

---

# Utilization of corn- and soy coproducts in feedlot diets, and evaluation of environmental factors contributing to the prevalence of *E.coli* 0157:H7shedding



---

**February 2016**

---

**By:**

M.A. Nelson, J. Johnston, G.I. Crawford, R.B. Cox and A.DiCostanzo

**Partners:**

Minnesota Corn

University of Minnesota

---

## **ABSTRACT**

The impact of using corn or soybean coproducts in high or low corn grain finishing diets of feedlot heifers was evaluated using forty-four purebred Limousin heifers. Heifers were randomly assigned to one of four dietary treatments (11 per treatment) resulting from a nested design with factors being dry rolled corn grain inclusion, main plot: 25% or 65% of diet dry matter, where nested treatments were soy (15% of diet dry matter derived from soy glycerin and soybean high-fiber coproduct) or corn coproduct (20% to 60% modified distillers grains with solubles) inclusion. Heifers were fed finishing diets for 129 d and were humanely harvested at a commercial facility. Soy coproduct inclusion in high-corn grain ( $P < 0.05$ ) but not in low-corn grain ( $P > 0.10$ ) diets led to lower ( $P < 0.05$ ) DMI, ADG and feed efficiency. Inclusion of modified distillers grains at concentrations equal to or greater than 40% of diet DM led to greater ( $P < 0.05$ ) DMI but numerically lower ADG which resulted in poorer ( $P < 0.05$ ) feed conversion efficiency. There was no treatment effect for HCW ( $P = 0.37$ ), BF ( $P = 0.10$ ), REA ( $P = 0.50$ ), KPH ( $P = 0.67$ ), or marbling score ( $P = 0.18$ ). Drip loss did not differ among treatments ( $P = 0.44$ ). At high corn grain inclusion, utilizing soy coproducts resulted in lower ( $P < 0.05$ ; more desirable) Warner–Bratzler shear force values of steaks. Treatment did not affect subjective scores for lean color ( $P = 0.06$ ), surface discoloration ( $P = 0.19$ ), and overall appearance ( $P = 0.52$ ) or objective scores for L\* ( $P = 0.32$ ), a\* ( $P = 0.49$ ), and b\* ( $P = 0.30$ ) of steaks. Treatment did not affect overall liking ( $P = 0.59$ ), flavor liking ( $P = 0.78$ ), texture liking ( $P = 0.38$ ), juiciness ( $P = 0.56$ ), or off flavor ( $P = 0.89$ ) of steaks. Subjective toughness ratings of steaks from heifers fed MDGS in high-corn grain diets were higher ( $P < 0.05$ ) than those from heifers fed MDGS in low-corn grain diets. Ground beef L\* values from heifers fed 25% low-corn grain diets were higher than those from heifers fed high-corn grain diets ( $P < 0.01$ ). Treatment had no effect on a\* ( $P = 0.44$ ) or b\* ( $P = 0.63$ ) in ground beef. Ground beef from heifers fed soy coproducts in a high-grain diet had the greatest ( $P < 0.05$ ) surface discoloration and last ( $P < 0.05$ ) desirable appearance. Treatment did not affect lean color ( $P = 1.00$ ) or overall appearance ( $P = 1.00$ ) subjective mean values or a\* ( $P = 0.88$ ) or b\* ( $P = 0.82$ ) in bologna. LO+MDGS had a higher mean subjective surface discoloration value (9.38) and L\* (55.22) compared to all other dietary treatments ( $P < 0.01$  and  $< 0.01$ , respectively) in bologna. Treatment did not affect TBARS but did effect C15:0 ( $P = 0.05$ ) and 9c,12c,15c-C18:3 ( $P = 0.04$ ) fatty acid levels. All other fatty acids and calculated iodine value were not influenced by treatment. Results indicate feeding 40% MDGS had no effect on carcass traits and fresh meat quality. However, feeding 60% MDGS detrimentally affected processed meat quality, but 15.2% soy coproduct inclusion decreased these negative effects.

## **INTRODUCTION**

Ethanol production in the United States increased from 3 billion gallons in 2003 to 13 billion gallons in 2013 (Renewable Fuels Association, 2014). Increasingly high amounts of corn coproducts are being utilized in feedlot feeds due to the high level of protein availability and economics.

Modified distillers grains (MDGS) is one corn coproduct producers can utilize in feeding systems. It contains roughly 28-30% crude protein, 50% water, and 126% total digestible nutrients (Lardy and Anderson). Feeding 50% MDGS to steers has been shown to increase their neutral detergent fiber digestibility ( $p < 0.01$ ) and decrease cost of gain ( $P < 0.01$ ) (Schroeder et al., 2014). When feeding MDGS, producers need to keep in mind that the shelf life is two to three weeks in cold seasons and less than one week in warmer seasons or climates (Lardy and Anderson).

Soybean coproducts such as soybean hulls are high in energy, provided by the hemicellulose, and low in protein (Lardy and Anderson). The total digestible nutrients is 80% and 12.4% crude protein (Lardy and Anderson).

Soy glycerin is another soybean coproduct that results from the production of biodiesel that contains an energy value very similar to corn and a dry matter percent of 85 (Lardy and Anderson). Lardy and Anderson reported that 10% of the initial weight of oil or fat entering biodiesel production will end up as crude glycerol. The total digestible nutrient in glycerol is 89.0%.

While the impact of feeding MDGS, soybean hulls, and soy glycerin has been evaluated, the combined impact of corn and soy coproduct has not. The objective of this study was to evaluate the effects of varying corn and soybean coproduct inclusion feeding strategy on carcass characteristics and meat quality in feedlot heifers.

Also, in spite of some recent findings from our laboratory demonstrating no relationship between using distillers grains with solubles and incidence of *E. coli* O157:H7, feeding distillers grains with solubles continues to be implicated with greater incidence of *E. coli* O157:H7 shedding. Proposing the current study, presented an opportunity to add additional data on this relationship.

Based on previous research conducted, we hypothesized treatment will have no effect on carcass characteristics or fresh beef quality but could detrimentally effect processed beef quality. Further, we hypothesized that feeding distillers grains with solubles has no impact on fecal shedding of *E. coli* O157:H7.

## **Materials and Methods**

Forty-four heifers (initial body weight = 943 lb) were utilized to determine the effect of feeding distillers grains with solubles, soy hulls and soy glycerin on live animal performance and carcass

characteristics. We sought unsuccessfully to find groups of cattle that would continuously shed *E. coli* O157:H7. Candidate heifers were under surveillance of *E. coli* O157:H7 at the farm of origin; yet, incidence of *E. coli* O157:H7 was under 10% and it declined to zero after 14 days. A similar trend was observed in previous studies.

Heifers were individually fed using a Calan gate individual feeding system. A nested design experiment was utilized with factors being dry rolled corn grain inclusion, main plot: 25% or 65% of diet dry matter, nested treatments were soy (15% of diet dry matter derived from soy glycerin and soybean high-fiber coproduct) or corn coproduct (20% to 60% modified distillers grains with solubles; Table 1) inclusion. Heifers were fed once daily at 0800 h, and weighed every 28 days during the experiment. After a 21-day step-up period, heifers were fed ad-libitum for the remainder of the experiment. Samples of each diet and individual ingredients were collected weekly and composited by weigh period for analyses of dry matter, organic matter, starch, crude protein, neutral detergent fiber, and ether extract. Feed refusals will be collected and recorded daily to determine dry matter intake.

Heifers were harvested at a commercial packing facility after 129 d on feed. Heifers were humanely harvested at an abattoir in Dakota City, NE (Tyson, Inc.). Hot carcass weight (HCW); 12th rib back fat (BF); rib eye area (REA); percent kidney, heart, and pelvic fat (KPH); and marbling score were collected 48 hours postmortem by trained plant personnel. Strip loins (IMPS #180) and shoulder clods (IMPS # 114) were collected from the right side of each carcass, labeled, vacuum packaged, and transported under refrigerated conditions to the University of Minnesota Meat Laboratory.

#### *Strip Loins*

Seven 1-inch steaks were serially cut from the anterior end of each strip loin for drip loss percentage, retail shelf life color analysis, and Warner-Bratzler shear force analysis. One 1-inch strip steak was weighed, suspended at 2.2°C for 24 hours in an isolated environment. Steaks were reweighed to calculate drip loss percentage (drip loss percentage = (final weight/initial weight) \* 100).

Two 1-inch strip steaks were placed on trays; wrapped in polyvinylchloride overwrap; and stored at 2.2°C for 7 days under cool white fluorescent lighting (Sylvania H968, 100w).

Subjective color scores of lean color, surface discoloration, and overall appearance were evaluated by an eight member trained panel. Lean color was evaluated on a 1-8 scale with 1 = extremely brown and 8 = extremely bright, cherry red. Surface discoloration was evaluated on a 1-11 scale with 1 = 91-100% discoloration and 11 = 0% discoloration. Overall appearance was evaluated on a 1-8 scale with 1 = extremely undesirable and 8 = extremely desirable.

Objective color scores of L\*, a\*, and b\* were evaluated the same day subjective color scores were obtained. Measurements were recorded using a spectrophotometry (HunterLab Miniscan ES, Hunter Associates Laboratory Inc., Reston, VA). L\* was evaluated on a 0-100 scale with 0 =

black and 100 = white; a\* was evaluated on a -100-100 scale with -100 = green and 100 = red; and b\* was evaluated on a -100-100 scale with -100 = blue and 100 = yellow.

Two 1-inch strip steaks were cooked using a standard electric kitchen oven (Fridgidaire, General Motors, USA) to an internal temperature of 71°C at the geometric center. Strip steaks were tempered to room temperature (22.2°C) and stored for further analysis at 2.2°C. Cores were removed from refrigerated conditions two hours prior to analysis and tempered to room temperature (22.2°C). Six maximum force readings per strip steak were recorded for Warner–Bratzler shear force values and averages were reported.

One-inch strip steaks were cooked to an internal temperature of 71°C at the geometric center using a standard electrical oven (Fridgidaire, General Motors, USA). After reaching an internal temperature of 71°C at the geometric center, steaks were removed from the oven and immediately cut into 1 x 1 x 2.54 cm cubes. Cubes were placed in double broilers until served to panelists (n = 122). Each panelist received two samples per dietary treatment in lidded 2 oz. plastic cups. Panelists were 18+ years, with no food allergies, consumed beef at least twice a month, and were compensated for participating. Panelists were asked to taste one sample piece and rate it for overall liking, flavor liking, and texture liking on a magnitude scale. Panelists were then asked to taste the second sample piece and rate it for intensity of off flavor, juiciness, and toughness on line scales.

#### *Shoulder Clods*

Shoulder clods were ground individually twice with a 0.375 cm grinder plate. Two pounds of ground beef were placed on trays and overwrapped with PVC, placed under fluorescent lighting, and stored at 2.2°C for 14 days. Subjective and objective color scores were evaluated every other day using the same scales and methods as strip steak subjective and objective color analysis.

Samples of ground beef on day 0 and day 14 were collected for thiobarbituric acid reactive substances (TBARS) analysis. Samples were vacuum packaged, frozen immediately, analyzed using the thiobarbituric acid assay developed by Tarlagid et al., and measured using a spectrophotometer (Spectronnic 20<sup>+</sup>, Spectronic Instruments, Inc., 532 nm). Analysis of TBARS was done at Agricultural Utilization Research Institute (AURI) located in Marshall, Minnesota, USA.

Blended meat blocks (11.34 kg, 3 animals/treatment, 2 blocks/treatment) were utilized to make an emulsified bologna product. Ground beef was chopped mixed with a commercial seasoning blend and ice for four minutes; stuffed in inedible collagen casings; and cooked and cooled according to Appendix A and B. Once cooled, three 0.375 cm slices were collected per log, placed on trays, and vacuum-sealed. Slices were placed under fluorescent lighting and stored at 2.2°C for 14 days. Subjective and objective color score were evaluated every other day. Subjective color scores were obtained by an 8-member trained panel with lean color evaluated on a 1-8 scale with 1 = extremely brown and 8 = extremely bright, pink. Surface discoloration

was evaluated on a 1-11 scale with 1 = 91-100% discoloration and 11 = 0% discoloration. Overall appearance was evaluated on a 1-8 scale with 1 = extremely undesirable and 8 = extremely desirable. Objective color analysis was obtained using the same methods as loin steaks and ground beef samples.

Bologna slices (0.375 cm) were served to panelists (n = 108) for sensory attribute evaluation. Panelists were 18+ years, with no food allergies, consumed bologna within the last six months, and were compensated for participating. Two samples per dietary treatment were served to each panelist at 2.2°C in lidded 2 oz. plastic cups. Subjects were asked to taste one sample piece and rate it for overall liking, flavor liking, and texture liking on a magnitude scale. Subjects were asked to taste the second sample piece and rate it for intensity of off flavor and toughness on line scales.

### *Backfat*

Ten grams of backfat was collected from each strip steak utilized for Warner-Bratzler shear force analysis. Objective color scores of L\*, a\*, and b\* were obtained using a spectrophotometer (HunterLab Miniscan ES, Hunter Associates Laboratory Inc., Reston, VA). L\* was evaluated on a 0-100 scale with 0 = black and 100 = white; a\* was evaluated on a -100-100 scale with -100 = green and 100 = red; and b\* was evaluated on a -100-100 scale with -100 = blue and 100 = yellow. Samples were then vacuum packaged per animal and stored frozen until fatty acid analysis.

Gas chromatography (HP 6890 series, Santa Clara, CA) with flame ionization detection was used to obtain fatty acid profiles. Total content of myristic (C14:0), pentadecanoic (C15:0), palmitic (C16:0), heptadecanoic (C17:0), stearic (C18:0), nonadecanoic (C19:0), eicosanoic (C20:0), tetradecenoic (9c-C14:1), palmitoleic (9c-C16:1), oleic (6t-C18:1), vaccenic (11t-C18:1), petroselinic (6c-C18:1), oleic (9c-C18:1), vaccenic (11c-C18:1), nonadecenoic (10c-C19:1), linoleic (9c,12c-C18:2), nonadecanoic (10c,13c-C19:2) and alpha linolenic (9c,12c,15c-C18:3) acid were recorded. The fatty acid profile was used to calculate the iodine value. Fatty acid analysis occurred at AURI in Marshall, Minnesota, USA.

### *Data Analysis*

Heifers were used as experimental units for data analysis. The effect of treatment on response variables was determined by analysis of variance for a nested design using the Mixed procedure of SAS (SAS Inst. Inc., Cary, NC). Pairwise comparisons were made using the LSMEANS function of SAS, with significance considered at  $P < 0.05$ .

Continuous data was analyzed using the MIXED procedure in SAS (SAS Inst. Inc., Cary, NC) while categorical data was analyzed using the GLM procedure in SAS. Continuous data included ADG, DMI, final BW and feed efficiency (analyzed as gain achieved per lb feed), HCW, BF, REA, marbling score, drip loss, L\*, a\*, b\*, maximum force, overall liking, flavor liking, texture liking, off flavor, juiciness, toughness, TBARS, and calculated iodine values. Categorical data included

KPH, lean color, surface discoloration, overall appearance, and fatty acid. Experimental unit was individual heifer, as all animals were fed individually using a Calan gate system. Response variables evaluated included carcass characteristics and fresh meat quality characteristics. The following outliers were removed from the dataset: one HI+SOY REA value; drip loss from one HI+SOY and one LO+MDGS+SOY steak; one HI+MDGS a\* value and one HI+MDGS b\* value on Day 0 of steak retail shelf life; one HI+SOY and one HI+MDGS a\* value and one HI+SOY b\* value on Day 1 of steak retail shelf life; one LO+MDGS b\* value for Day 3 steak retail shelf life; one HI+MDGS and one LO+MDGS a\* value and one LO+MDGS b\* value on Day 4 steak retail shelf life; one HI+SOY L\* value on Day 5 steak retail shelf life; one LO+MDGS+SOY L\* value, one HI+MDGS a\* value, and one HI+MDGS b\* value on Day 6 steak retail shelf life. One HI+SOY L\*, three LO+MDGS+SOY a\*, and one HI+SOY a\* were all removed from Day 0 ground retail shelf life. One LO+MDGS a\* value from Day 4 ground retail shelf life; one LO+MDGS L\* value on Day 8 ground retail shelf life; one LO+MDGS+SOY L\* and one LO+MDGS+SOY b\* value from Day 10 ground retail shelf life; one HI+MDGS L\*, one HI+SOY and one LO+MDGS a\*, and one HI+SOY and LO+MDGS from Day 6 ground retail shelf life were all removed. Outliers on Day 7 ground retail shelf life included one LO+MDGS L\*, two HI+SOY b\*, and one LO+MDGS b\* values. One LO+MDGS+SOY L\* value was removed on Day 0 bologna retail shelf life. Day 2 bologna retail shelf life has two outliers, one LO+MDGS and one HI+MDGS a\* values. One HI+SOY L\* and one HI+MDGS a\* value was removed from Day 10 bologna retail shelf life. One HI+MDGS L\*, a\*, and b\* values were removed from Day 15 bologna retail shelf life.

**Table 1.** Experimental Diets

Ingredients (% DM)	Treatment <sup>1</sup>			
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY
Alfalfa Silage Wilted	9.8	9.1	9.8	9.1
Corn Grain, Rolled	65.0	65.0	25.0	25.0
RumaPro	0.0	8.0	0.0	8.0
QLF CoreMax 20 R600	2.5	0.0	2.5	0.0
QLF H.8 MGA	2.0	2.5	2.0	2.5
QLF UM Energy Bal 9 Custom	0.0	15.2	0.0	15.2
Distiller Grain, Corn, Modified	20.0	0.0	60.0	40.0
Kemin	0.3	0.3	0.3	0.3

<sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY).

## **RESULTS AND DISCUSSION**

Surveillance of candidate cattle to participate in this study for incidence of *E. coli* O157:H7 demonstrated that shedding occurred for only 14 days after which shedding stopped. This observation was made previously by the authors in cattle that were received at Rosemount Beef Unit. Even when cattle were experimentally infected with a strain of *E. coli* O157:H7, shedding was reduced to zero after 14 d. Therefore, we concluded that, at least in northern latitudes, prevalence of *E. coli* O157:H7 in finishing cattle is not related to feeding distillers grains with solubles and, likely other factors are associated with its occurrence and lack of prevalence after 14 days on feed.

Soy coproduct inclusion in high-corn grain ( $P < 0.05$ ) but not in low-corn grain ( $P > 0.10$ ) diets led to lower ( $P < 0.05$ ) DMI, ADG and feed efficiency (Table 3). Inclusion of modified distillers grains at concentrations equal to or greater than 40% of diet DM led to greater ( $P < 0.05$ ) DMI but numerically lower ADG which resulted in poorer ( $P < 0.05$ ) feed conversion efficiency (Table 3).

There was no treatment effect for HCW ( $P = 0.37$ ), BF ( $P = 0.10$ ), REA ( $P = 0.50$ ), KPH ( $P = 0.67$ ), or marbling score ( $P = 0.18$ ) (Table 2). These results are supported by previous research that concluded feeding 50% MDGS in finishing feedlot diets had no effect on rib eye marbling (Mello et al., 2015). Bittner et al., 2013, concluded that feeding 0, 12.5, 25, and 37.5% soybean hulls had no effect on marbling score ( $P=0.07$ ), rib eye area ( $P=0.54$ ), or 12<sup>th</sup> rib back fat ( $P=0.78$ ); however, it should be noted that increasing levels of soybean decreased dry matter intake ( $P=0.04$ ) and average daily gain ( $P<0.01$ ) in feedlot steers. Mueller and Boggs, 2011, reported that soy glycerin can be utilized up to 18% in feedlot cattle diets without negative carcass traits. McClelland, 2013, reported that feeding soybean glycerin at 10% does not affect feedlot cattle performance when compared with corn-based diets with no soy glycerin.



**Table 3.** Effects of experimental treatment on hot carcass characteristics in feedlot heifers

Carcass Traits	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-Value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
HCW, kg	394.85	381.88	406.09	384.65	10.50	0.37
BF, cm	0.98	0.89	1.36	1.10	0.13	0.10
REA, sq cm	119.35	118.21	115.31	113.20	3.17	0.50
KPH, %	2.36	2.20	2.27	2.27	0.09	0.67
Marbling score <sup>4</sup>	4.63	4.87	4.95	5.21	0.19	0.18

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at  $P \leq 0.05$ . <sup>4</sup>Marbling scores: 4.00=slight, 5.00=small.

Drip loss did not differ among treatments ( $P = 0.44$ ) (Table 3). Warner–Bratzler shear force values of steaks from HI+SOY were lower (3.17 kg) than LO+MDGS+SOY (3.79 kg;  $P = 0.03$ ) (Table 3). McCelland, 2013, reported a decrease in Warner Bratzler shear force values with feeding 10% crude glycerin and 35% MDGS ( $P = 0.03$ ) and no difference in Warner Bratzler shear force with the addition of glycerin to feedlot diets ( $P = 0.16$ ).

**Table 4.** Effects of experimental treatment on drip loss and shear force in feedlot heifers

Characteristic	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
Drip loss, %	1.82	2.63	2.05	1.50	0.46	0.44
WBSF, kg	3.53 <sup>a,b</sup>	3.17 <sup>a</sup>	3.35 <sup>a,b</sup>	3.79 <sup>b</sup>	0.15	0.03

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05.

Treatment did not affect subjective scores for lean color (P = 0.06), surface discoloration (P = 0.19), and overall appearance (P = 0.52) or objective scores for L\* (P = 0.32), a\* (P = 0.49), and b\* (P = 0.30) of steaks over 7 day retail shelf life (Table 4). Tables 5 – 12 illustrate the differences in subjective and objective color scores of strip steaks, per day, over the 7 days retail shelf life.

**Table 5.** Objective and subjective color scores for strip steaks from feedlot heifers over Day 0 – Day 7 retail shelf life

Color Scores	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	29.36	29.67	30.68	30.49	0.62	0.32
a*	11.24	10.55	10.63	11.44	0.48	0.49
b*	13.45	12.99	12.94	13.57	0.28	0.30
Lean color <sup>4</sup>	5.07	5.08	4.69	4.70	1.40	0.06
Surface Discoloration <sup>5</sup>	7.36	7.53	7.04	6.98	1.89	0.19
Overall appearance <sup>6</sup>	4.73	4.74	4.52	4.54	1.53	0.52

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 6.** Objective and subjective color scores for strip steaks from feedlot heifers on Day 0 retail shelf life

Color Scores – Day 0	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	26.71	26.73	27.00	26.59	1.03	0.99
a*	11.84	11.40	12.56	13.39	0.71	0.27
b*	12.76	13.39	14.03	14.42	0.59	0.22
Lean color <sup>4</sup>	7.10	7.14	7.02	7.10	0.86	0.87
Surface Discoloration <sup>5</sup>	10.99	10.92	11.00	11.00	0.53	0.44
Overall appearance <sup>6</sup>	7.71	7.59	7.69	7.71	0.78	0.71

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 7.** Objective and subjective color scores for strip steaks from feedlot heifers on Day 1 retail shelf life

Color Scores – Day 1	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	29.27	28.96	31.06	29.55	0.89	0.37
a*	10.50	10.95	10.92	11.22	0.58	0.83
b*	11.94	12.09	12.17	12.00	0.34	0.96
Lean color <sup>4</sup>	6.52	6.54	6.31	6.63	0.91	0.46
Surface Discoloration <sup>5</sup>	7.92	8.11	7.8	8.03	1.94	0.99
Overall appearance <sup>6</sup>	6.58	6.64	6.71	6.75	0.90	0.83

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 8.** Objective and subjective color scores from strip steaks from feedlot heifers on Day 2 retail shelf life

Color Scores – Day 2	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	20.68	21.83	22.59	22.66	1.17	0.56
a*	18.46	16.31	16.31	18.27	1.22	0.41
b*	16.64	15.55	15.08	17.12	0.76	0.24
Lean color <sup>4</sup>	5.80	6.11	5.46	5.90	1.08	0.13
Surface Discoloration <sup>5</sup>	8.98	9.11	8.69	9.00	1.20	0.64
Overall appearance <sup>6</sup>	6.02	6.09	5.91	6.07	0.94	0.86

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 9.** Objective and subjective color scores from strip steaks from feedlot heifers on Day 3 retail shelf life

Color Scores – Day 3	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	31.13	30.94	31.07	32.82	0.83	0.41
a*	11.63	11.04	11.39	11.68	0.42	0.70
b*	13.57	12.79	13.37	13.60	0.31	0.25
Lean color <sup>4</sup>	5.4 <sup>a</sup>	5.37 <sup>a,b</sup>	4.84 <sup>b</sup>	5.09 <sup>a,b</sup>	1.07	0.04
Surface Discoloration <sup>5</sup>	8.90	9.08	8.41	8.93	1.34	0.28
Overall appearance <sup>6</sup>	5.04	5.16	4.82	5.02	1.12	0.58

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 10.** Objective and subjective color scores from strip steaks from feedlot heifers on Day 4 retail shelf life

Color Scores – Day 4	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	32.69	32.57	32.51	32.12	1.09	0.99
a*	11.55	10.13	11.68	11.75	0.43	0.08
b*	13.86	12.63	13.04	13.59	0.55	0.36
Lean color <sup>4</sup>	4.46	4.43	3.86	3.83	1.16	0.07
Surface Discoloration <sup>5</sup>	6.68	6.86	6.26	6.57	1.70	0.84
Overall appearance <sup>6</sup>	3.92	3.83	3.43	3.50	1.22	0.38

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 11.** Objective and subjective color scores from strip steaks from feedlot heifers on Day 5 retail shelf life

Color Scores – Day 5	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	33.40	34.53	35.95	34.60	1.01	0.31
a*	10.96	10.42	9.53	10.90	0.63	0.36
b*	14.33	13.87	13.07	13.91	0.45	0.25
Lean color <sup>4</sup>	3.84 <sup>a</sup>	3.71 <sup>a,b</sup>	3.33 <sup>a,b</sup>	3.07 <sup>b</sup>	1.18	0.02
Surface Discoloration <sup>5</sup>	5.32	5.43	4.78	4.40	1.72	0.29
Overall appearance <sup>6</sup>	2.90 <sup>a</sup>	2.82 <sup>a,b</sup>	2.37 <sup>a,b</sup>	2.26 <sup>b</sup>	1.14	0.03

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 12.** Objective and subjective color scores from strip steaks from feedlot heifers on Day 6 retail shelf life

Color Scores – Day 6	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	31.22	30.38	32.91	32.30	1.04	0.34
a*	8.37	8.24	7.54	8.71	0.64	0.65
b*	14.43	13.51	13.08	13.73	0.42	0.14
Lean color <sup>4</sup>	2.80 <sup>a</sup>	2.78 <sup>a</sup>	2.49 <sup>a,b</sup>	1.93 <sup>b</sup>	1.20	0.01
Surface Discoloration <sup>5</sup>	3.17 <sup>a</sup>	3.55 <sup>a</sup>	2.71 <sup>a,b</sup>	1.67 <sup>b</sup>	1.58	<0.01
Overall appearance <sup>6</sup>	1.86	1.90	1.76	1.57	0.95	0.30

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 13.** Objective and subjective color scores from strip steaks from feedlot heifers on Day 7 retail shelf life

Color Scores – Day 7	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	29.80	32.12	32.33	33.58	1.11	0.10
a*	6.33	5.93	5.24	5.62	0.61	0.60
b*	10.10	9.98	9.79	10.19	0.46	0.94
Lean color <sup>4</sup>	3.20	3.14	2.49	1.83	1.29	0.37
Surface Discoloration <sup>5</sup>	4.00	4.86	2.43	1.33	1.76	0.18
Overall appearance <sup>6</sup>	1.80	2.00	2.29	1.00	0.92	0.14

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

Treatment did not affect overall liking (P = 0.59), flavor liking (P = 0.78), texture liking (P = 0.38), juiciness (P = 0.56), or off flavor (P = 0.89) of steaks (Table 13). Subjective toughness ratings of steaks from HI+MDGS were higher than LO+MDGS (10.54 and 9.11 respectively; P = 0.02) (Table 13). The subjective toughness results are different when compared to Warner Bratzler Shear Force analysis. We do not know what to attribute this difference to since the diet should not have altered the protein, collagen, or calcium content of the meat therefore there should have been no difference observed in toughness. Future studies should be conducted to determine if the difference was due to experimental diet or confounding factors.

**Table 14.** Effects of experimental treatments on sensory attributes in cooked strip steaks from feedlot heifers

Sensory Attributes	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
Overall Liking <sup>4</sup>	70.91	72.46	74.00	73.14	1.63	0.59
Flavor Liking <sup>4</sup>	72.09	72.37	73.84	71.39	1.71	0.78
Texture Liking <sup>4</sup>	65.80	69.21	69.92	69.69	1.89	0.38
Toughness <sup>5</sup>	10.54 <sup>a</sup>	9.17 <sup>ab</sup>	9.11 <sup>b</sup>	9.59 <sup>ab</sup>	0.39	0.04
Juiciness <sup>5</sup>	7.41	7.96	7.88	8.17	0.39	0.56
Off Flavor <sup>5</sup>	4.14	4.40	4.36	4.60	0.41	0.89

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Liking ratings were on a 120 point labeled affective magnitude scales, with the left most end labeled *strongest dislike imaginable* and the right most end labeled *strongest like imaginable*. <sup>5</sup>Intensity ratings were on a 20 point line scale with the left most ends labeled *none* and the right most ends labeled *extremely tough*, *extremely juicy*, and *extremely intense*.

L\* values for 25% corn diets were higher than 65% corn diets (P < 0.01) in ground beef (Table 14). Treatment did affect surface discoloration (P = 0.01) in ground beef, with HI+SOY having the highest subjective value (6.21) (Table 14). Treatment did have an effect on overall appearance (P = <.01) in ground beef, with HI+SOY having the highest mean subjective value (4.20) (Table 14). Treatment had no effect on a\* (P = 0.44) or b\* (P = 0.63) in ground beef (Table 14). Tables 15 – 22 show the objective and subjective color scores for ground beef daily, throughout the 14 day retail shelf life.

**Table 15.** Objective and subjective color scores for ground beef from feedlot heifers over Day 0 – Day 14 retail shelf life

Color Scores – Day 0 – Day 14	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	45.23 <sup>a</sup>	45.41 <sup>a</sup>	48.29 <sup>b</sup>	47.07 <sup>c</sup>	0.32	<0.01
a*	8.34	8.58	8.02	7.77	0.37	0.44
b*	14.46	14.77	14.58	14.56	0.17	0.63
Lean color <sup>4</sup>	3.88 <sup>abc</sup>	4.21 <sup>a</sup>	3.64 <sup>b</sup>	3.56 <sup>c</sup>	1.55	<0.01
Surface discoloration <sup>5</sup>	5.67 <sup>abc</sup>	6.20 <sup>a</sup>	5.36 <sup>b</sup>	5.47 <sup>c</sup>	1.95	0.01
Overall appearance <sup>6</sup>	3.79 <sup>abc</sup>	4.21 <sup>a</sup>	3.56 <sup>b</sup>	3.64 <sup>c</sup>	1.58	<0.01

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 16.** Objective and subjective color scores for ground beef from feedlot heifers on Day 0 retail shelf life

Color Scores – Day 0	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	44.23	44.13	46.88	45.38	0.78	0.07
a*	25.61	15.60	14.80	15.25	0.24	0.07
b*	17.92	17.87	17.63	17.52	0.21	0.46
Lean color <sup>4</sup>	5.63	5.39	6.03	5.43	1.55	0.65
Surface discoloration <sup>5</sup>	9.58	10.25	9.67	9.70	1.27	0.28
Overall appearance <sup>6</sup>	6.53	7.14	6.47	6.70	1.28	0.30

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at  $P \leq 0.05$ . <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 17.** Objective and subjective color scores from ground beef from feedlot heifers on Day 2 retail shelf life

Color Scores – Day 2	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	44.17 <sup>a</sup>	45.37 <sup>a,b</sup>	47.99 <sup>b</sup>	47.02 <sup>b</sup>	0.76	<0.01
a*	11.19	11.44	10.53	10.46	0.27	0.07
b*	14.72	15.35	15.10	14.86	0.29	0.45
Lean color <sup>4</sup>	6.55 <sup>a</sup>	6.78 <sup>a</sup>	5.96 <sup>a,b</sup>	6.22 <sup>a,b</sup>	1.17	0.01
Surface discoloration <sup>5</sup>	10.13 <sup>a</sup>	10.46 <sup>a</sup>	9.54 <sup>a,b</sup>	10.03 <sup>a,b</sup>	1.26	0.03
Overall appearance <sup>6</sup>	6.65 <sup>a</sup>	6.98 <sup>a</sup>	6.30 <sup>a,b</sup>	6.38 <sup>a,b</sup>	1.13	0.02

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 18.** Objective and subjective color scores from ground beef from feedlot heifers on Day 4 retail shelf life

Color Scores – Day 4	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	43.73 <sup>a</sup>	43.77 <sup>a,b</sup>	47.11 <sup>b</sup>	45.91 <sup>a,b</sup>	0.90	0.05
a*	8.58	9.30	8.29	8.31	0.31	0.10
b*	13.73	14.40	13.85	14.16	0.21	0.13
Lean color <sup>4</sup>	5.24 <sup>a</sup>	5.68 <sup>a</sup>	4.63 <sup>a,b</sup>	4.79 <sup>a,b</sup>	1.37	<0.01
Surface discoloration <sup>5</sup>	7.73 <sup>a</sup>	8.49 <sup>a</sup>	7.05 <sup>a,b</sup>	7.53 <sup>a</sup>	1.64	0.02
Overall appearance <sup>6</sup>	5.14 <sup>a</sup>	5.63 <sup>a</sup>	4.59 <sup>a,b</sup>	4.80 <sup>a,b</sup>	1.37	<0.01

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 19.** Objective and subjective color scores from ground beef from feedlot heifers on Day 6 retail shelf life

Color Scores – Day 6	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	44.47	44.48	47.28	47.05	0.90	0.20
a*	7.60 <sup>a</sup>	8.07 <sup>a</sup>	7.15 <sup>a</sup>	6.88 <sup>a,b</sup>	0.30	0.05
b*	14.07 <sup>a</sup>	14.45 <sup>a</sup>	13.94 <sup>a</sup>	13.69 <sup>a,b</sup>	0.16	0.01
Lean color <sup>4</sup>	4.10 <sup>a</sup>	4.60 <sup>a</sup>	3.92 <sup>a</sup>	3.67 <sup>a,b</sup>	1.38	0.04
Surface discoloration <sup>5</sup>	5.83	6.40	5.65	5.61	1.77	0.47
Overall appearance <sup>6</sup>	3.91	4.38	3.60	3.70	1.37	0.09

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 20.** Objective and subjective color scores from ground beef from feedlot heifers on Day 8 retail shelf life

Color Scores – Day 8	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	46.35 <sup>a</sup>	46.64 <sup>a</sup>	49.95 <sup>b</sup>	47.23 <sup>a,b</sup>	0.84	0.03
a*	6.42	6.74	6.37	6.58	0.28	0.80
b*	13.24	13.51	13.67	13.77	0.19	0.22
Lean color <sup>4</sup>	3.01 <sup>a</sup>	3.49 <sup>a</sup>	2.60 <sup>a,b</sup>	2.69 <sup>a,b</sup>	1.25	<0.01
Surface discoloration <sup>5</sup>	4.00 <sup>a</sup>	4.73 <sup>a</sup>	3.48 <sup>a,b</sup>	3.51 <sup>a,b</sup>	1.58	0.02
Overall appearance <sup>6</sup>	2.59 <sup>a</sup>	3.11 <sup>a</sup>	2.30 <sup>a,b</sup>	2.37 <sup>a,b</sup>	1.25	0.02

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 21.** Objective and subjective color scores from ground beef from feedlot heifers on Day 10 retail shelf life

Color Scores – Day 10	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	45.59	46.01	48.59	48.29	1.08	0.13
a*	6.23	6.46	5.87	5.80	0.27	0.29
b*	13.79	13.81	13.70	13.69	0.20	0.96
Lean color <sup>4</sup>	2.10	2.61	1.92	1.83	1.20	0.09
Surface discoloration <sup>5</sup>	2.40	2.86	2.19	2.20	1.32	0.32
Overall appearance <sup>6</sup>	1.73	2.22	1.69	1.55	1.12	0.11

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at  $P \leq 0.05$ . <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 22.** Objective and subjective color scores from ground beef from feedlot heifers on Day 12 retail shelf life

Color Scores – Day 12	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	47.28	45.99	49.13	47.57	0.86	0.11
a*	5.59	5.86	5.36	5.37	0.17	0.29
b*	14.10	14.44	14.39	14.14	0.20	0.55
Lean color <sup>4</sup>	1.33 <sup>a</sup>	1.85 <sup>a</sup>	1.56 <sup>a</sup>	1.03 <sup>a,b</sup>	1.00	0.02
Surface discoloration <sup>5</sup>	1.37 <sup>a</sup>	1.89 <sup>a</sup>	1.63 <sup>a</sup>	1.17 <sup>a,b</sup>	0.98	0.03
Overall appearance <sup>6</sup>	1.07	1.33	1.30	1.00	0.78	0.11

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 23.** Objective and subjective color scores from ground beef from feedlot heifers on Day 14 retail shelf life

Color Scores – Day 14	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	46.26 <sup>a</sup>	46.72 <sup>a</sup>	49.74 <sup>b</sup>	48.23 <sup>a,b</sup>	0.73	0.01
a*	5.48	5.66	5.55	5.48	0.19	0.89
b*	14.14	14.14	14.29	14.60	0.17	0.15
Lean color <sup>4</sup>	1.22	1.29	1.20	1.16	0.73	0.70
Surface discoloration <sup>5</sup>	1.66	1.71	1.53	1.50	1.06	0.77
Overall appearance <sup>6</sup>	1.12	1.16	1.09	1.20	0.68	0.68

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

Treatment did not affect lean color (P = 1.00 ) or overall appearance (P = 1.00) subjective mean values or a\* (P = 0.88) or b\* (P = 0.82) in bologna (Table 23). LO+MDGS had a higher mean subjective surface discoloration value (9.38) and L\* (55.22) compared to all other dietary treatments (P < 0.01 and < 0.01, respectively) in bologna (Table 23). Tables 24 – 31 show the objective and subjective color scores every other day during the 14 day retail shelf life.

**Table 24.** Objective and subjective color scores for bologna from feedlot heifers over Day 0 – Day 14 retail shelf life

Color Scores – Day 0 – Day 14	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	53.02 <sup>a</sup>	52.82 <sup>a</sup>	55.23 <sup>b</sup>	53.41 <sup>a</sup>	0.28	<0.01
a*	5.04	5.23	4.71	4.77	0.51	0.88
b*	15.17	15.10	14.98	14.97	0.18	0.82
Lean color <sup>4</sup>	2.52	2.59	2.53	2.52	1.37	1.00
Surface discoloration <sup>5</sup>	8.60 <sup>a</sup>	8.61 <sup>a</sup>	9.38 <sup>b</sup>	8.72 <sup>a</sup>	1.73	<0.01
Overall appearance <sup>6</sup>	2.59	2.59	2.59	2.59	1.53	1.00

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 25.** Objective and subjective color scores from bologna from feedlot heifers on Day 0 retail shelf life

Color Scores – Day 0	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	49.92 <sup>a</sup>	50.15 <sup>a</sup>	51.53 <sup>b</sup>	50.05 <sup>a</sup>	0.27	<0.01
a*	13.55 <sup>a</sup>	13.82 <sup>a</sup>	13.27 <sup>a</sup>	12.89 <sup>a,b</sup>	0.17	0.01
b*	17.05	16.16	16.98	16.19	0.49	0.43
Lean color <sup>4</sup>	6.63	6.63	6.63	6.63	1.19	1.00
Surface discoloration <sup>5</sup>	11.00	11.00	11.00	11.00	0.00	1.00
Overall appearance <sup>6</sup>	7.88	7.88	7.88	7.88	0.58	1.00

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 26.** Objective and subjective color scores from bologna from feedlot heifers on Day 2 retail shelf life

Color Scores – Day 2	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	50.71 <sup>a</sup>	50.47 <sup>a</sup>	52.17 <sup>b</sup>	51.13 <sup>a</sup>	0.24	<0.01
a*	6.53	6.77	6.33	6.31	0.16	0.16
b*	16.48	16.61	16.64	16.35	0.21	0.76
Lean color <sup>4</sup>	3.60	3.56	3.63	3.60	0.73	0.95
Surface discoloration <sup>5</sup>	10.83	10.79	10.88	10.85	0.63	0.77
Overall appearance <sup>6</sup>	4.00	4.00	4.00	4.00	1.16	1.00

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 27.** Objective and subjective color scores from bologna from feedlot heifers on Day 4 retail shelf life

Color Scores – Day 4	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	52.34 <sup>a</sup>	52.03 <sup>a</sup>	54.30 <sup>b</sup>	52.49 <sup>a</sup>	0.21	<0.01
a*	4.54	4.80	4.30	4.32	0.21	0.33
b*	15.77	15.74	15.62	15.68	0.22	0.96
Lean color <sup>4</sup>	2.57	2.62	2.64	2.55	0.87	0.94
Surface discoloration <sup>5</sup>	9.26	8.88	9.57	8.98	1.47	0.45
Overall appearance <sup>6</sup>	2.31	2.31	2.33	2.31	1.05	1.00

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 28.** Objective and subjective color scores from bologna from feedlot heifers on Day 6 retail shelf life

Color Scores – Day 6	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	53.25 <sup>a</sup>	53.02 <sup>a</sup>	55.72 <sup>b</sup>	53.57 <sup>a</sup>	0.18	<0.01
a*	3.90	4.09	3.49	3.66	0.21	0.23
b*	14.95	14.95	14.59	14.77	0.23	0.65
Lean color <sup>4</sup>	1.81	1.81	1.77	1.81	0.81	0.99
Surface discoloration <sup>5</sup>	6.75	6.79	7.71	7.00	1.91	0.55
Overall appearance <sup>6</sup>	1.63	1.63	1.63	1.63	0.84	1.00

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 29.** Objective and subjective color scores from bologna from feedlot heifers on Day 8 retail shelf life

Color Scores – Day 8	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	54.75 <sup>a</sup>	54.49 <sup>a</sup>	56.92 <sup>b</sup>	54.93 <sup>a</sup>	0.21	<0.01
a*	3.50	3.77	3.26	3.41	0.18	0.26
b*	14.41	14.55	14.36	14.32	0.37	0.97
Lean color <sup>4</sup>	1.56	1.60	1.54	1.56	0.81	0.97
Surface discoloration <sup>5</sup>	8.08	8.10	9.46	8.17	1.76	0.14
Overall appearance <sup>6</sup>	1.38	1.38	1.38	1.35	0.83	1.00

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 30.** Objective and subjective color scores from bologna from feedlot heifers on Day 10 retail shelf life

Color Scores – Day 10	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	54.03 <sup>a</sup>	53.80 <sup>a</sup>	56.69 <sup>b</sup>	54.55 <sup>a</sup>	0.21	<0.01
a*	2.84	3.24	2.77	2.93	0.17	0.23
b*	14.74	14.65	14.36	14.69	0.25	0.72
Lean color <sup>4</sup>	1.33	1.33	1.43	1.31	0.74	0.75
Surface discoloration <sup>5</sup>	7.74	8.00	9.26	7.93	1.75	0.09
Overall appearance <sup>6</sup>	1.19	1.17	1.17	1.19	0.69	0.99

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 31.** Objective and subjective color scores from bologna from feedlot heifers on Day 12 retail shelf life

Color Scores – Day 12	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	54.66 <sup>a</sup>	54.23 <sup>a</sup>	57.23 <sup>b</sup>	54.77 <sup>a</sup>	0.22	<0.01
a*	2.69	2.88	2.42	2.53	0.18	0.31
b*	14.29	14.22	13.83	14.08	0.27	0.64
Lean color <sup>4</sup>	1.43	1.44	1.43	1.43	0.71	1.00
Surface discoloration <sup>5</sup>	7.69	7.65	8.76	8.00	1.74	0.20
Overall appearance <sup>6</sup>	1.22	1.22	1.22	1.22	0.65	1.00

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable.

**Table 32.** Objective and subjective color scores from bologna from feedlot heifers on Day 14 retail shelf life

Color Scores – Day 14	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	54.83 <sup>a</sup>	54.41 <sup>a</sup>	57.27 <sup>b</sup>	55.21 <sup>a</sup>	0.31	<0.01
a*	2.19	2.46	2.12	2.13	0.15	0.36
b*	13.72	13.96	13.46	13.66	0.31	0.73
Lean color <sup>4</sup>	1.25	1.23	1.23	1.23	0.65	0.99
Surface discoloration <sup>5</sup>	7.56	7.73	8.46	7.88	1.83	0.58
Overall appearance <sup>6</sup>	1.13	1.13	1.13	1.13	0.58	1.00

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05. <sup>4</sup>Lean color - 1 = extremely brown and 8 = extremely bright, cherry red. <sup>5</sup>Surface discoloration - 1 = 91-100% discoloration and 11 = 0% discoloration. <sup>6</sup>Overall appearance - 1 = extremely undesirable and 8 = extremely desirable. Treatment did not have an effect on sensory attributes in bologna from feedlot heifers (Table 32).

**Table 33.** Effects of experimental treatments on sensory attributes in cooked bologna from feedlot heifers

Sensory Attributes	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
Overall Liking <sup>4</sup>	75.07	77.08	75.98	74.85	1.59	0.75
Flavor Liking <sup>4</sup>	74.13	76.17	75.55	75.49	1.79	0.87
Texture Liking <sup>4</sup>	72.70	76.44	75.49	74.26	1.60	0.39
Toughness <sup>5</sup>	6.97	7.51	6.08	6.12	0.43	0.09
Off Flavor <sup>5</sup>	5.30	4.60	4.99	5.35	0.44	0.61

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at  $P \leq 0.05$ . <sup>4</sup>Liking ratings were on a 120 point labeled affective magnitude scales, with the left most end labeled *strongest dislike imaginable* and the right most end labeled *strongest like imaginable*. <sup>5</sup>Intensity ratings were on a 20 point line scale with the left most ends labeled *none* and the right most ends labeled *extremely tough*, *extremely juicy*, and *extremely intense*.

Treatment had no effect on TBARS in ground beef from feedlot heifers (Table 33). TBARS did increase from Day 0 to Day 14 samples, indicating lipid peroxidation occurred over the retail shelf life duration (Table 33). This agrees with and supports results from ground beef retail shelf life.

**Table 34.** Effects of experimental treatment on thiobarbituric acid reactive substances (TBARS) in ground beef from feedlot heifers

TBARS	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-Value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
Day 0	0.80	1.00	1.00	1.03	0.14	0.66
Day 14	2.60	2.18	2.36	2.44	0.12	0.14

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05.

Treatment did not affect objective color scores in lipid from feedlot heifers (Table 34).

**Table 35.** Objective color scores for lipid from feedlot heifers

Color Score	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
L*	73.41	74.22	72.96	76.25	0.98	0.16
a*	1.37	1.32	1.40	1.74	0.38	0.88
b*	10.71	10.17	11.19	11.19	0.78	0.51

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain, 20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at P ≤ 0.05.

Treatment affected C15:0 (P = 0.05) and 9c,12c,15c-C18:3 (P = 0.04) (Table 35). All other fatty acid levels and calculated iodine value were not influenced by treatment (Table 35). Previous research has found that feeding 0, 10, 20, 30, 40, and 50% MDGS linearly increased steric, linoleic, polyunsaturated fatty acids, and n-6 fatty acids (Mello et al., 2015). Saturated fatty acids containing 6 to 14 carbons were not influenced by treatment (Mello et al., 2015). The addition of soy glycerin and soybean hull to the diet could be the cause for no treatment influence.

**Table 36.** Effects of experimental treatment on beef fatty acid composition in feedlot heifers

Fatty Acid Composition	Treatment <sup>1</sup>				SEM <sup>2</sup>	P-Value <sup>3</sup>
	HI+MDGS	HI+SOY	LO+MDGS	LO+MDGS+SOY		
C14:0	3.33	3.83	3.87	3.58	0.21	0.20
C15:0	0.58 <sup>a</sup>	0.69 <sup>a</sup>	0.53 <sup>a</sup>	0.62 <sup>b</sup>	0.04	0.05
C16:0	24.91	26.14	25.57	20.08	0.63	0.41
C17:0	1.50	1.37	1.20	1.42	0.10	0.19
C18:0	13.66	12.81	12.62	13.17	1.17	0.91
C19:0	0.06	0.06	0.15	0.10	0.05	0.56
C20:0	0.02	<0.01	<0.01	<0.01	0.01	0.62
9c-C14:1	0.80	1.06	1.08	0.95	0.16	0.52
9c-C16:1	3.52	4.43	3.75	3.52	0.39	0.30
6t-C18:1	0.46	0.34	0.48	0.35	0.06	0.27
11t-C18:1	4.40	4.14	4.80	4.92	0.32	0.34
6c-C18:1	0.13	0.24	0.08	0.13	0.07	0.50
9c-C18:1	37.58	35.99	36.58	36.33	1.20	0.75
11c-C18:1	1.51	1.54	1.28	1.22	0.11	0.13
10c-C19:1	0.02	<0.01	<0.01	<0.01	0.01	0.62
9c,12c-C18:2	3.12	2.61	3.33	3.18	0.20	0.09
10c,13c-C19:2	0.26	0.23	0.23	0.22	0.05	0.91
9c,12c,15c-C18:3	0.04 <sup>a</sup>	<0.01 <sup>a</sup>	0.13 <sup>a,b</sup>	0.12 <sup>b</sup>	0.03	0.04
Iodine Value	46.74	45.16	46.87	46.13	0.97	0.58

Means within a row with different letters differ significantly. <sup>1</sup>Treatments: 65.0% corn grain,

20.0% modified distillers grains with solubles (HI+MDGS); 65% corn grain, 15.2% soy coproduct (HI+SOY); 25.0% corn grain, 60.0% modified distillers grains with solubles (LO+MDGS); and 25.0% corn grain, 15.2% soy coproduct, 40.0% modified distillers grains with solubles (LO+MDGS+SOY). <sup>2</sup>Standard error of least square means, n = 11 heifers/treatment. <sup>3</sup>Significance is declared at  $P \leq 0.05$ .

## **CONCLUSION**

Results indicate feeding high levels of corn or soy coproduct in feedlot heifer diets does not have an effect on carcass characteristics, drip loss, or subjective retail shelf life evaluation; however, combining all coproducts in a low grain inclusion diet impacted Warner–Bratzler shear force.

## **ACKNOWLEDGEMENTS**

Funding for this project was provided by Minnesota Corn Growers Association and Agriculture Utilization Research Institute.

## **REFERENCES**

- Bittner, C.J., G.E. Erickson, T.L. Mader, and L.J. Johnson. 2013. Utilization of Soybean Hulls When Fed in Combination with MDGS in Finishing Diets. 2013 Nebraska Beef Cattle Report: 86-87.
- Lardy, Greg and Vern Anderson. 2009. Alternative Feeds for Ruminants. North Dakota State University: Extension Service. AS-1182.
- McCelland, K.M. 2013. Dietary Influence on Lipid Composition and Oxidation of Fresh and Processed Meat Products. PhD Dissertation. University of Minnesota – Twin Cities, Saint Paul.
- Mello, A.S., B.E. Jenschke, L.S. Senaratne, T.P. Carr, G.E. Erickson, and C.R. Calkins. 2015. Effects of feeding modified distillers grains plus solubles on marbling attributes, proximate composition, and fatty acid profile of beef. *J. Anim. Sci.* 90: 4634-4640.
- Mueller, C.J., and D.L. Boggs. 2011. Use of soybean hulls with or without corn by-product protein sources in feedlot backgrounding diets. *Prof. Anim. Sci.* 27:228-234.
- Renewable Fuels Association. 2014. Statistics. Accessed Feb. 27, 2015. <http://www.ethanolrfa.org/pages/statistics>.

Schroeder, A. R., M. Iakiviak, and T.L. Felix. 2014. Effects of feeding dry or modified wet distillers grains solubles with or without supplemental calcium oxide on ruminal metabolism and microbial enzymatic activity of beef cattle. *J. Anim. Sci.* 92: 3997-4004.

Tarladgis, B.G., B.M. Watts, M.T. Younathan, and L. Dugan Jr. 1960. A distillation method for the quantitative determination of malonaldehyde in rancid foods. *J. Am. Oil Chem. Soc.* 37: 44-48.

Veracini, J.L., P.M. Walker, B.R. Wiegand, R.L. Atkinson, M.J. Faulkner, and L.A. Forster. 2013. Effects of reduced-fat modified wet distillers grains with solubles on beef steer performance and carcass composition. *Prof. Anim. Sci.* 29:518–528.