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Effects of feeding wet distillers grains to cattle during different phases of production on lipid oxidation of cooked ground beef patties during storage[1]

N. T. Dierks, B. D. Cleveland, K. A. Varnold, G. E. Erickson, PAS, and G. A. Sullivan[2]
Department of Animal Science, University of Nebraska, Lincoln 68583-0908

ABSTRACT

As a coproduct of the fuel ethanol industry, distillers grains are commonly included in cattle diets and can alter fatty acid composition and increase lipid oxidation in beef. However, to our knowledge, current research has only evaluated raw beef products. This study investigated how supplementing dried distillers grains with solubles (DDGS) during backgrounding (0 or 0.6% of BW per steer daily) and including wet distillers grains with solubles (WDGS) in finishing diets (0 or 35% inclusion, DM basis) affected beef fatty acid profiles and lipid oxidation in cooked beef patties during refrigerated and frozen storage. Beef shoulder clods (n = 16) were independently ground and evaluated for fatty acid composition. From each clod, beef, salt, and sodium phosphate were mixed, and patties were formed, cooked, and placed in refrigerated and frozen storage. Backgrounding supplementation with DDGS caused a greater saturated:unsaturated fatty acid ratio ($P = 0.04$). Inclusion of 35% WDGS during finishing resulted in greater C18:0, C20:2, C22:0, and PUFA content ($P \leq 0.04$). For cooked beef patties in refrigerated storage, backgrounding DDGS supplementation resulted in greater oxidation ($P < 0.01$), but including 35% WDGS during finishing decreased oxidation ($P = 0.02$). A backgrounding × finishing diet interaction ($P < 0.01$) for lipid oxidation in frozen, cooked beef patties was identified. Backgrounding DDGS supplementation increased lipid oxidation regardless of finishing diet. For cattle without backgrounding supplementation, less lipid oxidation occurred with WDGS inclusion in finishing diets. Although backgrounding DDGS supplementation resulted in few differences in fatty acid composition, it resulted in increased lipid oxidation.

Key words: cooked ground beef, distillers grains, fatty acid composition, lipid oxidation

INTRODUCTION

The quantity and composition of animal fat affects many aspects of the quality and shelf life of animal products. Because of rumen biohydrogenation, beef contains less PUFA than nonruminant species, and shifts in dietary lipid sources result in less variation in the overall fatty acid composition than in nonruminant species (Wood et al., 2004). Lipid oxidation occurs more readily in PUFA than MUFA (Holman and Elmer, 1947). As a result, fatty acid composition and amount of PUFA in meat affects oxidative stability.

Distillers grains (**DG**), the by-product when fermenting grains into alcohol, are commonly fed to livestock. With the rapid expansion of the fuel ethanol industry, DG have become a common ingredient in cattle diets. Corn starch is converted to ethanol and removed during ethanol production; therefore, the fat, fiber, and protein content of the DG are concentrated 3-fold relative to the concentration in corn (Klopfenstein et al., 2008). Consequently, including DG in cattle finishing diets increases the dietary intake of PUFA and increases the amounts of PUFA found in the beef (Depenbusch et al., 2009; Senaratne, 2009; Koger et al., 2010; Mello et al., 2012a,b). Studies have reported increased lipid oxidation in fresh beef strip steaks (Mello et al., 2012a; Buttrey et al., 2013), top blade steaks (Mello et al., 2012a), and ground beef (Koger et al., 2010) during storage from cattle finished on diets with DG inclusion of 30, 35, 15, and 40%, respectively. Supplementing cattle with dried DG during a stocker phase has been shown to increase the amount of linoleic acid in strip steaks (Buttrey et al., 2012). Regardless of phase of production, feeding DG can affect the fatty acid composition of beef.

However, no published research has investigated the effect of feeding DG to cattle on the shelf life of processed beef products. Cooked beef products are more susceptible to oxidation than fresh beef because of the release of iron from myoglobin during cooking (Min et al., 2010). This, combined with the increased concentration of PUFA in beef from cattle fed DG, creates concerns about lipid oxidation. The objective of this study was to determine the effects of feeding DG during backgrounding and in finishing diets on the fatty acid composition of raw beef and

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[2] Corresponding author: gary.sullivan@unl.edu

lipid oxidation in cooked beef patties stored in refrigerated and frozen storage.

MATERIALS AND METHODS

Dietary Treatments and Beef Patty Manufacture

All animal protocols performed in this study were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee (Protocol #902). Crossbred steers (n = 32) were fed in a 2 × 2 factorial arrangement of treatments consisting of background supplementation and finishing diet. During backgrounding, cattle grazed on smooth bromegrass (*Bromus inermis*) and were supplemented with dry distillers grains plus solubles (**DDGS**) at 0.6% of BW per steer daily (DM basis) or received no supplementation for 177 d following weaning. While on pasture, steers were fed DDGS daily by hand delivery in bunks with grazing paddocks. The grazing portion of the experiment is a long-term (10-yr) study designed to evaluate supplementation effects on cattle performance and pasture management (Greenquist et al., 2009; Watson et al., 2012, 2015). During finishing, cattle were fed a corn-based diet with either 0 or 35% inclusion of wet distillers grains plus solubles (**WDGS**; DM basis) for 119 d (Table 1). Both diets contained monensin (Rumensin, Elanco Animal Health, Indianapolis, IN) and tylosin (Tylan, Elanco Animal Health). Diets containing WDGS provided more CP, NDF, and fat compared with the corn-based diet (Table 1). Nutrients were analyzed on weekly feed samples that were composited by month for N using a combustion N-Nitrogen (LECO TruSpec FP528, St. Joseph, MI; AOAC, 1990a, method 990.06) and for NDF using the procedure outlined by Van Soest et al. (1991) with heat stable amylase added. Ingredients were analyzed for ether extract using a biphasic lipid extraction procedure outlined by Bremer (2010). Briefly, samples were heated in a 1:1 mixture of hexane and diethyl ether for 9 h, dilute HCl was added, and samples were centrifuged to separate the lipid layer from other liquid. The lipid layer was pipetted off, heated to remove remaining solvent, and weighed. Diet nutrient composition was calculated from analyzed ingredients weighted for inclusion. Cattle were slaughtered at a commercial abattoir. At the time of grading, any USDA Choice carcasses were selected and retained until reaching 4 carcasses for each dietary treatment. A total of 16 untrimmed beef shoulder clods (Institutional Meat Purchasing Specifications # 114; USDA, 2014) from the right side of the carcasses were collected on d 2 postmortem. Vacuum packaged subprimals were transported to the University of Nebraska–Loeffel Meat Laboratory and stored at 1°C until the day of processing. On d 7 postmortem, beef patties were manufactured from each clod. Each clod was independently processed, and the grinder was cleaned of visual materials between samples. The dorsal portion (30 to 35 cm) of each shoulder clod was ground through a 12.7-mm plate (Model 4732, Hobart Corp., Troy, OH), and a sample was taken to determine fatty acid profile and proximate composition. A 2.27-kg portion of each clod was mixed for 1 min (RM-20, Manica USA, St. Louis, MO) with 1.5% salt and 0.25% sodium phosphate (Brifisol 512, Bk Giulini, Ladenburg, Germany), and fine ground using a 3.17-mm plate. Sodium chloride and sodium phosphate were used in this experiment because they are common ingredients in ready-to-eat meat products. From each clod, 20 patties (113 g each) were formed using a hand press, stored overnight, and cooked on a belt grill (Model TB-G60V3, Magikitch'n, Quakertown, PA) for 2 min at a setting of 190.5°C for the top plate and 177°C for the bottom plate. Internal temperature was measured on each patty at the end of cooking to ensure patties reached 71°C. Cooked samples were cooled and designated for refrigerated (4°C) or frozen (−20°C) shelf life. All patties were stored aerobically in zip-top polyethylene bags (Ziploc Storage Bags, 1 gallon, S. C. Johnson, Racine, WI) and placed in a cardboard box for dark storage.

Proximate Composition

Moisture and fat content were evaluated on samples taken from the raw coarse ground shoulder clod. For cooked samples, fat, moisture, protein, and ash content were evaluated. Fat content was determined as outlined by AOAC (AOAC, 1990b) using the Soxhlet extraction process. Moisture and ash were measured using thermo-gravimetric analysis (LECO Corporation, model 604–100–400). Protein was calculated by difference. All samples were run in duplicate.

Fatty Acid Composition

For fatty acid determination, fats were extracted following the procedures of Folch et al. (1957). Meat from raw patties was powdered by dipping in liquid nitrogen and blended in a Waring commercial blender (Model 51BL32, Waring Commercial, Torrington, CT) until a fine powder was created. One gram of powdered patties was mixed with 10 mL of 2:1 chloroform:methanol solution, vortexed, and rested at room temperature for 1 h. The resulting homogenate was filtered into new tubes, brought to 15 mL with 2:1 chloroform:methanol solution. Samples were mixed with 2 mL of 0.74% KCl solution, vortexed, purged with nitrogen gas, and kept in a −20°C freezer overnight to allow for phase separation. The next day, 2 mL of the lower phase was collected, placed under constant gas purging, and heated to 60°C until completely dried down. The fatty acid methyl esters were prepared as described by Morrison and Smith (1964) and Metcalfe et al. (1966). Fatty acid profiles were determined using gas chromatography (6890, Agilent Technologies, Santa Clara, CA) with a flame ionization detector (G1531–60690, Agilent Technologies). A Chrompack CP-Sil 88 (0.25 mm × 100 m) column (Agilent Technologies) with helium as the carrier gas and a flow rate of 1.1 mL/min was used. The injector