The impact of post-harvest interventions on the color stability, and subsequently, the palatability, of beef from cattle fed wet distillers grains

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STORY IN BRIEF

Two hundred and forty heifers were fed out at Oklahoma State University in Stillwater, OK in one of two treatment groups: A dry rolled corn (CON) diet or a diet including 30% wet distillers grains plus solubles (WDGS). Chuck rolls (n = 60) and paired strip loins (n =75 pairs) were collected from each treatment group and processed at 3 d and 14 d, respectively. After grinding, each chuck was separated into polyvinyl chloride film (PVC) overwrapped packages and high oxygen modified atmosphere packages (MAP) each containing approximately 1 lb of ground beef. After the aging period, one strip loin from each pair was injected with an enhancement solution. Steaks from each strip loin were fabricated and packaged, half PVC overwrap and half MAP, then evaluated for color, tenderness, and palatability. Color was evaluated subjectively using a trained color panel and objectively using a HunterLab Miniscan XE. Warner-Bratzler shear force was used for evaluation of tenderness and trained sensory panel was used to assess palatability. Stage of lipid oxidation was also observed. Sensory panelists did find MAP WDGS ground beef had less beefy flavor and more painty flavor intensities than the MAP CON ground beef. Cattle fed WDGS discolored more and had less bright steaks than cattle fed the CON when MAP and enhanced. Distillers fed, non-enhanced MAP steaks were redder and yellower than control steaks upon removal from simulated retail display. In sensory panels, WDGS, non-enhanced PVC products were juicier and more tender, initially, and contained less connective tissue than the steaks from CON carcasses. Essentially, MAP packaging, but not enhancing products, from cattle fed WDGS may be the best way to maintain a visually appealing appearance in the retail case, but at possible risk to product juiciness.

Key Words: beef heifers, wet distillers grains, color, palatability, enhancement, packaging

INTRODUCTION

In the last several years, there has been a large increase in fuel ethanol production (Klopfenstein et al., 2008) which has conversely led to an increase in processed by-products (Clemens et al., 2008). As a result, the utilization of distillers grains (DG) in beef cattle diets has become more popular. Research has begun to focus on the response of meat quality to the increasing usage of DG in finishing diets.

When evaluating meat quality, two major factors play critical roles in consumer decisions: color and tenderness (Grobbel et al., 2008). If color and palatability are negatively impacted by inclusion of DG, there are several post-harvest interventions that can be used to combat these effects. Two popular interventions in recent years have been increasingly utilized: modified atmosphere packaging (MAP) and enhancement injection solutions.

Modified atmosphere packaging is a technique that has been used for several years because of its ability to maintain color over a longer period of time in the retail case than more traditional oxygen permeable packaging methods. Likewise, enhancement solutions can be used to reduce variation in tenderness that is common in beef products (Hoffman et al., 2008) while having the distinct benefit of creating a more tender, juicy, and often flavorful product. In addition, enhancement can be effectively used to reduce variation that may result from using DG in cattle diets that were produced in different plants.

The first objective of this experiment was to determine the impact of using post-harvest interventions on the color stability of beef products from cattle that have been fed DG. Secondly, this experiment sought to determine the impact of these interventions on the palatability of beef steaks after they have been in retail display.

MATERIALS AND METHODS

Cattle and Treatments. Two hundred and forty heifers were fed at Oklahoma State University's Willard Sparks Beef Research Center in Stillwater, Oklahoma. The heifers were assigned to one of two treatment groups: dry rolled corn (CON), the control group; or 30 % wet distillers grains plus solubles (WDGS). Cattle were shipped to a commercial harvest facility for harvest and data collection.

Harvest and Data Collection. On the day of harvest, tag transfer was completed and hot carcass weights (HCW) were recorded (n = 236) and liver scores were collected. Complete carcass data were collected (n = 232): ribeye area (REA); marbling score at the 12^{th} and 13^{th} rib interface; kidney, pelvic, and heart (KPH) fat; fat thickness (FT); and maturity. Quality and Yield grades (QG/YG) were calculated according to these data.

Strip Loin and Chuck Collection. Approximately one half of the product collected was graded as USDA Choice while the other half was graded as USDA Select. A total of 60 chuck rolls were collected from the right side, 30 from the CON diet and 30 from the WDGS diet. A total of 75 pairs of strip loins were selected: 38 pairs of loins from the CON diet and 37 pairs from the WDGS diet. Product was vacuum packaged, boxed and immediately transported to the Oklahoma State University Robert M. Kerr Food and Agricultural Products Center (FAPC).

Sample Preparation. Chuck rolls were ground 3 d post harvest. Eight 1 lb samples of finely ground product were selected from each chuck. Four samples were placed in a styrofoam tray with a soaker pad and over-wrapped with a polyvinyl chloride (PVC) film. The other four samples were placed in plastic trays with a soaker pad and sealed in a high oxygen (HiO_2) modified atmosphere. A sample of ground product was collected from each chuck for fat analysis. Samples were powdered and analyzed via the Soxhlet extraction procedure.

After 14 d of aging one strip loin from each pair (n = 75 pairs) was injected with an enhancement solution (E). The other strip loin from the pair remained non-enhanced (NE). Each strip loin was faced at the anterior end and nine 1 inch steaks were subsequently cut and packaged. The face steak was vacuum packaged and frozen in a blast freezer (-20ºC) for further pre-display thiobarbituric acid reactive (TBAR) substance analysis. Two steaks each were identified for Warner-Bratzler shear force (WBSF) analysis, full retail display, for 3 d of retail display, and one steak for MAP 1 d display. The final two steaks were cut in half and packaged alongside the four steaks identified for 3 d retail display and full retail display for later TBAR analysis. Half of these steaks (one from each category) were placed in a styrofoam tray with a soaker pad and over-wrapped with a PVC film. The other half of the steaks were placed in plastic trays on a soaker pad and sealed in a HiO_2 MAP package. The MAP products were placed in dark storage for 5 d to simulate commercial transportation while the PVC products were immediately placed directly under retail lighting.

Color Evaluation. Products identified for retail display were placed in a coffin style display case. A six person panel of trained Oklahoma State University personnel evaluated color subjectively every 12 h in retail display. Panelists assigned scores to each package of ground beef (n = 240) for ground meat color and discoloration. Strip steaks (n = 296) were evaluated based on muscle color score, surface discoloration (% metmyoglobin), and overall acceptability. Since most retailers attempt to move steaks within 5 d, steaks were evaluated for 5 d then removed from the case. Product was then vacuum packaged and placed in the blast freezer for TBAR analysis, sensory analysis, or WBSF.

Objective color was evaluated by measuring each steak using a HunterLab Miniscan XE spectrophotometer to determine color coordinate values for 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). Objective evaluation for PVC packaged steaks was taken upon time of initial retail display, 1 d in retail, 3 d in retail, and at 5 d in retail. Steaks which were MAP were evaluated immediately prior to packaging, before being placed in the retail case (referred to as 1 d), at 3 d retail display, and at 5 d retail display.

Warner-Bratzler Shear Force. After display, as described above, steaks were vacuum packaged and frozen until further analysis. Steaks were then allowed to temper for 24 h prior to cooking. After cooking to an internal temperature of 70ºC, steaks were allowed to cool for 24 h before determining shear force values. After cooling, six cores from each steak were removed. Mean peak force (kg) of WBSF was then determined by averaging the six cores.

Sensory Evaluation. Steaks that remained in the retail case for 5 d were designated for sensory analysis. The sensory panel consisted of eight trained panelists. The panelists scored (AMSA, 1995) the steaks for initial and sustained juiciness, initial and overall tenderness, and connective tissue amount. Four flavor attributes were evaluated. These included beef flavor, painty/fishy, livery/metallic, and salty. Sensory samples for ground beef were formed into ¼ lb patties using a patty former, then cooked on the impingement oven as described above. Ground beef product was evaluated for three flavor profiles: beef flavor, painty/fishy flavor, and livery/metallic flavor.

Thiobarbituric Acid Reactive Substance (TBAR). Upon removal from the retail case, steaks identified for TBAR analysis were vacuum packaged and frozen in a blast freezer at -20ºC. Products were either designated as pre-display (collected when steaks were fabricated), 1 d (MAP only), 3 d, or 5 d samples. Lipid peroxidation was determined by a modified method of Buege and Aust (1978).

Statistical Analysis. The analysis of variance model (ANOVA) for WBSF, sensory, TBAR, and MAP packaged color attributes included treatment as the fixed effect, and strip identification number as random effect. Diet, enhancement and packaging method were treatment variables. The analysis of variance model for PVC samples for subjective and objective color attributes were analyzed using time as a repeated measure, sample as the subject, and treatment as the fixed effect. The ANOVA model for ground beef was set up in the same manner as the steaks for analysis of sensory, TBAR, and subjective color attributes with diet and packaging method as treatment variables. When the model was significant (α=0.05), least square means was computed and statistically separated using the pair-wise t-test (PDIFF option of SAS).

RESULTS AND DISCUSSION

Carcass Data. . No significant differences were found in the carcass data from this project. However, ***c***arcasses from cattle fed the WDGS diet tended (P = 0.09) to have a higher HCW than cattle fed the CON diet and cattle fed the CON diet exhibited a tendency (P = 0.07) to have higher marbling scores than cattle fed the WDGS diet. Al-Suwaiegh et al. (2002) found that HCW, FT, and YG were all higher in cattle fed wet distillers grain at the inclusion level of 30% than cattle fed dry rolled corn, but there were no differences between treatments in dressing percentage (DP), loin muscle area (LMA) and marbling score.

Color Evaluation. Upon removal of steaks from the case at 120 h, only 13% of the steaks were deemed moderately undesirable or less. At this time, no differences were found in muscle color and overall acceptability. When observing package by enhancement interactions, in the enhanced MAP steaks cattle fed the WDGS diet discolored more (P = 0.01) than cattle fed the CON diet. Gill et al. (2008) conducted a study in which results yielded no differences in visual appearance, but objective evaluation revealed that cattle fed DG in the diet (either sorghum or corn, 15% inclusion) yielded steaks which were brighter, but less red overall than steaks from cattle fed simply steam flaked corn (SFC).

Ground beef was on average 81.29% lean and there were no differences in percent lean of CON product and WDGS product. Upon removal from the case at 120 h, only 11% of ground beef products exhibited greater than small discoloration (20-39%). There were no differences in ground meat color or discoloration of ground beef.

Instrumental analysis of packaged strip steak color at 120 h revealed no significant differences for L*, a*, and b* values of PVC steaks. Analysis of MAP steaks revealed enhancement had a significant effect d 5; MAP E CON steaks were significantly brighter than MAP E WDGS steaks. Likewise, MAP NE WDGS were more red and more yellow than MAP NE CON steaks A study by Gill et al. (2008) found that steaks from cattle fed distillers grains in the diet were brighter, but less red then steaks from cattle fed a normal SFC diet. The use of MAP may have been the reason that steaks were significantly redder, unlike in the study by Gill et al. (2008).

Tenderness and Sensory Evaluations. The packaging x enhancement interaction for WBSF indicated no differences in product from the CON and WDGS diets. Gill et al. (2008) also found no differences in instrumental tenderness when comparing a SFC diet to a diet containing 15% DG. Sensory panel findings indicated that there were some significant differences between dietary treatments in packaging x enhancement interactions for juiciness and tenderness. Table 1 shows distillers products were ranked higher for initial juiciness than CON diet within the NE

PVC products (P = 0.03). Products derived from the CON diet carcasses had a higher sustained juiciness than other treatments in the NE MAP grouping (P = 0.04). Non-enhanced WDGS steaks which had been PVC packaged were initially and overall more tender then CON steaks and contained less connective tissue. Results indicated that there were no significant interactions in flavor intensities. In consumer panels in a study by Roeber et al. (2005), steaks from steers fed at 25% wet distillers grains received the highest numerical tenderness and juiciness. Steaks from steers fed 50% wet distillers grains received the lowest numerical tenderness and juiciness scores. This may indicate that a 25% inclusion rate is the threshold. Roeber et al. (2005) also reported that flavor ratings did not differ among treatments.

Table 1. Least squares means ± SEM for sensory juiciness ratings of strip steaks (n =296) by post-harvest interventions stratified by dietary treatments

Post-Harvest Interventions[1]	Treatment[2]	Initial Juiciness[3]	P > F	Sustained Juiciness[3]	P > F
Enhanced MAP	Control	5.39 ± 0.07	0.24	5.17 ± 0.08	0.17
	30 % WDGS	5.51 ± 0.07		5.32 ± 0.08	
Enhanced PVC	Control	5.83 ± 0.05	0.17	5.63 ± 0.05	0.75
	30 % WDGS	5.93 ± 0.05		5.65 ± 0.05	
Non-enhanced MAP	Control	4.77 ± 0.08	0.10	4.51[a] ± 0.09	0.04
	30 % WDGS	4.58 ± 0.08		4.26[b] ± 0.09	
Non-enhanced PVC	Control	5.06[a] ± 0.07	0.03	4.74 ± 0.08	0.12
	30 % WDGS	5.30[b] ± 0.07		4.91 ± 0.07	

[a, b] LS means with different letters, within the same post-harvest intervention and in the same column, are different (P < 0.05)
[1]Interventions: MAP = modified atmosphere packaging, PVC = polyvinyl chloride overwrap
[2]Treatment: Control = dry rolled corn diet, WDGS = wet distillers grains plus solubles
[3]Juiciness: 1= extremely dry, 8 = extremely juicy

Sensory panelists ranked WDGS MAP ground beef as having less beefy and more painty flavor intensities than CON MAP products . Zakrys et al. (2009) found that oxidation flavors increased in high oxygen packed samples. Consumer panelists found products packed under 50% O_2 to be the most acceptable, followed by samples packed under 80% O_2 (Zakrys et al., 2009). Zakrys et al. (2009) suggested that this may be due to adaptation to or familiarity with oxidized flavors by panelists. No interactions were found among livery flavors in the current study.

Thiobarbituric Acid Reactive Substance Analysis. On d 5 of retail display of MAP steaks, NE product from the WDGS diet cattle were more oxidized than the product from the CON group. All other treatments showed no significant differences in oxidation effects. Ground beef products showed no differences in TBAR concentrations for either MAP or PVC packaged items. In the previously mentioned study by Gill et al. (2008), TBAR concentrations also indicated that diet (SFC vs. 15% DG) had no effect on lipid oxidation. All TBAR values in this study were well below the threshold reported by Campo et al. (2006) at which consumers stopped accepting oxidation flavors in beef.

Implications. Based on the results of this study, feeding distillers grains will not have an effect on carcass characteristics. Results indicated that MAP packaging, but not enhancing, products from cattle fed WDGS may be the best way to maintain a visually appealing appearance in the retail case, but at a possible risk to product juiciness. If enhanced and MAP packaged, the distillers product does not seem to maintain visual appearance in the retail case like the control product. Visual appearance of ground beef seemed to be positively impacted by using the MAP method of packaging, but the product tasted more oxidized and less beefy to panelists. Further research is needed to pin point the best combination of post-harvest interventions to preserve color and palatability in beef from cattle fed WDGS.

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