not seen with C-WDG−fed lambs where fiber digestibility was not effected ($P \geq 0.15$) by increased inclusions of C-WDG in the diets, suggesting that the secondary fermentation process may be affecting the bioavailability of the residual fiber of C-WDG, especially at higher inclusions such as 45% of diet DM. There was a tendency for fat digestibility to linearly increase ($P$ = 0.09) with increasing T-WDG inclusions in the diet. However, fat digestibility of C-WDG was linearly improved ($P \leq 0.01$), suggesting that although more oil is being removed during the production process, the remaining oil in the WDG is more available to the animal. Protein digestibility was increased ($P \leq 0.03$) as dietary inclusions of both T-WDG and C-WDG increased. The majority of the digestibility differences reported were primarily driven by the 45% DM dietary inclusion of both sources of WDG.

**Experiment 2: Feedlot Performance Study.** Consistent with previous research, steers finished on TRAD had heavier ($P \leq 0.01$) FBW and HCW and tended ($P$ = 0.07) to have larger ribeye areas (REA) than their counterparts fed CON. While DMI did not differ ($P$ = 0.31), TRAD−fed cattle had improved ($P < 0.01$) ADG and thus better feed conversion ($P < 0.01$) compared to cattle fed CON.

Between steers fed TRAD and CEL, FBW and ADG did not differ ($P \geq 0.12$); however, due to greater DMI ($P$ = 0.02), CEL−fed steers' feed conversion was poorer ($P$ = 0.01). Although fiber digestibility was not improved in C-WDG diets in the first experiment, the increased fat and protein digestibility of C-WDG may help explain the lack of differences between performance results of steers fed TRAD or CEL. While HCW, REA, and marbling scores were not different ($P \geq 0.16$), steers finished on CEL had leaner carcasses ($P \leq 0.04$) as indicated by decreased backfat thickness and yield grade compared to TRAD−fed steers.

Steers fed CEL+CCDS had lesser ($P \leq 0.04$) DMI and ADG compared to steers finished on CEL; however, feed conversion was not different ($P$ = 0.56). Final body weights and HCW of CEL+CCDS fed steers tended to be lighter ($P \leq 0.09$) than CEL cattle. The addition of CCDS appeared to hinder performance of steers, most likely due to the sulfur content of CCDS. Previous research has shown that dietary sulfur concentrations greater than 0.4% often results in decreased DMI and growth performance. The addition of more moderate inclusions of CCDS in the previous study may have resulted in more favorable performance.

## Conclusion

The feeding value, defined as the percentage change in feed conversion, of T-WDG used in this experiment was calculated to be approximately 165% of the corn it replaced in diet, thus exceeding performance expectations based on previous research which has estimated the feeding value of WDG to be approximately 135% of corn. The secondary fermentation process of C-WDG resulted in increased fat and nitrogen digestibility and decreased DM digestibility in experiment one, but steers fed C-WDG in experiment two had similar performance to steers fed TRAD. The feeding value of C-WDG fed in the present study was calculated to be approximately 120% of corn, which it replaced. Feeding value as defined here may overestimate the actual percentage change in energy value. For more information on this relationship in corn co-product diets, see ISU Extension factsheets on Ethanol Co-products for Beef Cattle: IBCR 200A and IBCR 200B. In summary, the use of WDG derived from a secondary fermentation process for conversion of corn kernel fiber into cellulosic ethanol (C-WDG) maintained a significant performance advantage to cattle when replacing corn in finishing diets. As the ethanol industry continues to look for ways to extract more value from the corn kernel corn, the variability of the distillers grains produced will most likely increase. Therefore, additional research will play an important role in understanding the nutrient value of evolving distillers grains.

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**Table 1.** Nutrient composition of co-products (% DM basis).

| | T-WDG[1] | C-WDG[2] | CCDS[3] |
|---|---|---|---|
| Dry matter | 32.5 | 34.0 | 25.7 |
| Crude protein | 34.1 | 39.1 | 22.2 |
| Neutral detergent fiber | 32.2 | 32.7 | – |
| Acid detergent fiber | 13.3 | 15.2 | – |
| Starch | 5.1 | 1.6 | – |
| Fat | 7.7 | 7.3 | 10.3 |
| Sulfur | 0.74 | 0.72 | 2.10 |

[1]Traditional wet distillers grains.
[2]Cellulosic wet distillers grains derived from secondary fermentation of corn kernel fiber.
[3]Corn condensed distillers solubles.

**Table 2.** Ingredient and nutrition composition of diets fed to lambs in Experiment 1 (% DM basis).

| | | T-WDG[2] | | C-WDG[3] | |
|---|---|---|---|---|---|
| | CORN[1] | 30% | 45% | 30% | 45% |
| Dry rolled corn | 65 | 50 | 35 | 50 | 35 |
| Chopped bromegrass hay | 10 | 10 | 10 | 10 | 10 |
| Finely ground corn[4] | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 |
| Traditional wet distillers grains | 7.5 | 30 | 45 | - | - |
| CEL wet distillers grains[3] | 7.5 | - | - | 30 | 45 |
| Limestone | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 |
| Ammonium chloride | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Salt | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 |
| Vitamin A, D and E premix[5] | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Trace mineral premix[6] | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 |
| Bovatec[7] | 0.0125 | 0.0125 | 0.0125 | 0.0125 | 0.0125 |

[1]CORN: corn-based control diet with 7.5% traditional wet distillers grains and 7.5% cellulosic wet distillers grains (DM basis).
[2]Traditional wet distillers grains included at 30% and 45% of the diet (DM basis).
[3]Cellulosic wet distillers grains derived from secondary fermentation of corn kernel fiber included at 30% and 45% of the diet (DM basis).
[4]Carrier for micro-ingredients.
[5]Vitamin A, D and E premix contained 4,410,000 IU/kg$^{-1}$ of Vitamin A, 1,100,000 IU/kg$^{-1}$ of Vitamin D, and 900 IU/kg$^{-1}$ of Vitamin E.
[6]Provided per kg of diet DM: 30 mg of Zn (zinc sulfate), 25 mg of Mn (manganese sulfate), 0.6 mg of I (calcium iodate), 0.22 mg Se (sodium selenite), and 0.2 mg of Co (cobalt carbonate).
[7]Provided lasalocid at 25g/t of diet (Zoetis, New York, NY).

**Table 3.** Ingredient and nutrient composition of diets fed to steers in Experiment 2 (% DM basis).

| | CON[1] | TRAD[1] | CEL[1] | CEL+CCDS[1] |
|---|---|---|---|---|
| Dry rolled corn | 70 | 53 | 53 | 53 |
| Chopped bromegrass hay | 12 | 12 | 12 | 12 |
| Traditional wet distillers grains | 13 | 30 | - | - |
| CEL wet distillers grains[2] | - | - | 30 | 18 |
| Corn condensed distillers solubles | - | - | - | 12 |
| Dried distillers grains plus solubles[3] | 3.13 | 3.13 | 3.13 | 3.13 |
| Limestone | 1.41 | 1.41 | 1.41 | 1.41 |
| Salt | 0.31 | 0.31 | 0.31 | 0.31 |
| Vitamin A premix[4] | 0.11 | 0.11 | 0.11 | 0.11 |
| Trace mineral premix[5] | 0.024 | 0.024 | 0.024 | 0.024 |
| Rumensin90[6] | 0.01 | 0.01 | 0.01 | 0.01 |
| Analyzed composition | | | | |
| Crude protein | 12.29 | 16.63 | 18.12 | 16.08 |
| Neutral detergent fiber | 23.85 | 26.48 | 25.89 | 22.46 |
| Acid detergent fiber | 11.90 | 12.72 | 13.27 | 11.00 |
| Starch | 48.91 | 37.98 | 39.92 | 39.03 |
| Fat | 4.97 | 6.13 | 6.29 | 7.35 |
| Sulfur | 0.21 | 0.36 | 0.34 | 0.47 |
| NEg, *Mcal/lb* | 0.56 | 0.57 | 0.58 | 0.60 |

[1]Treatments: CON: control; TRAD: 30% traditional wet distillers grains; CEL: 30% cellulosic wet distillers grains; CEL+CCDS: 18% cellulosic wet distillers grains and 12% corn condensed distillers solubles.
[2]Cellulosic wet distillers grains derived from secondary fermentation of corn kernel fiber.
[3]Carrier for micro-ingredients.
[4]Vitamin A premix contained 4,400,000 IU/kg$^{-1}$.
[5]Provided per kg of diet DM: 30 mg Zn (zinc sulfate), 20 mg Mn (manganese sulfate), 10 mg Cu (copper sulfate), 0.5 mg I (calcium iodate), 0.1 mg Se (sodium selenite), and 0.1 mg Co (cobalt carbonate).
[6]Provided monensin at 27g/t of diet (Elanco Animal Health, Greenfield, IN).

**Table 4.** Influence of traditional and cellulosic[1] wet distillers grains on lamb daily dry matter intake, diet digestibility, and fecal and urine output (Experiment 1).

| | | T-WDG[3] | | C-WDG[4] | | | *P*-values | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CORN[2] | 30% | 45% | 30% | 45% | SEM | Linear T-WDG | Quadratic T-WDG | Linear C-WDG | Quadratic C-WDG |
| Lambs (*n*) | 10 | 10 | 10 | 10 | 10 | | | | | |
| DM intake, *lbs/d* | 2.60 | 2.58 | 2.57 | 2.38 | 2.58 | 0.06 | 0.32 | 0.25 | 0.43 | 0.02 |
| OM intake, *lbs/d* | 2.51 | 2.47 | 2.58 | 2.29 | 2.45 | 0.06 | 0.52 | 0.25 | 0.25 | 0.02 |
| DM digestibility, *%* | 80.6 | 80.0 | 77.4 | 78.3 | 75.3 | 0.57 | <0.01 | 0.09 | <0.01 | 0.24 |
| OM digestibility, *%* | 81.8 | 81.2 | 78.6 | 79.4 | 76.5 | 0.52 | <0.01 | 0.05 | <0.01 | 0.20 |
| Daily output | | | | | | | | | | |
| Fecal, *lbs DM/d* | 0.51 | 0.51 | 0.62 | 0.53 | 0.64 | 0.02 | <0.01 | 0.01 | <0.01 | 0.01 |
| Urine, *L/d* | 1.76 | 2.31 | 2.41 | 2.23 | 2.54 | 0.16 | 0.01 | 0.42 | 0.02 | 0.98 |

[1]Cellulosic wet distillers grains derived from secondary fermentation of corn kernel fiber.
[2]CORN: corn-based control diet with 7.5% traditional wet distillers grains and 7.5% cellulosic wet distillers grains (DM basis).
[3]Traditional wet distillers grains included at 30% and 45% of the diet (DM basis).
[4]Cellulosic wet distillers grains included at 30% and 45% of the diet (DM basis).

**Table 5.** Influence of traditional and cellulosic[1] wet distillers grains on dietary concentrations and digestibility of nutrients by lambs (Experiment 1).

| | | T-WDG[3] | | C-WDG[4] | | | *P*-values | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CORN[2] | 30% | 45% | 30% | 45% | SEM | Linear T-WDG | Quadratic T-WDG | Linear C-WDG | Quadratic C-WDG |
| Diet concentrations, *%* | | | | | | | | | | |
| Neutral detergent fiber | 24.6 | 26.9 | 32.2 | 31.0 | 33.6 | 0.83 | <0.01 | 0.03 | <0.01 | 0.29 |
| Acid detergent fiber | 8.8 | 9.7 | 11.4 | 10.4 | 10.3 | 0.42 | 0.05 | 0.21 | 0.02 | 0.18 |
| Hemicellulose | 15.7 | 17.2 | 20.7 | 20.6 | 23.4 | 0.58 | <0.01 | 0.04 | <0.01 | 0.68 |
| Fat | 2.7 | 3.5 | 4.2 | 3.6 | 4.3 | 0.13 | <0.01 | 0.43 | <0.01 | 0.66 |
| Crude protein | 13.0 | 16.2 | 19.8 | 18.4 | 22.7 | 0.46 | <0.01 | 0.05 | <0.01 | 0.34 |
| Nitrogen | 2.1 | 2.6 | 3.2 | 2.9 | 3.6 | 0.07 | <0.01 | 0.04 | <0.01 | 0.30 |
| Sulfur | 0.21 | 0.32 | 0.41 | 0.32 | 0.41 | 0.02 | <0.01 | 0.19 | <0.01 | 0.59 |
| Digestibility, *%* | | | | | | | | | | |
| Neutral detergent fiber | 50.8 | 51.8 | 55.1 | 53.0 | 50.2 | 1.40 | 0.05 | 0.38 | 0.90 | 0.15 |
| Acid detergent fiber | 50.2 | 51.8 | 51.2 | 50.6 | 47.0 | 1.74 | 0.01 | 0.24 | 0.25 | 0.28 |
| Hemicellulose | 51.2 | 51.8 | 53.8 | 54.0 | 51.6 | 1.39 | 0.20 | 0.59 | 0.70 | 0.15 |
| Ether extract | 81.5 | 84.1 | 82.8 | 85.1 | 87.9 | 1.15 | 0.09 | 0.20 | <0.01 | 0.77 |
| Nitrogen | 73.9 | 79.5 | 80.8 | 80.8 | 82.7 | 0.56 | <0.01 | 0.03 | <0.01 | 0.02 |
| Nitrogen balance, *g/d* | 6.4 | 6.3 | 7.6 | 5.9 | 9.1 | 3.43 | 0.48 | 0.57 | 0.13 | 0.14 |

[1]Cellulosic wet distillers grains derived from secondary fermentation of corn kernel fiber.
[2]CORN: corn-based control diet with 7.5% traditional wet distillers grains and 7.5% cellulosic wet distillers grains (DM basis).
[3]Traditional wet distillers grains included at 30% and 45% of the diet (DM basis).
[4]Cellulosic wet distillers grains included at 30% and 45% of the diet (DM basis).

**Table 6.** Influence of traditional and cellulosic[1] wet distillers grains on steer performance and carcass characteristics (Experiment 2).

| | CON[2] | TRAD[2] | CEL[2] | CEL+ CCDS[2] | SEM | *P*-values CON vs TRAD[3] | TRAD vs CEL[4] | CEL vs CEL+CCDS[5] |
|---|---|---|---|---|---|---|---|---|
| Performance | | | | | | | | |
| Initial BW[6], *lbs* | 931 | 928 | 926 | 929 | 1.49 | 0.17 | 0.24 | 0.14 |
| Final BW[7], *lbs* | 1261 | 1291 | 1275 | 1256 | 7.19 | 0.01 | 0.12 | 0.09 |
| DMI, *lbs/d* | 23.5 | 23.2 | 24.0 | 22.0 | 0.23 | 0.31 | 0.02 | <0.01 |
| ADG, *lbs/d* | 3.51 | 3.86 | 3.71 | 3.48 | 0.07 | <0.01 | 0.17 | 0.04 |
| Gain:feed | 0.149 | 0.166 | 0.154 | 0.157 | 0.003 | <0.01 | 0.01 | 0.50 |
| Feed:gain | 6.74 | 6.04 | 6.51 | 6.41 | 0.12 | <0.01 | 0.01 | 0.56 |
| Carcass characteristics | | | | | | | | |
| HCW, *lbs* | 802 | 821 | 811 | 800 | 4.59 | 0.01 | 0.16 | 0.07 |
| Backfat thickness, *in* | 0.48 | 0.49 | 0.45 | 0.48 | 0.01 | 0.52 | 0.04 | 0.15 |
| Ribeye area, $in^2$ | 12.79 | 13.24 | 13.29 | 13.12 | 0.17 | 0.07 | 0.84 | 0.50 |
| Marbling score[8] | 455 | 450 | 450 | 441 | 10.51 | 0.75 | 0.98 | 0.56 |
| Yield grade | 3.1 | 3.1 | 2.8 | 3.0 | 0.07 | 0.75 | 0.03 | 0.16 |

[1]Cellulosic wet distillers grains derived from secondary fermentation of corn kernel fiber.
[2]Treatments: CON: corn-based control with 13% traditional wet distillers grains; TRAD: 30% traditional wet distillers grains; CEL: 30% cellulosic wet distillers grains; CEL+CCDS: 18% cellulosic wet distillers grains and 12% corn condensed distillers solubles.
[3]Contrast comparing CON and TRAD.
[4]Contrast comparing TRAD and CEL.
[5]Constract comparing CEL and CEL+CCDS.
[6]A 4% pencil shrink was applied to all live weights.
[7]Final body weights were calculated from HCW using a common dressing percentage of 63.55%.
[8]Marbling score: 300=slight, 400=small, and 500=modest.