Effects of Modified Distillers Grains with Solubles and Crude Glycerin Inclusion in Beef Cattle Finishing Diets on Beef Quality

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Abstract

Steers and heifers (n = 48) were assigned randomly to one of four treatment groups and fed individually. Treatments were as follows: steam-flaked corn diet with no modified distillers grains with solubles (MDGS) or glycerin (CON); CON with 35% MDGS (MDGS); CON with 10% glycerin (GLY); and CON with 35% MDGS and 10% glycerin (MDGS/GLY). When cattle reached a mean weight of 590 kg, they were humanely harvested at a commercial abattoir. Strip loins and shoulder clods were removed from the right side of each carcass. Treatment had no effect any specific fatty acid ($P > 0.05$), vacuum purge loss ($P = 0.75$), cooking loss ($P = 0.40$), Warner-Bratzler shear force values ($P = 0.94$), strip steak L*, a*, or b* values ($P > 0.05$) or ground beef L*, a*, or b* values ($P > 0.05$). CON and MDGS had higher values for consumer overall liking and texture liking of strip steaks ($P < 0.05$). Treatment did not affect flavor liking ($P < 0.05$).

Keywords: beef, distillers grains, glycerin

Introduction

Increasing corn prices as well as changes in management have led feedlot producers to look for new, more economical feedstuffs for cattle finishing diets. Coproducts from the ethanol industry such as distillers grains are one of the most common choices (Depenbusch et al. 2009). Distillers grains can be used in several different forms (wet, dry, or modified) depending on the feeding needs of the producer and accessibility to these coproducts. However, in the production of distillers grains the starch is removed and the crude protein, fat, and fiber levels are concentrated and increased (Aldai et al., 2010). These fats are largely polyunsaturated and increasing unsaturated fatty acid percentages in beef can lead to increased lipid oxidation and decreased color stability (Wood et al., 2003). While the fatty acid profile of ruminants is largely influenced by rumen microflora, dietary changes can potentially manipulate saturation levels (Harfoot and Hazelwood, 1997). Aldai et al. (2010) found that cattle fed either corn or wheat dried distillers grains had decreased monounsaturated fatty acids (MUFA) and increased polyunsaturated fatty acids (PUFA) as compared to the control. Saturated fatty acids remained unchanged. Gill et al. (2008) found that when 15% distillers grains were fed in beef cattle finishing diets conjugated linoleic acid (CLA) increased over the control. Dried and wet distillers grains can even vary in their effect in fat deposition. Gill et al. (2008) found that dried distillers grains increased linoleic acid concentrations compared with wet distillers grains.

Further processed meat products such as bologna and summer sausage can be negatively influenced by increases in unsaturation. Unsaturation can lead to increased lipid oxidation which can cause off flavors, off odors, and decreased color stability. Also, in response to the high temperatures and mechanical manipulation of processing meats, more unsaturated fats can “grease out” or develop fat pockets due to lower melting points and decreased fat stability and density (McClements and Decker, 2008).

Another co-product, crude glycerin, has come about due to rapid expansions in the biodiesel industry and has become an affordable feedstuff (Parsons et al., 2009). Recent studies in swine nutrition have investigated the use of this co-product in response to the unsaturation issues found with feeding distillers grains. Duttlinger et al. (2012) found that the addition of glycerin increased MUFA in both jowl and backfat and oleic acid in backfat samples, thus increasing saturation. Glycerin in beef cattle diets has been shown to potentially increase dry matter intake and feed efficiency while having no effects on carcass characteristics (Parsons et al., 2009; Schneider et al., 2010). However, many studies feeding glycerin to ruminants fail to address whether this co-product can increase saturation when fed in combination with distillers grains, as has been shown in swine and poultry. Therefore the objective of this study was to evaluate the effects of modified distillers grains with solubles (MDGS) at 35% and crude soybean glycerin at 10% inclusion in beef cattle finishing diets on carcass characteristics, meat color, fatty acid profiles, and sensory attributes of fresh and processed beef.

Materials and Methods

Treatments and Experimental Design

Forty-eight crossbred steers and heifers were fed individually using a Calan gate system and assigned randomly to one of four treatments arranged in a 2 x 2 factorial design. Cattle were divided into four pens blocked by sex and treatments were evenly distributed between pens. Treatments were: traditional steam flaked corn diet (CON); CON with 35% modified distillers grains with solubles (MDGS); CON with 10% crude soybean glycerin (GLY); CON with 35% MDGS and 10% crude soybean glycerin (MDGS/GLY). Crude glycerin and MDGS inclusion was in place of steam flaked corn in MDGS, GLY, and MDGS/GLY treatments (Table 1).

Harvest and Fabrication

When cattle reached a mean weight of 590 kg, they were humanely harvested at a commercial abattoir in two groups. Kidney, pelvic, and heart (KPH) fat percentage, hot carcass weight (HCW), ribeye area, backfat at the 12th rib, quality grade, marbling score, and yield grade were collected 48 hours postmortem. Strip loins (IMPS #180A) and shoulder clods (IMPS #114) were removed from the right side of each carcass, trimmed, labeled, and vacuum packaged. Cuts were transported refrigerated to the University of Minnesota Meats Laboratory.

Strip Loins

Strip loins were weighed (Accu-weigh, Model DP-6200, Yamato Corporation, USA; Made in China) in packaging and after packaging removal to calculate vacuum purge loss percentage. Seven 2.54-cm steaks were cut serially from the anterior end of each strip loin for further analysis. One steak was weighed (Mettler, Model PM 600, Mettler Instrument Co., Highstown, NJ), suspended for 24 hours at refrigerated temperature and isolated atmosphere, and then re-weighed to calculate drip loss percentage. One additional steak was weighed, cooked (standard electric kitchen oven, Fridgidaire, General Motors, USA) to an internal temperature of 71º C, tempered to room temperature, and re-weighed to calculate cooking loss percentage (AMSA, 1995). Six cores were taken from each cooked steak and evaluated for Warner-Bratzler shear force (AMSA, 1995). Cores were averaged. Two steaks were placed on trays with polyvinylchloride (PVC) overwrap (oxygen transmission rate 1400 cc/m^2) and stored at 4º C under cool white fluorescent lighting (cool white fluorescent lighting, Sylvania H968, 100w, 2, 640 LUX) for seven days (Retail case Hussmann, GF-8, AA Equipment Company, Inc. Minneapolis, MN). Objective color values (CIE, *L*, a*, and b**) were taken at six locations on each steak with a Minolta CR-310 with illuminant D65, 2.54-cm diameter aperture, and 2º standard observer (Minolta Co., Ltd Radiometric Instruments Operations, Osaka, Japan; AMSA, 1991). Subjective color scores (lean color, surface discoloration, and overall appearance) were evaluated by an eight member trained panel for seven days. Lean color was evaluated on a 1-8 scale with 1 = extremely brown and 8

= extremely bright, cherry red. Surface discoloration was evaluated on 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 (AMSA, 1991). The three remaining steaks from each treatment were cooked to an internal temperature of 71º C for an eight member untrained consumer sensory panel. Each panelist received two 1-cm x 1-cm x 1-cm pieces of steak from each replication of each treatment with three replications per treatment. Panelists were asked to evaluate steak cubes for overall liking, flavor liking, texture liking, toughness, juiciness, and off flavor (AMSA, 1995).

Shoulder Clods

Shoulder clods were cut and ground individually, twice through a 0.375-cm grinder plate (Biro Grinder, Model 346; Biro Manufacturing Company; Marble Head, OH). Two batches of ground beef from each shoulder clod were vacuum packaged (ULTRAVAC, Model 500, Koch Equipment, LLC, Kansas City, MO) and stored frozen for bologna production. Fresh, ground beef (0.5 kg) from each shoulder clod was placed on a tray with PVC overwrap and stored at 4º C under cool white fluorescent lighting for seven days. Objective color values (CIE, *L*, a*, and b**) were taken at six locations on each ground beef package with a Minolta CR-310 with illuminant D65, 2.54-cm diameter aperture, and 2º standard observer (AMSA, 1991). Subjective color scores (lean color, surface discoloration, and overall appearance) were evaluated by an eight member trained panel for seven days. Lean color was evaluated on a 1-8 scale with 1 = extremely brown and 8 = extremely bright, cherry red. Surface discoloration was evaluated on 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 (AMSA, 1991).

Bologna

Three animals from each treatment were combined into one bologna batch. Batches were made from 11.34 kg (25 lbs) of ground beef (shoulder clods) with a commercial seasoning blend (Bologna SCTP, Newly Wed Food, Chicago, IL), 1.13 kg (2.5 lbs) of ice, sodium tripolyphosphate, and cure (Heller's Modern Cure #47688, Newly Wed Food, Chicago, IL). Ground beef and ingredients were emulsified (Alipina, PB 80-890-II Gossau S G, Switzerland, Speed setting 2, 3 knife head with Alipina tangential form blades) and then stuffed (Handtmann VF-608, Albert Handtmann Maschimen Fabrik GmbH & Co., Biberach, Germany) into inedible collagen casings (Bologna 10.8 cm Walsrober Casings, Mar/Co Sales, Burnsville, MN). Bologna was cooked to an internal temperature of 65.5º C, smoked for 1 hour (Enviro-Pak, Model CVU 500E-IT, Portland, OR), cooled overnight to 4º C and then sliced. Slices were 12-cm in diameter and 4-mm thick (Globe Slicer, Model 400, Globe Slicing Machine Co, Inc., Stamford, CT). One slice from each batch was placed on a tray with PVC overwrap and stored at 4º C under cool white fluorescent lighting for ten days with six replications of each batch. Objective color values (CIE, *L*, a*, and b**) were taken at six locations on each slice with a Minolta CR-310 with illuminant D65, 2.54-cm diameter aperture, and 2º standard observer (AMSA, 1991). Subjective color scores (lean color, surface discoloration, and overall appearance) were evaluated by an eight member trained panel for ten days, every other day. Lean color was evaluated on a 1-8 scale with 1 = extremely brown and 8 = extremely bright, cherry red. Surface discoloration was evaluated on 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 (AMSA, 1991). For sensory evaluation, bologna slices were cut into eight sections and each untrained consumer panelist received two pieces from each replication with three replications per treatment. Panelists were asked to evaluate bologna for overall liking, flavor liking, texture liking, toughness, and off flavor (AMSA, 1995).

Fatty acid profile and TBARS

A 10 gram backfat sample was collected from the posterior end of each strip loin before cutting steaks, vacuum packaged, and stored frozen until fatty acid profile analysis. Subsets of three animals from each treatment were selected randomly for analysis. Fatty acid profiles were determined by gas chromatography (HP 6890 series, Santa Clara, CA) with a flame ionization detector (AOCS, 1998; AOCS Ce 1-62 and Ce 2-66). Samples were run in duplicate at the Agricultural Utilization Research Institute (AURI, Marshall, MN). Samples were evaluated for individual fatty acids, total saturated fatty acids (SFA), total unsaturated fatty acids (UFA), total mono-unsaturated fatty acids (MUFA), total polyunsaturated fatty acids (PUFA), and total trans fatty acids (TFA) and iodine value was calculated from the fatty acid profile using the most current equation from the American Oil Chemist Society (AOCS, 1998) as follows:

$$Iodine\ Number = 16{:}1\ (0.95) + 18{:}1\ (0.86) + 18{:}2\ (1.732) + 18{:}3\ (2.616) + 20{:}1\ (0.785) + 22{:}1\ (0.723)$$

Samples of each ground beef batch were collected on days 0 and 7 for analysis, vacuum packaged, and stored frozen immediately for thiobarbituric acid reactive substances (TBARS) analysis (AOCS, 1998). Secondary lipid oxidation products of lipid oxidation were measured using the thiobarbituric acid assay (Tarladgis et al. 1960). Subsets of three animals from each treatment were selected randomly for analysis at the AURI (Marshall, MN). Samples were run in duplicate and measured with a spectrophotometer (Spectronic 20^+, Spectronic Instruments, Inc.) at 532 nm and reported at TBARS.

Statistical Analysis

Data were analyzed as a 2 x 2 factorial design with MDGS and glycerin inclusion as main effects. Categorical data (yield grade, quality grade, and marbling score) were subjected to the GENMOD procedure of SAS (SAS Inst, Inc., Cary, NC. Version 9.1), while all other remaining data were analyzed using the MIXED procedure. Subjective color scoring was correlated to objective color scores using PROC CORR. Animal was considered the experimental unit and an alpha level of 5% was used to determine statistical significance. Carcasses determined to be "dark cutting" were removed from color and drip loss data as well as not being used in bologna production. Hot carcass weight was used as a covariate for ribeye area, backfat, KPH %, yield grade, quality grade, and marbling score.

Results and Discussion

Carcass Data, Moisture Loss, and Shear Force

The addition of MDGS and crude glycerin did not affect carcass measurements ($P > 0.05$) except KPH fat percentage (Table 2). The addition of MDGS increased KPH fat percentage ($P = 0.04$). Similarly, Schneider et al. (2010) found no differences with the addition of glycerin on most carcass characteristics with the exception of decreased percentage of carcasses grading USDA Choice.. However, Parsons et al. (2009) found that the addition of more than 8% glycerin decreased hot carcass weights, Longissimus muscle area, 12^{th} rib backfat, and marbling scores. Also, Luebbe et al. (2012)

found feeding wet distillers grains (WDG) negatively affected carcass characteristics including hot carcass weight, 12^{th} rib backfat, and marbling scores. Similar to our results, Depenbusch et al. (2009) found no differences in carcass characteristics when feeding either wet or dried distillers grains. Glycerin and MDGS did not affect vacuum purge loss (P = 0.67 and 0.19, respectively), drip loss (P = 0.10 and 0.25, respectively), or cooking loss (P = 0.15 and 0.29, respectively; Table 3). The addition of glycerin did not affect Warner-Bratzler shear force values (P = 0.16), however when MDGS was added, shear force values were decreased (P = 0.03; Table 3).

Objective Color Scores

The addition of MDGS did not affect L*, a*, or b* in strip steaks (P = 0.90, 0.72, and 0.60, respectively). Similarly, glycerin did not affect objective color of strip steaks (L*, a*, b*; P = 0.57, 0.53, and 0.59, respectively; Table 4). When considering ground beef objective color MDGS and glycerin did not affect L*, a*, or b* values (MDGS P = 0.29, and 0.98, respectively; Glycerin P = 0.25, and 0.23, respectively; Table 5). In a more processed product like bologna MDGS decreased L* while glycerin increased L* values (P = 0.02 and P < 0.001, respectively). With MDGS and glycerin, a* (P = 0.78 and 0.07, respectively) and b* (P = 0.38 and 0.94, respectively; Table 6) were not affected. Leupp et al. (2009) found reductions in L* and b* in fresh strip steaks when cattle were fed distillers grains in the growing period and reductions in a* when fed distillers grains in the finishing period. Perhaps the addition of glycerin helped to mitigate these effects in our experiment, however no interaction was detected (P > 0.05).

Sensory, Fatty Acid Profile, and TBARS

The addition of MDGS did not affect overall liking, flavor liking, texture liking, toughness, or juiciness in cooked strip steaks (P > 0.05; Table 7). However, the addition of MDGS resulted in an increase in off flavors(P = 0.03). Leupp et al. (2009) found that with the addition of distillers grains in beef finishing diets, steaks were more juicy and flavorful, while tenderness remained unaffected. Gill et al. (2008) found no sensory differences when feeding wet or dry distillers grains to beef cattle. When glycerin was added, overall liking, flavor liking, and texture liking decreased (P = 0.0001, 0.01, and < 0.0001, respectively), while juiciness and off flavor increased (P < 0.0001) in strip steak samples. Toughness was not affected by glycerin (P = 0.42). In bologna samples the addition of MDGS did not affect overall liking or texture liking (P = 0.06 and 0.85, respectively; Table 8). However, flavor liking decreased (P = 0.005) while toughness and off flavor increased (P = 0.03 and < 0.0001, respectively).

In bologna, the inclusion of glycerin increased overall liking, flavor liking and texture liking (P < 0.0001) while decreasing toughness (P < 0.0001). Off flavor was not affected by glycerin (P = 0.09). The addition of coproducts had no effect any specific fatty acid (P > 0.05; Table 9). Additionally, there were no differences with MDGS or glycerin for SFA (P = 0.35 and 0.77, respectively), MUFA (P = 0.50 and 0.83, respectively), or PUFA (P = 0.27 and 0.61, respectively). However, there was an increase in total TFA with the inclusion of glycerin (P = 0.02). Aldai et al. (2010) found that including corn or wheat distillers grains at 20% of the diet of beef cattle did not change SFA, but decreased MUFA, specifically C18:1. They also found an increase in PUFA when feeding 20% distillers grains. Gill et al. (2008) reported increases in C18:2 when dry distillers grains were fed at 15% of the diet. No differences were shown with the inclusion of MDGS or glycerin for TBARS values on d 0 (P = 0.63 and 0.62, respectively; Table 10). However on day 7 the addition of MDGS increased TBARS values (P = 0.02).

Conclusions

Results from this study suggest that the inclusion of modified distillers grains plus solubles and crude glycerin in beef cattle finishing diets did not negatively impact carcass and meat quality characteristics. Results also indicate that the addition of modified distillers grains plus solubles and crude glycerin in beef finishing diets did not negatively affect color stability of strip steaks and ground beef, but may impact sensory characteristics of beef strip steaks and bologna.

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