

Quality Effects on Beef from Cattle Fed High-Protein Corn Distillers Grains and Other Ethanol By-Products

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Summary with Implications

The objective of this study was to evaluate the effects of feeding high protein corn distillers grains on fresh beef quality. Steers were fed one of five diets, either a corn control, high protein distillers grains plus solubles, dry distillers grains plus solubles, wet distillers grains plus solubles, or bran plus solubles diet. Strip loins were aged for 2, 9, or 23 days and placed under retail display conditions for 0 or 7 days. Dietary treatment had no effect on tenderness within each aging period. There were also no differences between treatments for proximate composition, free calcium in the muscle, and sarcomere length. Results suggest that feeding high protein distillers grains decreases color stability and increases lipid oxidation when compared to corn diets leading to reduced shelf life.

Introduction

Feeding distillers grains from ethanol production to cattle has been widely implemented since distillers grain has been reported to have a better feeding value than corn. However, previous research has shown that feeding distillers grains to cattle can increase polyunsaturated fatty acid content in muscle, resulting in greater discoloration and lipid oxidation in strip loins leading to reduced shelf life. Recently, the ethanol industry has adopted a process called dry fractionation, which separates the corn kernel into its germ, bran, and endosperm. The endosperm is the sole fraction introduced into the ethanol production process resulting in distillers grain with higher crude protein levels due to more

efficient fermentation. The quality effects of feeding this type of distillers grain are not widely understood. Therefore, the purpose of this study was to determine the quality effects on beef from cattle fed high protein distillers grains.

Procedure

A total of 300 steers were allocated in 30 pens (10 hd/pen) and fed one of five diets for 190 days: a corn control diet (Control), or a diet containing 40% high protein dry distillers grains plus solubles (HP-DDGS), 40% dry distillers grains plus solubles (DDGS), 40% wet distillers grains plus solubles (WDGS), or 40% bran plus solubles (Bran) diet. Inclusion rates of distillers grains were calculated on a dry matter basis. Eighteen USDA Choice carcasses (3 hd/pen) were randomly selected within each treatment (n=90). Hot carcass weight at harvest was 862 lbs (SD 69.7 lbs). Strip loin samples from the right side were collected and divided into three sections and randomly assigned to one of the three aging periods (2, 9, or 23 d). Three one-inch steaks were fabricated at each aging period [one steak for tenderness measurement for 0 d of retail display, one steak for WBSF, visual discoloration, and objective color for 7 d of retail display, and one steak was cut in half for lipid oxidation for 0 d of retail display and all other laboratory analysis]. A one half-inch steak was cut in half and utilized for lipid oxidation after 4 and 7 d of retail display. After fabrication all steaks used for WBSF, color analysis, and lipid oxidation were placed on foam trays, overwrapped with oxygen permeable film, and placed under retail display conditions for 7 d at 37°F.

For all steaks (never frozen), internal raw temperature and weight were recorded. Steaks were cooked to 80°F and turned over until they reached a target temperature of 160°F on an indoor grill (Hamilton Beach-31605A, Hamilton Beach Brands, Glen Allen, VA). After cooking, internal

temperature and weight were recorded. The steak was then bagged and stored in the cooler (33°F) for approximately 24 hours. Six cores (1/2-inch diameter) were removed parallel to the muscle fiber orientation and were sheared with a Food Texture Analyzer with a Warner-Bratzler blade to determine Warner-Bratzler shear force (WBSF).

Objective color was measured daily for 7 d using a Minolta Colorimeter (CR-400, Minolta Camera Company, Osaka, Japan). The D65 illuminant setting and 2° observer with an 8 mm diameter measurement area were used. Color values were obtained by averaging 6 readings from various areas of the steak surface. The CIE L*, a*, and b* values correspond to lightness, redness, and yellowness, respectively. Visual discoloration was evaluated daily for 7 d on a scale from 0–100% discoloration by 5 trained panelists.

Thiobarbituric acid reactive substance values (TBARS) were measured for all aging periods at 0, 4, and 7 d of display. Duplicate five gram samples of powdered strip loin steak with no subcutaneous fat were measured. Results were expressed in mg of malonaldehyde per kg of muscle tissue.

Sarcomere length was measured for powdered muscle samples aged for 2 d with 0 d of retail display by the laser diffraction method. Results were expressed in μm .

Moisture and ash (%) of lean muscle (no subcutaneous fat) were quantified with a LECO Thermogravimetric Analyzer in duplicate (Model 604–100–400, LECO Corporation, St. Joseph, MI). Fat content was quantified in triplicate by ether extraction according to the Soxhlet procedure.

Ten grams of powdered sample were weighed out in duplicate and 90 mL of distilled, deionized water was added along with a magnetic stir bar. The samples were mixed continuously throughout the measurement process. Sample pH was measured using a calibrated pH meter (Orion 410Aplus, ThermoFisher Scientific, Waltham, MA). Values of the duplicated samples were averaged for a final pH value

for all aging periods with 0 d of retail display.

Three grams of powdered sample were centrifuged at 196,000 x g (Beckman Optima XPN-90 Ultracentrifuge, Type 50.2 Ti rotor, Beckman Coulter, Brea, CA) at 40°F for 30 minutes. Seven hundred µL of the supernatant were collected and treated with 0.1 mL of 27.5% trichloroacetic acid (TCA). Samples were centrifuged at 6,000 x g (accuSpin Micro 17R, ThermoFisher Scientific, Waltham, MA) for 10 min. Four hundred µL of supernatant were transferred to a syringe, and the volume was brought to 4 mL with deionized, distilled water. The diluted sample was filtered through a 13 mm diameter Millex-LG 0.20µm syringe filter (Millipore, Bedford, MA). Calcium concentration was quantified using an inductively-coupled plasma emission spectrometer (iCAP 6500 Radial; Thermo Electron, Cambridge, UK) with appropriate calcium concentration standards.

Objective and subjective color data were analyzed as a split-plot repeated measures design with dietary treatment as the whole-plot, aging period as the split-plot and retail display time as the repeated measures. Tenderness and lipid oxidation data were analyzed as a split-split-plot design with treatment as the whole-plot, aging period as the split-plot and retail display time as the split-split-plot. Proximate analysis and sarcomere were analyzed as a complete random design. Free calcium and pH were analyzed as 5 x 3 factorial arrangement of treatments. Data were analyzed using the PROC GLIMMIX procedure of SAS and pen was the experimental unit. All means were separated with the LS MEANS statement and the TUKEY adjustment with an alpha level of 0.05 and tendencies were considered at an alpha level of 0.1.

Results

There were no tenderness differences among diets within the same aging periods. The only effects observed for tenderness were in regards to retail display, indicating an increase in tenderness as time in retail display conditions increased (2 d: $P < 0.0001$, 9 d: $P = 0.0002$, 23 d: $P < 0.0001$, respectively).

Muscle L* and a* exhibited dietary treatment by retail display interactions ($P = 0.0005$, and $P < 0.001$, respectively). The

Table 1. Discoloration (%) of strip loin steaks (*Longissimus lumborum*) from steers fed either a corn diet, 40% high protein dry distillers grains plus solubles (HP-DDGS), 40% dry distillers grains plus solubles (DDGS), 40% wet distillers grains plus solubles (WDGS), or 40% bran plus solubles (Bran) with 2, 9, and 23 d of aging at 5, 6, and 7 d of retail display.

Days in retail display	Aging period								
	2			9			23		
	5	6	7	5	6	7	5	6	7
Dietary treatments									
Corn	0.29 ^a	0.72 ^a	1.59 ^b	0.13 ^a	0.68 ^b	1.68 ^b	3.13 ^a	15.75 ^c	38.85 ^d
WDGS	0.47 ^a	1.77 ^a	4.74 ^b	0.31 ^a	1.64 ^{ab}	5.67 ^b	6.02 ^a	34.45 ^{bc}	63.63 ^{bc}
Bran	0.07 ^a	1.06 ^a	2.89 ^b	0.87 ^a	3.26 ^{ab}	6.79 ^b	18.98 ^a	46.24 ^{ab}	68.30 ^{ab}
DDGS	0.59 ^a	1.92 ^a	4.82 ^b	0.15 ^a	1.92 ^{ab}	4.83 ^b	13.88 ^a	45.05 ^{ab}	74.19 ^{ab}
HP-DDGS	0.44 ^a	4.86 ^a	15.32 ^a	1.74 ^a	7.67 ^a	19.88 ^a	16.30 ^a	64.31 ^a	85.79 ^a

^{a-d} Means in the same column with different superscripts are different ($P < 0.05$)

L* values for steaks from cattle fed WDGS were greater (lighter; $P < 0.05$) than all treatments at 0 d of retail display other than steaks from cattle fed HP-DDGS, which was similar. There were no differences ($P > 0.05$) in lightness among any of the other treatments at day 0 of retail display. After 7 d of retail display, steaks from cattle fed HP-DDGS had greater L* values than steaks from the Control cattle ($P = 0.004$). Redness (a*) values were greater ($P < 0.05$) for steaks from cattle fed DDGS than both steaks from the Bran treatment and Control after 0 d of retail display. The HP-DDGS steaks had lower ($P > 0.05$) redness values than all other treatments following 7 d of retail display while steaks from Control-fed cattle had the greatest a* value ($P < 0.05$). In general, a lighter, redder beef color is preferred. A 3-way interaction of dietary treatment, aging, and retail display was identified for b* values ($P = 0.006$). At 2 and 23 d aging with 0 d retail display there were no differences among dietary treatments ($P > 0.05$). However, during 9 d of aging with 0 d of retail display steaks from cattle supplemented with DDGS was significantly more yellow (greater b* value) than steaks from Control-fed cattle ($P = 0.03$). For steaks with 2 d of aging and 7d of retail display, Control, WDGS, and DDGS were all significantly more yellow than the HP-DDGS treatment. At 9 d of aging with 7 d of retail display, steaks from Bran and DDGS had greater yellowness values ($P < 0.05$) compared to HP-DDGS. There were no differences ($P > 0.05$) in b* values between dietary treatments at 23 d of aging and 7 d of retail display.

Table 2. Lipid oxidation value (TBARS; mg malonaldehyde/kg of meat) of strip loin steaks (*Longissimus lumborum*) from steers fed either a corn diet, 40% high protein dry distillers grains plus solubles (HP-DDGS), 40% dry distillers grains plus solubles (DDGS), 40% wet distillers grains plus solubles (WDGS), or 40% bran plus solubles (Bran) with 0, 4, and 7 d retail display.

Dietary treatment	Days in retail display		
	0	4	7
Corn	0.67 ^a	1.45 ^a	2.38 ^c
WDGS	0.77 ^a	2.04 ^a	4.27 ^{ab}
Bran	0.73 ^a	2.08 ^a	3.86 ^b
DDGS	0.85 ^a	1.64 ^a	3.19 ^{bc}
HP-DDGS	0.80 ^a	2.40 ^a	5.15 ^a

^{a-c} Means in the same column with different superscripts are different ($P < 0.05$)

After 7 d of retail display following 2 and 9 d of aging, panelists judged the steaks from cattle fed HP-DDGS had more discoloration ($P < 0.05$) than all other treatments, which were similar. Following 23 d of aging, steaks from cattle fed HP-DDGS had the most discoloration and all treatments except WDGS were more discolored than Control ($P < 0.05$) after 6 and 7 d of retail display.

A retail by treatment interaction ($P < 0.001$) was observed for lipid oxidation. After 7 d of retail display, steaks from cattle fed HP-DDGS had greater TBARS values ($P < 0.05$) than all other treatments except steaks from WDGS-fed cattle. There were no differences in lipid oxidation between steaks from cattle fed WDGS, Bran, and DDGS. The lowest concentration of TBARS occurred in steaks from cattle fed Con-

trol, which were different ($P < 0.05$) from all steaks except those from the DDGS treatment.

As expected, no differences were observed among treatments for sarcomere length ($P = 0.07$), fat ($P = 0.51$), moisture ($P = 0.71$), or ash ($P = 0.74$). An aging effect was found for pH ($P < 0.0001$). However, the difference in values were of little practical significance (5.48 at 2 d, 5.44 at 9 d, 5.49 at 23 d, respectively). As aging increased, there was a significant increase of free calcium levels in the meat ($P < 0.0001$)

(2 d: 60.06 μM ; 9 d: 66.27 μM ; 23 d: 67.82 μM). Although there were no statistical differences ($P = 0.07$) in free calcium content between dietary treatments, there was a tendency where steaks from WDGS had the greatest free calcium levels and Control steaks the lowest (68.15 μM , and 62.05 μM , respectively).

Conclusions

Although the feeding of high protein distillers grain to cattle did not alter the

tenderness of the muscle, there could be significant economic ramifications due to the increase in lipid oxidation and discoloration under retail display conditions which resulted in shorter shelf life.

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