Impact of feeding various amounts of wet and dry distillers grains to yearling steers on palatability, fatty acid profile, and retail case life of longissimus muscle

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J ANIM SCI 2011, 89:179-184.
doi: 10.2527/jas.2010-3137 originally published online October 8, 2010

Impact of feeding various amounts of wet and dry distillers grains to yearling steers on palatability, fatty acid profile, and retail case life of longissimus muscle[1]

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ABSTRACT: Due to increased production of ethanol, abundance of distillers grains (DG) is increasing. Steers (n = 176) were assigned to 1 of 5 treatment groups: steam-flaked corn (SFC), 10% dry DG (DDG), 10% wet DG (WDG), 20% WDG, or 30% WDG. The objectives were to determine the effects of feeding greater amounts of WDG, or DDG on meat quality. Steaks, 2.54 cm, were cut from strip loins and identified for simulated retail display, Warner-Bratzler shear force analysis, palatability, and fatty acid composition. Steaks from cattle fed 10% WDG and 30% WDG had smaller ($P < 0.05$) Warner-Bratzler shear force values than steaks from cattle fed 20% WDG. Trained sensory panelists found no differences ($P > 0.05$) in overall tenderness and off-flavors. No differences were found in total SFA and MUFA composition among treatments; however, 20% and 30% WDG had a greater proportion of PUFA and n-6 fatty acids than 10% WDG. No differences were found during simulated retail display between various amounts of WDG. Further research needs to be conducted to evaluate methods that aid in increasing shelf life of steaks from cattle fed greater rates of WDG.

Key words: beef, distillers grain, fatty acid, shear force, strip loin

J. Anim. Sci. 2011. 89:179–184
doi:10.2527/jas.2010-3137

INTRODUCTION

Increased ethanol production has lead to an abundance of a coproduct, distillers grain (**DG**), which has given cattle feeders the option to consider DG as a feed source. Traditionally, DG are dried; this drying process, however, tends to increase energy costs incurred by the ethanol plant and may produce changes that reduce its nutritional value. Stock et al. (2000) reported that drying of distillers coproducts can decrease the energy value but does not affect its protein value. Thus, wet DG (**WDG**) can have added value, not only to the ethanol plant, but to cattle producers as well. Loza et al. (2010) stated that WDG has traditionally been fed as a protein source; however, more recently it is included in cattle diets as an energy source due to cost competitiveness.

Visual muscle color has a substantial influence on consumer purchasing decisions. According to Morrissey et al. (1994), consumers relate a bright cherry red color to freshness and discriminate against meat that has turned brown. O'Sullivan et al. (2002, 2003) showed that the feeding regimen of an animal can affect meat color and quality. Dahlen et al. (2001) reported that steaks from steers fed a combination of condensed distillers solubles and barley coproduct were redder than steaks from steers fed corn gluten feed. Roeber et al. (2005) determined that a greater percentage of steaks from steers fed 40% WDG or 40% dry DG (**DDG**) were considered moderately unacceptable during retail display when compared with steers fed smaller amounts of DG.

Gray et al. (1994) reported that feeding regimen can also affect flavor and lipid oxidation. Mancini and Hunt (2005) found that color effects were attributed to the relationship between lipid and pigment oxidation, particularly the instability of PUFA. Previous studies demonstrated that fatty acid composition of bovine tis-

[1]This project was funded by beef and veal producers and importers through their $1-per-head checkoff and was produced for the Cattlemen's Beef Board (Centennial, CO) and state beef councils by the National Cattlemen's Beef Association (Centennial, CO). This project was also funded in part by the Oklahoma State Agricultural Experiment Station (Stillwater), project 2583.

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Received May 6, 2010.
Accepted September 27, 2010.

sues can be influenced by dietary regimens (Rule et al., 1994; Mandell et al., 1997).

Tenderness is another sensory factor that is considered an important trait of meat quality. According to Boleman et al. (1995) and Miller et al. (2001), consumers would be willing to pay increased prices for beef as long as it is guaranteed tender. Unfortunately, tenderness is a highly variable characteristic. In a study by Roeber et al. (2005), Warner-Bratzler shear force (**WBSF**) values were not different among dietary treatments: corn-corn silage diet with soybean meal or diets formulated with 12.5% DDG, 25% DDG, 25% WDG, 50% DDG, or 50% WDG. Koger (2004) also found no differences in WBSF values when evaluating inclusion of 20% WDG, 40% WDG, 20% DDG, or 40% WDG in finishing rations. Thus, ration formulation may negatively affect meat quality, composition, and ultimately shelf life. Therefore the objectives of this study were to determine the effects of feeding greater levels of WDG or DDG to finishing steers on meat quality characteristics.

MATERIALS AND METHODS

All procedures were reviewed and approved by the Oklahoma State University (**OSU**) Animal Care and Use Committee.

Cattle

One hundred seventy-six yearling steers (average initial BW = 408 ± 28 kg) were delivered to a commercial feedlot facility near Goodwell, Oklahoma, in early May 2007. Upon arrival, steers were individually weighed and ear tagged. Steers were blocked by initial BW and allocated into 1 of 30 pens with 6 head per pen. Treatments were deemed as SFC, 10% WDG, 10% DDG, 20% WDG, and 30% WDG. Based on visual appraisal, cattle were sent to a commercial harvest facility when the block was expected to have sufficient finish to grade 65% USDA Choice. Cattle averaged 123 d on feed with a range of 101 to 143 d.

Strip Loin Collection and Sample Preparation

Strip loins were tagged to maintain identity during fabrication. Carcasses were fabricated according to Institutional Meat Purchasing Specifications (**IMPS**; USDA, 1996). Strip loins (IMPS 180) were collected, vacuum packaged, and placed in ice chests for transit back to OSU Robert M. Kerr Food and Agricultural Products Center. Strip loins were aged 14 d postmortem at 2°C.

After aging, the anterior end of the strip loin was faced and a sample from each strip face was vacuum packed and placed in a blast freezer (−20°C) for subsequent fatty acid profiling analysis. A 2.54-cm-thick steak was cut from the anterior end and labeled for simulated retail display. The remaining portion of the strip loin was vacuum packaged and frozen at −20°C for further shear force and taste panel analysis.

Simulated Retail Display

Steaks labeled for retail display were placed on a styrofoam tray with a soaker pad and were overwrapped with a polyvinyl chloride film (**PVC**). Trays were placed into a coffin-style display case that was maintained at 2 ± 1°C under constant light conditions (Phillips Delux Warm White Florescent lamps, Somerset, NJ). The surface of the meat was exposed to (900 to 1,365 lx) as recommended by AMSA (1991). Each steak was objectively and subjectively evaluated for color attributes at 12-h intervals during retail display for 7 d.

Objective Color Evaluation

Color of each steak was measured using a HunterLab Miniscan XE hand-held spectrophotometer equipped with a 6-mm aperture (Hunter Laboratory Associates Inc., Reston, VA) to determine **L*** (brightness: 0 = black, 100 = white), **a*** (redness/greenness: positive values = red, negative values = green), and **b*** (yellowness/blueness: positive values = yellow, negative values = blue). Three readings were obtained for each steak and were averaged to obtain the final L*, a*, b* values for each steak at each time of evaluation.

Subjective Color Evaluation

Subjective color was evaluated by a 6-person trained panel of OSU personnel. Panelists assigned scores to each steak for muscle color, surface discoloration, and overall appearance at every evaluation time as outlined by Hunt et al. (1991). Panelists characterized meat color (8 = extremely bright cherry red, to 1 = extremely dark red), surface discoloration [7 = no discoloration (0%), to 1 = total discoloration (100%)], and overall appearance (8 = extremely desirable, to 1 = extremely undesirable). As with objective evaluation, steaks were evaluated every 12 h for 7 d.

Fatty Acid Profiling

Steaks for fatty acid analysis were trimmed of all subcutaneous fat, cubed, frozen in liquid nitrogen, and pulverized in a Waring blender to a powder-like consistency. The samples remained in the freezer until analysis. To extract lipids from the tissues, it is necessary to find solvents that will not dissolve the lipids but will overcome the interactions between the lipids and the tissue matrix (Christie, 2003). Fatty acid methyl ester procedure was determined by gas chromatography as described by Bligh and Dyer (1959) with modifications. Identification of the fatty acids were made by comparing the relative retention times of fatty acid methyl

ester peaks from samples with those of an external standard run simultaneously. Methyl ester peaks from samples were calculated as percentages of fatty acids.

Tenderness Determination

One 2.54-cm steak was cut from each strip loin for WBSF determination. Steaks were allowed to temper at 4°C for 24 h. Steaks were cooked on an impingement oven (model 1132–000-A, Lincoln Impinger, Fort Wayne, IN) at 180°C to an internal temperature of 70°C. Internal steak temperatures were monitored with copper constantan thermocouples (model OM-202, Omega Engineering Inc., Stamford, CT).

After cooking, steaks were held at 4°C for 24 h before conducting shear force analysis. Six cores, 1.27 cm, were removed parallel to muscle fiber orientation. Each core was sheared once with the Warner-Bratzler head on the Instron Universal Testing Machine (model 4502, Instron Corp., Canton, MA) at a crosshead speed of 200 mm/min. Peak force (kg) of cores was recorded by an IBM PS2 (Model 55 SX) using software provided by the Instron Corporation. Mean peak WBSF was then calculated by averaging the 6 cores.

Palatability Determination

Steaks were assigned a randomized 3-digit number for sensory sessions. Steaks were allowed to temper 24 h before each session and were then cooked as described above for WBSF analysis. After cooking, samples were uniformly cut into 2.54 × 2.54 cm cubes and placed in a cup with the corresponding identification number. Cups were placed in a warmer (Food Warming Equipment, model PS-1220-15, Crystal Lake, IL) until served to panelists.

The sensory panel consisted of 8 trained OSU personnel. Panelists were trained on tenderness, juiciness, and 3 specific flavor attributes (Cross et al., 1978). Sensory sessions were conducted twice a day for 2 wk, and each session contained 10 samples. Samples were evaluated using a standard ballot from the American Meat Science Association (AMSA, 1995). The ballot consisted of a numerical, 8-point scale for initial and sustained juiciness (8 = extremely juicy, 1 = extremely dry), tenderness (8 = extremely tender, 1 = extremely tough), and connective tissue amount (8 = none, 1 = abundant). Three flavor attributes (beef flavor, painty/fishy, and livery) were evaluated. The flavor intensity of each attribute was scored on a 3-point scale (1 = not detectable, 3 = strongly detectable).

During sessions, panelists were randomly seated in individual booths in a temperature- and light-controlled room. The 10 samples were served in a randomized order according to panelist. The panelists were provided distilled, deionized water and unsalted crackers to cleanse their palates.

Statistical Analysis

Data were analyzed using the mixed procedure (SAS Inst. Inc., Cary, NC). The ANOVA model for WBSF, sensory, and fatty acid analysis included treatment as the fixed effect and individual sample as the random effect. The ANOVA model for color attributes were analyzed using a repeated measures model with time as the repeated measure, identification number as the subject, and treatment as the fixed effect. A pivot table was used to determine at which hour 75% of steaks were deemed moderately undesirable. When the model was significant ($\alpha = 0.05$), least squares means were calculated and separated using preplanned contrasts (control vs. DG, 10% DDG vs. 10% WDG, 10% WDG vs. 20% WDG vs. 30% WDG, and WDG vs. DDG).

RESULTS AND DISCUSSION

Color Evaluation

The main effects of dietary treatment on L*, a*, and b* and subjective evaluation values at 48 h of simulated retail display (time at which 75% of steaks be-

Table 1. Least squares means ± SEM and main contrasts for instrumental color analysis of strip loin steaks under retail display

Treatment[1]	L*[2]	a*[3]	b*[4]
SFC	39.53 ± 0.71	11.53 ± 0.56	13.49 ± 0.35
10% DDG	39.47 ± 0.72	10.82 ± 0.57	13.50 ± 0.36
10% WDG	39.37 ± 0.69	11.57 ± 0.55	13.67 ± 0.34
20% WDG	39.98 ± 0.70	10.74 ± 0.55	13.27 ± 0.35
30% WDG	38.20 ± 0.69	10.48 ± 0.55	12.52 ± 0.034
		P-value	
Main contrast			
Wet vs. dry	0.74	0.86	0.41
SFC vs. DG	0.72	0.32	0.53
10% W vs. 10% D	0.90	0.29	0.70
% WDG	0.22	0.50	0.04

[1]Treatments: SFC = steam-flaked corn; D = dry; W = wet; DG = distillers grains.
[2]L* = brightness (0 = black; 100 = white).
[3]a* = redness (positive values = red; negative values = green).
[4]b* = yellowness (positive values = yellow; negative values = blue).

Table 2. Least squares means ± SEM and main contrasts for visual color evaluation of strip loin steaks for muscle color, surface discoloration, and overall acceptability

Treatment[1]	Muscle color[2]	Surface discoloration[3]	Overall acceptability[4]
SFC	3.97 ± 0.20	3.60 ± 0.27	3.28 ± 0.22
10% DDG	3.63 ± 0.20	4.25 ± 0.27	2.59 ± 0.22
10% WDG	3.59 ± 0.19	3.54 ± 0.26	3.20 ± 0.21
20% WDG	3.81 ± 0.19	4.06 ± 0.27	2.85 ± 0.22
30% WDG	3.56 ± 0.19	4.23 ± 0.26	2.75 ± 0.21
		P-value	
Main contrast			
Wet vs. dry	0.51	0.33	0.18
SFC vs. DG	0.30	0.17	0.08
10% W vs. 10% D	0.17	0.04	0.03
% WDG	0.56	0.84	0.56

[1]Treatments: SFC = steam-flaked corn; D = dry; W = wet; DG = distillers grains.
[2]Muscle color: 1 = extremely dark red; 8 = extremely bright cherry red.
[3]Surface discoloration: 1 = no discoloration; 7 = total discoloration.
[4]Overall acceptability: 1 = extremely undesirable; 8 = extremely desirable.

ing evaluated were deemed moderately undesirable) are presented in Table 1 and Table 2. When comparing color scores from main contrast of 10% WDG and 10% DDG, steaks from both treatment groups had a moderately dark cherry red color at 48 h. Furthermore, steaks from 10% DDG carcasses had a greater percentage of surface discoloration ($P < 0.05$), which resulted in those steaks being scored as very undesirable, whereas 10% WDG steaks were deemed as moderately undesirable ($P < 0.05$, Table 2). Steaks from cattle fed 10% WDG had greater ($P < 0.05$) b* values, which indicates more yellowness, than 30% WDG. On the other hand, L* and a* values were not significantly different ($P > 0.05$; Table 1). Previous research indicated that steaks from cattle fed SFC had decreased L*, and greater a* and b* values than steaks from cattle diets containing DG (Gill et al., 2008).

Tenderness and Sensory Attributes

Warner-Bratzler shear force values indicated that no differences among the control and distillers diets were observed (Table 3). Roeber et al. (2005) and Koger (2004) found that WBSF values did not differ when evaluating various inclusion amounts of WDG and DDG in cattle rations. However, when comparing strip loin steaks from cattle fed various percentages of WDG, steaks from steers fed 30% WDG and 10% WDG had smaller ($P < 0.05$) WBSF (3.83 ± 0.13 kg and 4.13 ± 0.13 kg) values than 20% WDG (4.33 ± 0.13 kg). Overall tenderness determined by a trained sensory panel verified WBSF results; panelists found no differences among treatments. Dahlen et al. (2001) documented that flavor, juiciness, connective tissue, and off-flavor intensity were not influenced by dietary treatment when comparing steaks from cattle fed a combination of condensed distillers solubles and barley coproduct with those fed wet corn gluten feed.

Fatty Acid Analysis

The chemical composition and percentage of fatty acids are presented in Table 4. No differences were found in total SFA or total MUFA. Comparing steaks from

Table 3. Least squares means ± SEM and main contrasts for Warner-Bratzler shear force (WBSF) and sensory characteristics of strip loin steaks

Treatment[1]	WBSF, kg	Overall tenderness[2]	Livery flavor[3]
SFC	4.01 ± 0.13	5.55 ± 0.08	1.12 ± 0.02
10% DDG	4.08 ± 0.14	5.53 ± 0.08	1.09 ± 0.02
10% WDG	4.13 ± 0.13	5.69 ± 0.08	1.09 ± 0.02
20% WDG	4.33 ± 0.13	5.74 ± 0.08	1.12 ± 0.02
30% WDG	3.83 ± 0.13	5.66 ± 0.08	1.15 ± 0.02
		P-value	
Main contrast			
Wet vs. dry	0.90	0.08	0.34
SFC vs. DG	0.58	0.25	0.77
10% W vs. 10% D	0.84	0.22	0.88
% WDG	0.04	0.45	0.09

[1]Treatments: SFC = steam-flaked corn; D = dry; W = wet; DG = distillers grains.
[2]Tenderness: 1 = extremely tough; 8 = extremely tender.
[3]Flavor intensity: 1 = not detectable; 3 = strongly detectable.

Table 4. Least squares means ± SEM and main contrasts for total fatty acid percentages found in LM (n = 81)[1]

	Treatment					Main contrast (*P*-value)			
Fatty acid	SFC	10DDG	10WDG	20WDG	30WDG	D vs. W	10D vs. 10W	% WDG	SFC vs. DG
Total SFA[2]	48.46 ± 8.65	48.81 ± 8.07	48.02 ± 9.30	50.60 ± 12.50	48.19 ± 9.55	0.96	0.82	0.64	0.87
Total MUFA[3]	45.06 ± 2.99	46.15 ± 2.17	46.59 ± 2.25	45.53 ± 2.99	45.40 ± 3.04	0.69	0.65	0.18	0.26
Total PUFA[4]	9.73 ± 2.93	9.15 ± 1.86	8.94 ± 1.98	11.53 ± 3.74	9.99 ± 3.19	0.23	0.89	0.04	0.83
Total n-3	1.67 ± 0.76	1.46 ± 0.45	1.57 ± 0.43	1.77 ± 0.68	1.68 ± 0.67	0.24	0.63	0.41	0.75
Total n-6	7.97 ± 2.35	7.57 ± 1.61	7.33 ± 1.57	9.65 ± 3.54	8.23 ± 2.57	0.24	0.78	0.03	0.75

[1]SFC = steam-flaked corn; D = dry; W = wet; DG = distillers grains; 10D = 10% dry; 10W, 20W, and 30W = 10, 20, and 30% wet, respectively.
[2]SFA = calculated sum of fatty acids presented in this study that contain no double bonds.
[3]MUFA = calculated sum of fatty acids presented in this study that contain 1 double bond.
[4]PUFA = calculated sum of fatty acids presented in this study that contain 2 or more double bonds.

cattle fed varying percentages of WDG demonstrated that the LM from cattle fed 20 and 30% WDG were greater ($P < 0.05$) in PUFA than cattle fed 10% WDG (Table 4). Conversely, Koger (2004) reported greater concentration of PUFA in the LM from cattle fed 40% DG compared with cattle fed 20% DG. Greater ($P < 0.05$) content of n-6 fatty acids can be found in 20% and 30% WDG steaks compared with 10% WDG (Table 4).

Conclusions

Based on the results from this study, feeding various amounts of DDG or WDG to cattle does not negatively affect sensory attributes or eating quality. Cattle producers are able to save money by replacing a percentage of steam-flaked corn with DG in feed rations without causing detrimental effects to product quality. Warner-Bratzler shear force values even indicated that steaks from cattle fed 30% WDG were more tender than steaks from cattle fed 10 and 20% WDG. Beef from cattle fed 20 or 30% WDG had greater proportions of PUFA and therefore may be more susceptible to oxidative rancidity, which can result in a shortened shelf life. Further research should be done to evaluate shelf life of steaks from cattle fed greater inclusion rates of WDG, such as different processing techniques, injection of antioxidants, various forms of packaging, or addition of vitamin E to the diet.

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