Effect of Feeding Distillers Grains and Supplementing with Dietary Antioxidants on Ground Beef Shelf Life and Fatty Acid Profile

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Summary

Ground beef from cattle fed corn-based diets with no wet distillers grains, wet distillers grains plus solubles, wet distillers grains + 1000 IU/hd/d vitamin E, wet distillers grains + 150 ppm/hd/d, Ethoxyquin/TBHQ (Agrado Plus, Novus International, St. Louis, MO), or wet distillers grains + 500 IU/hd/d vitamin E + 150 ppm/hd/d Ethoxyquin/TBHQ during the finishing phase were compared to analyze lipid oxidation and fatty acid composition. All ground beef lipid oxidation (raw or cooked) increased over time. Raw beef samples from cattle supplemented vitamin E sustained lower TBARS values than corn after 2 d of simulated retail display. An increase in PUFA and C18:2 was observed in lean and composite fatty acids in WDGS versus corn finished cattle. The potential susceptibility to oxidation found by feeding distillers grains was counteracted by supplementation of Vitamin E in the diet.

Introduction

From each 56 lb. bushel of corn used in dry-mill ethanol production, about 17 lb. of distillers grains (DGS) is available for livestock feed and beef cattle account for nearly half of this consumption. As a result of the rapid growth of the ethanol industry, many cattle producers include ethanol by-products in cattle diets. Previous research has reported that steaks from cattle fed wet distillers grains plus solubles (WDGS) have increased concentrations of poly-unsaturated fatty acids (PUFA), and have decreased oxidative stability. Grinding of beef products disrupts the membranes that contain greater concentrations of PUFA and allows increased exposure to oxygen, thus increasing the rate of lipid oxidation. Furthermore, cooking beef increases lipid oxidation by release of free and heme iron from myoglobin. In turn, this decreases overall desirability by increasing "warmed over" or "rancid" flavors. Therefore, the objective of this trial was to evaluate the effect of feeding distillers grains and the addition of dietary antioxidants during the finishing phase on ground beef lipid oxidation and fatty acid composition.

Procedure

Cattle (n = 100) were randomly assigned to one of five finishing diets: corn-based diet with no WDGS (CON), WDGS (30% DM Basis), WDGS + 1000 IU/hd/d vitamin E (WDGSE), WDGS + 150 ppm/hd/d Agrado Plus (WDGSA), or WDGS + 500 IU/hd/d vitamin E + 150 ppm/hd/d Agrado Plus (WDGSAE). At the conclusion of the finishing phase, cattle were harvested at commercial abattoir. Forty-eight h post-harvest, seven USDA Choice beef shoulder clods from each dietary treatment group were collected from the right side of carcasses, vacuum packaged, and shipped to the University of Nebraska Loeffel Meat Laboratory. On d 14, subcutaneous fat, lean and ground composite samples were collected from each shoulder clod for fatty acid analysis. Shoulder clods were independently ground. From each shoulder clod, 4 oz. patties using a manual, single-patty press were formed to evaluate raw ground beef. A piston stuffer with a Colosimo press attachment was used to make skinless links to evaluate cooked ground beef products. Three raw beef patties from each shoulder clod were over-wrapped with oxygen permeable PVC film and placed under simulated retail display for 7 d at 37°F. During raw patty retail display, thiobarbituric reactive substances (TBARS) were evaluated as a measure of oxidation on d 0, 1, 2, 3, 5 and 7 using ½ of a beef patty per day of evaluation. For skinless links manufacture, beef was mixed with 0.75% salt and 0.25% sodium phosphate and cooked to an internal temperature of 160°F. Cooked beef links were placed in zip-top bags under refrigerated and frozen conditions. Refrigerated cooked links were analyzed for TBARS every 3 days beginning at d 0, and frozen links were evaluated every 28 d until 252 d of storage. Data were analyzed by treatment with repeated measures (day) utilizing the PROC GLIMMIX procedures of SAS.

Results

All fatty acid data are reported in Table 1. There was a treatment effect ($P \leq 0.03$) for the lean portions for C10:0, C17:0, C17:1, C18:1, C18:2 and PUFA. With the exception of C10:0, beef from the WDGS group possessed greater fatty acids (C17:0, C17:1, C18:1, C18:2 and PUFA). The lowest concentrations fatty acids concentrations were observed in beef from the control group.

A treatment effect ($P \leq 0.01$) was observed for fatty acid concentrations (C15:0, C16:0, C17:0, C17:1 and C18:2) within the subcutaneous fat samples. Subcutaneous fat from CON beef had lower ($P \leq 0.01$) concentrations of C15:0 and C17:1 compared to all other treatment groups. For C16:0, corn had greater ($P \leq 0.01$) concentrations than beef from WDGSE and WDGSAE; WDGSA and WDGS were intermediate. The CON group had lower ($P \leq 0.01$) concentrations of C17:0 than WDGS, WDGSE and WDGSAE. WDGS and WDGSE beef had greater ($P = 0.01$) concentrations of C18:2 than CON with WDGSA and WDGSAE similar to all treatments.

For the composite (ground) samples, a treatment effect ($P \leq 0.03$) was observed for C15:0, C16:1, C17:0, C17:1, C18:0, C18:1T, C18:2, C20:3ω6, UFA, SFA:UFA and PUFA. Fatty acid C15:0 and SFA:UFA in ground beef from a CON were lower ($P \leq 0.01$) than all other dietary treatments. Control ground beef samples also had lower ($P \leq 0.02$) concentrations of C17:0, C20:3ω6 and PUFA than WDGS finished cattle; the remaining treatment groups were similar. For C17:1, C18:1T and UFA, CON ground beef had lower ($P \leq 0.02$) concentrations than WDGS and WDGSE, with cattle supplemented Agrado having intermediate

Table 1. Effect of including wet distillers grain and supplementing with vitamin E and/or Agrado Plus during finishing on fatty acid composition (mg/100g raw sample) of beef shoulder clod composite, lean tissue and subcutaneous fat samples

Composite	Corn[d]	WDGS[e]	WDGSE[f]	WDGSA[g]	WDGSAE[h]	P-value
C15:0 (mg/100g)	81.01[k]	146.40[j]	131.17[j]	126.24[j]	124.21[j]	0.001
C16:1 (mg/100g)	718.66[j]	572.96[jk]	547.91[k]	599.76[jk]	516.59[k]	0.01
C17:0 (mg/100g)	283.23[k]	503.02[j]	468.45[jk]	389.71[jk]	429.57[jk]	0.014
C17:1 (mg/100g)	221.62[k]	337.27[j]	329.73[j]	298.64[jk]	310.38[jk]	0.022
C18:0 (mg/100g)	3013[jk]	3741[j]	3524[jk]	3001[jk]	2655[k]	0.027
C18:1T (mg/100g)	606[k]	1183[j]	1098[j]	888[jk]	943[jk]	0.003
C18:2 (mg/100g)	618[l]	1209[j]	1029[jk]	944[jk]	932[k]	< 0.001
C20:3w6 (mg/100g)	19.15[k]	25.69[j]	25.23[jk]	24.78[jk]	21.88[jk]	0.022
UFA (mg/100g)[a]	2956[k]	4190[j]	3937[j]	3557[jk]	3446[jk]	0.007
SFA:UFA (mg/100g)[b]	2.92[k]	2.33[k]	2.30[k]	2.35[k]	2.20[k]	< 0.001
PUFA (mg/100g)[c]	1569[k]	2241[j]	1973[jk]	1963[jk]	1875[jk]	0.003
Lean	Corn[d]	WDGS[e]	WDGSE[f]	WDGSA[g]	WDGSAE[h]	P-value
C10:0 (mg/100g)	2.44[jk]	2.75[jk]	4.52[j]	3.92[jk]	2.17[k]	0.019
C17:0 (mg/100g)	39.58[k]	158.56[k]	133.14[jk]	127.68[jk]	103.00[jk]	0.035
C17:1 (mg/100g)	40.84[k]	164.38[j]	82.31[jk]	139.53[jk]	105.12[jk]	0.013
C18:1 (mg/100g)	1505[k]	3269[j]	2069[jk]	3116[jk]	2186[jk]	0.032
C18:2 (mg/100g)	197.40[k]	490.97[j]	374.56[jk]	388.21[jk]	330.40[jk]	0.014
PUFA (mg/100g)[c]	242.86[k]	603.25[j]	458.07[jk]	489.24[jk]	474.71[jk]	0.043
Fat	Corn[d]	WDGS[e]	WDGSE[f]	WDGSA[g]	WDGSAE[h]	P-value
C15:0 (mg/100g)	469.14[k]	818.29[j]	742.71[j]	741.33[j]	930.83[j]	< 0.001
C16:0 (mg/100g)	22946[j]	20799[jk]	20175[k]	21704[jk]	19482[k]	0.002
C17:0 (mg/100g)	1148[k]	2334[j]	2358[j]	1838[jk]	2638[j]	< 0.001
C17:1 (mg/100g)	1535[k]	2549[j]	2389[j]	2336[j]	3005[j]	< 0.001
C18:2 (mg/100g)	1837[k]	3351[j]	3320[j]	2714[jk]	2818[jk]	0.013

[a]Unsaturated Fatty Acids: C14:1, C15:1, C16:1T, C16:1, C17:1, C18:1T, C18:1, C18:1V, C18:2TT, C18:2, C18:3ω3, C18:3ω6, C20:1, C20:3, C20:3ω6, C20:4, C20:5, C22:1, C22:4, C22:5.
[b]Saturated Fatty Acid to Unsaturated Fatty Acid Ratio.
[c]Polyunsaturated Fatty Acids: C18:2TT, C18:2, C18:3ω3, C18:3ω6, C20:1, C20:3, C20:3ω6, C20:4, C20:5, C22:1, C22:4, C22:5.
[d]Corn control finishing diet.
[e]Wet distillers grains at 30% DM inclusion.
[f]Wet distillers grains + 1000 IU/hd/d vitamin E.
[g]Wet distillers grains + 150 ppm/hd/d Agrado Plus.
[h]Wet distillers grains + 500 IU/hd/d vitamin E + 150 ppm/hd/d Agrado Plus.
[j-l]Means within a row without a common superscript are significantly different (P ≤ 0.05)

values. WDGSAE had lower ($P \leq 0.03$) concentrations of C18:0 than WDGS; WDGSA, WDGSE and CON values were intermediate. For C18:2, CON had the lowest ($P \leq 0.01$) concentrations than all dietary treatments, followed by WDGSAE. Ground beef from WDGS had the highest ($P \leq 0.01$) C18:2 concentrations, when compared to CON, WDGSE, WDGSA, and WDGSAE. Fatty acid C16:1 was the only fatty acid where higher ($P = 0.01$) concentrations were observed in CON ground beef than WDGS and WDGSE, with WDGSA and WDGSAE ground beef being intermediate.

A day x dietary treatment effect ($P = 0.03$) was observed for oxidation of raw patties. On 2–7 d of simulated retail display, the CON had higher ($P \leq 0.01$) TBARS values than the patties from WDGSE and WDGSAE treatment groups. On d 3 and 5, the CON patties were more ($P \leq 0.01$) oxidized than all other dietary treatments. On d 7 of simulated retail display, beef from WDGS displayed greater ($P \leq 0.01$) TBARS values than WDGSAE (Table 2). Beef from cattle fed all diets, with the exception of WDGSAE, displayed an increase in TBARS concentrations from 5–7 d (Table 2). The inclusion of vitamin E resulted in less ($P \leq 0.01$) lipid oxidation in patties than the patties from CON on d 2, 3, 5, and 7 (Table 2). A day of storage effect ($P = 0.01$, Table 3) was observed for lipid oxidation in cooked beef links in refrigerated storage where TBARS concentrations increased over time. A trend ($P = 0.10$) for dietary effect was observed, beef links from WDGSA beef tended to have higher TBARS values than the treatments groups. Regardless of treatment, frozen beef links had greater ($P \leq 0.01$) oxidation as d in storage increased (Figure 1). Treatment has no effects (P = 0.13) on TBAR concentrations.

An increase in C18:2 (linoleic acid) and PUFA was observed for all treatment groups containing WDGS in lean and ground samples. This did not directly related to amount of lipid oxidation in samples as TBARS concentrations patties from CON samples were among the most oxidized. A trend ($P = 0.10$) for refrigerated in cooked beef links suggests that cattle fed WDGSA had greater lipid oxidation than other dietary treatments and may be due to heating causing ethoxyquin to become oxidized, and acting as a pro-oxidant. These

dietary effects did not carry through to the frozen links, however, suggesting that frozen storage may reduce the pro-oxidant effect. Therefore, vitamin E supplementation may counteract against the susceptibility to oxidation found by feeding distillers grains in both cooked and raw ground beef.

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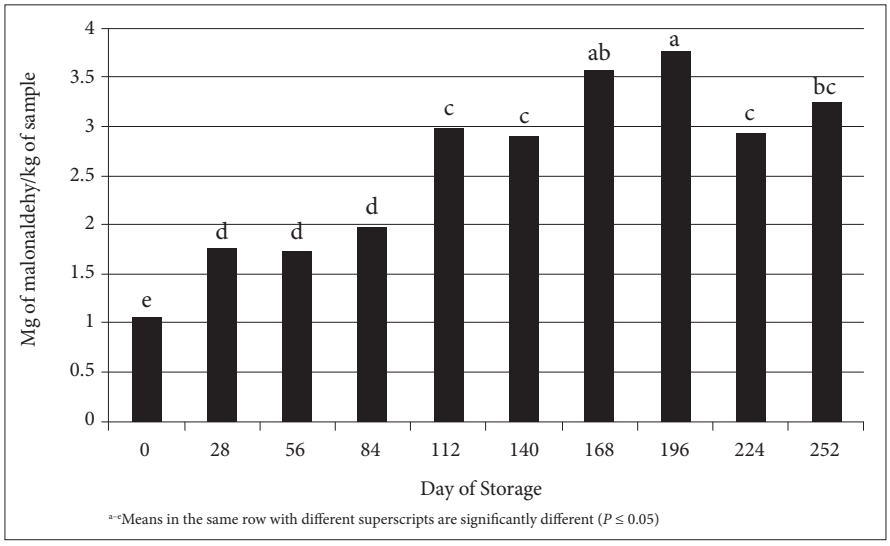

Figure 1. Effect of storage time on lipid oxidation (mg of malonaldehyde/kg of product) in frozen ready-to-eat beef links

Table 2. Interaction effects of dietary treatment and day of storage (P = 0.03) on lipid oxidation in raw ground beef patties from cattle fed finishing diets containing wet distillers grain and supplemented with vitamin E and/or Agrado Plus

Day[a]	Dietary Treatment				
	Corn[b]	WDGS[c]	WDGSE[d]	WDGSA[e]	WDGSAE[f]
0	1.6^{mn}	1.75^{lmn}	1.41^{n}	1.58^{mn}	1.51^{mn}
1	2.26^{klm}	1.45^{mn}	1.66^{lmn}	1.94^{lmn}	1.94^{lmn}
2	2.97^{jk}	2.16^{klm}	1.78^{lmn}	2.01^{klmn}	1.72^{lmn}
3	3.52^{ji}	2.35^{kl}	1.95^{lmn}	2.29^{kl}	1.88^{lmn}
5	4.51^{hi}	3.02^{jk}	2.28^{klm}	2.92^{jk}	2.12^{klmn}
7	5.94^{g}	5.24^{gh}	3.69^{hij}	4.58^{ghi}	3.21^{ijk}

[a]All values are reported as mg of malonaldehyde/kg of sample
[b]Corn control finishing diet
[c]Wet distillers grains at 30% DM inclusion
[d]Wet distillers grains + 1000 IU/hd/d vitamin E
[e]Wet distillers grains + 150 ppm/hd/d Agrado Plus
[f]Wet distillers grains + 500 IU/hd/d vitamin E + 150 ppm/hd/d Agrado Plus
[g-n]Means within the table without a common superscript are significantly different ($P \leq 0.05$)

Table 3. Effect of days of refrigerated storage on lipid oxidation in cooked beef links

Day	Thiobarbituric Acid Reactive Substances[a]
0	1.05^{g}
3	2.12^{f}
6	2.74^{de}
9	2.51^{ef}
12	3.79^{cd}
15	4.17^{bc}
18	4.88^{b}

[a]mg of malonaldehyde/kg of sample
[b-g]Means in the same column without a common superscript are significantly different ($P \leq 0.05$)