Effects of Dietary Antioxidant Supplementation on Cattle Finished with 30% Wet Distillers Grains Plus Solubles on Fatty Acid Profiles and Display Life

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Summary

Steers were finished on either 0% wet distillers grains plus solubles or 30% wet distillers grains plus solubles with four antioxidant treatments to evaluate the effects of finishing diets containing wet distillers grains plus solubles, vitamin E and Agrado Plus on beef fatty acid profiles, discoloration and lipid oxidation of retail-displayed beef. The inclusion of 30% wet distillers grains plus solubles increased total polyunsaturated fatty acids of beef, but did not promote discoloration or lipid oxidation compared to the 0% wet distillers grains plus solubles diet. In both diets, feeding vitamin E alone or vitamin E+ Agrado Plus was effective in reducing lipid oxidation and maintaining color stability, while supplementing Agrado Plus alone had minimal effects in improving lipid and color stability.

Introduction

Feeding wet distillers grains plus solubles (WDGS) in beef feedlot diets increases muscle tissue polyunsaturated fatty acids (PUFA) concentration (2008 *Nebraska Beef Cattle Report*, pp.120–121) and decreases beef display life, while feeding antioxidants like vitamin E (E; 2009 *Nebraska Beef Cattle Report*, pp.116–117) and Agrado Plus (AG; Novus International; 2011 *Nebraska Beef Cattle Report*, pp.103–104) have been shown to mitigate such effects. Vitamin E is a well-studied fat soluble antioxidant that has been reported to improve marketability of fresh meat products through delaying lipid and muscle pigment oxidation. Furthermore, AG is a mixture of synthetic antioxidants ethoxyquin and tertiary butylhydroquinone (TBHQ) and has been used in the industry as a dietary lipid preservative. Research has shown that E is stabilized when AG is added to the feed, which may create an additive antioxidant effect when the two antioxidants are fed in combination. However, there are no available data on the synergistic relationship that E and AG may have in regard to beef quality. Therefore, it is important to investigate the effects of WDGS and the combination of E and AG on muscle tissue fatty acids and redox potential to understand the overall changes of beef shelf-life resulting from diet modifications.

Procedure

One hundred and sixty Continental x British steers were blocked by BW, stratified by BW within each block, and assigned randomly to pens within block. Pens were randomly assigned to one of the eight treatments with two pens/treatment and 10 head/pen. Cattle were fed for 106 d on a corn-based diet with 0% WDGS or 30% WDGS (DM basis) with four dietary antioxidant treatments (control; E at 1,000 IU/hd/d; AG at 215 ppm of feed; a combination of E at 500 IU/hd/d and AG at 215 ppm of feed). It is important to note that although 0% WDGS-control, 0% WDGS+AG, 30% WDGS-control and 30% WDGS+AG treatments were not supplemented with additional E, 50 IU/hd/d of E was included in the mineral premix for all dietary treatments. For ease of comprehension, 0% WDGS-control, 0% WDGS+AG, 30% WDGS-control and 30% WDGS+AG treatments are referred as dietary treatments without additional E supplementation throughout this paper.

Ten strip loins (*Longissimus lumborum*) from each treatment (n = 80) were collected and aged for 2, 7, or 14 d. Steaks were removed from each loin at each aging period and placed under retail display conditions (36 ± 4°F, and exposed to continuous 1,000–1,800 lux warm white fluorescent lighting) for 0, 4, and 7 d. One steak was designated to evaluate daily objective color (a*-redness) and subjective discoloration scores (0% = no discoloration to 100% = full discoloration) during the 7 d retail display period. Steak samples designated for lipid oxidation (via thiobarbituric acid reactive substances assay [TBA]) were obtained on d 0, 4 and 7 of retail display for each aging period. Muscle tissue fatty acid profiles (via gas chromatography), E and ethoxyquin analyses (via high performance liquid chromatography) were obtained on d 0 of retail display after 14 d of aging. At the end of the allotted treatments, all samples were vacuum packaged and frozen at −112°F until analyzed.

Data were analyzed using the GLIMMIX procedure of SAS (version 9.2, Cary, NC, 2009). Data for TBA were analyzed as a split-split plot design with dietary treatments as the whole-plot, aging period as the split-plot and retail display time as the split-split plot. Color data were analyzed as a split-split-plot repeated measures design with dietary treatments as the whole-plot, aging period as the sub-plot and retail display d as the repeated measures. The E and ethoxyquin concentrations and fatty acid profiles were analyzed as a completely randomized design. Separation of means was conducted using LSMEANS procedure with PDIFF or SLICEDIFF options at $P \leq 0.05$.

Results

Feeding WDGS decreased ($P \leq 0.05$) the fatty acid proportions of 14:0, 14:1 and 16:1, but increased ($P \leq 0.05$) 15:0, 17:0, 17:1, 18:1 trans, 18:2, 20:1 and total PUFA in muscle when compared to the fatty acid profiles of steers fed 0% WDGS (Table 1). It is well known that the majority of the unsaturated fatty acids (UFA) are fermented and biohydrogenated to saturated fatty acids (SFA) in the rumen. However, WDGS has 3x the amount of PUFA compared to corn, which leads to greater absorption of

Table 1. Fatty acid profiles of strip steaks from steers fed a corn-based diet with 0% wet distillers grains plus solubles (WDGS) or 30% WDGS supplemented with or without vitamin E (E) or Agrado (AG) or a combination of E and AG

Fatty Acids, %	0% WDGS	0% WDGS+E	0% WDGS+AG	0% WDGS+E+AG	30% WDGS	30% WDGS+E	30% WDGS+AG	30% WDGS+E+AG	*P*-value
C14:0	2.00^{bcd}	2.34^{bc}	2.23^{bcd}	2.39^{b}	1.83^{cd}	1.73^{d}	2.01^{bcd}	1.73^{d}	≤ 0.01
C14:1	0.61^{bcd}	0.66^{bc}	0.60^{bcd}	0.68^{b}	0.45^{cd}	0.42^{d}	0.60^{bcd}	0.51^{bcd}	≤ 0.01
C15:0	0.42^{cd}	0.37^{d}	0.42^{cd}	0.47^{bcd}	0.60^{b}	0.52^{bcd}	0.59^{b}	0.53^{bc}	≤ 0.01
C15:1	0.67	0.63	0.56	0.62	0.52	0.52	0.53	0.59	0.25
C16:0	24.73	23.34	22.34	23.43	21.64	22.24	20.98	22.84	0.54
C16:1	2.17^{bc}	2.43^{bc}	2.69^{b}	2.73^{b}	1.91^{c}	2.01^{c}	2.25^{bc}	1.88^{c}	0.02
C17:0	1.48^{de}	1.27^{e}	1.42^{de}	1.65^{bcd}	2.43^{b}	2.14^{bcd}	1.93^{bcde}	2.28^{bc}	≤ 0.01
C17:1	1.01^{bc}	0.90^{c}	1.08^{bc}	1.16^{bc}	1.48^{b}	1.35^{bc}	1.51^{b}	1.33^{bc}	≤ 0.01
C18:0	14.95	13.82	13.15	14.25	15.33	16.76	13.12	15.19	0.37
C18:1T	2.02^{ed}	1.44^{e}	2.05^{cde}	1.85^{e}	3.50^{b}	3.25^{b}	3.03^{bcd}	3.15^{bc}	≤ 0.01
C18:1	32.36	34.52	36.23	34.17	33.14	34.29	34.63	31.47	0.84
C18:1V	1.07	1.22	1.44	1.27	1.09	1.04	1.25	1.16	0.19
C18:2	3.58^{cd}	3.09^{d}	3.39^{d}	3.60^{cd}	5.48^{b}	4.77^{bc}	4.87^{bc}	4.88^{bc}	≤ 0.01
C18:3	0.21	0.19	0.2	0.2	0.25	0.28	0.21	0.25	0.1
C20:1	0.49^{bc}	0.41^{bc}	0.43^{bc}	0.38^{c}	0.54^{bc}	0.59^{b}	0.64^{b}	0.50^{bc}	≤ 0.01
C20:3	0.27	0.25	0.26	0.28	0.24	0.24	0.23	0.27	0.63
C20:4	0.75	0.73	0.71	0.8	0.63	0.66	0.71	0.73	0.66
C22:5	0.29	0.22	0.2	0.21	0.17	0.17	0.18	0.22	0.06
SFA[a]	43.5	41.06	39.55	42.19	39.17	43.38	38.51	42.51	0.57
MUFA[a]	41.38	41.86	45.15	43.12	45.51	42.98	43.93	39.22	0.71
PUFA[a]	4.60^{c}	4.09^{c}	4.65^{c}	4.92^{bc}	6.58^{b}	5.68^{bc}	5.89^{bc}	5.85^{bc}	≤ 0.01

[a]SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, and PUFA = polyunsaturated fatty acids
[b–e]Within a row, means without a common superscript differ at $P \leq 0.05$.

PUFA in the duodenum, thus increased the deposition of PUFA in muscle tissue.

Least square means of a* and discoloration at d 7 of retail display are separated and ranked in Table 2. Although only steaks from 0% WDGS+E+AG and 30% WDGS+E+AG treatments had greater ($P \leq 0.05$) a* values compared to the steaks without E treatments, the trend that separated out the ones with E treatments and the ones without E treatments were evident on d 6 of retail display (data not shown). On d 7 of the retail display, all steaks from steers supplemented with E or the combination of E and AG had greater ($P \leq 0.05$) a* values than the steaks without E treatments with one exception. The a* values from 30% WDGS+AG treatments

Table 2. Ranking of objective redness (a*) and discoloration (average of all three aging periods) of strip steaks (*m. longissimus lumborum*) from steers fed a corn-based diet with 0% wet distillers grains plus solubles (WDGS) or 30% WDGS supplemented with or without vitamin E (E) or Agrado (AG) or a combination of E and AG after 7 d of retail display

Dietary treatments	a*	Dietary treatments	Discoloration, %
30% WDGS+E+AG	21.30^{a}	30% WDGS+E+AG	2.01^{b}
0% WDGS+E+AG	20.94^{a}	0% WDGS+E+AG	2.11^{b}
30% WDGS+E	20.69^{ab}	0% WDGS+E	2.29^{b}
0% WDGS+E	20.69^{ab}	30% WDGS+E	2.37^{b}
30% WDGS+AG	20.59^{ab}	30% WDGS+AG	3.92^{c}
0% WDGS+AG	19.89^{bc}	0% WDGS+AG	4.59^{ac}
0% WDGS	19.66^{c}	30% WDGS	4.68^{ac}
30% WDGS	19.37^{c}	0% WDGS	5.71^{a}
P-value	≤ 0.01	*P*-value	≤ 0.01

[a–c]Within a column, means without a common superscript differ at $P \leq 0.05$.

Table 3. Lipid oxidation value (TBA; malonaldehyde mg/kg of meat; average of all three aging periods), vitamin E (E; ug/g) and ethoxyquin (ug/100 g) concentrations of strip steaks (*m. longissimus lumborum*) from steers fed a corn-based diet with 0% wet distillers grains plus solubles (WDGS) or 30% WDGS supplemented with or without vitamin E (E) or Agrado (AG) or a combination of E and AG

	0% WDGS	0% WDGS+E	0% WDGS+AG	0% WDGS+E+AG	30% WDGS	30% WDGS+E	30% WDGS+AG	30% WDGS+E+AG	*P*-value
TBA									≤ 0.01
d 0	1.83^{a}	1.22^{ab}	1.17^{ab}	0.99^{b}	0.88^{b}	1.19^{ab}	1.19^{ab}	1.11^{ab}	
d 4	3.51^{a}	1.97^{bc}	2.36^{c}	1.36^{b}	1.73^{bc}	1.66^{bc}	1.82^{bc}	1.50^{b}	
d 7	5.04^{a}	2.45^{b}	3.71^{c}	1.65^{b}	2.99^{bc}	2.17^{b}	2.78^{b}	1.82^{b}	
Vitamin E	2.95^{cd}	5.20^{a}	2.18^{d}	4.49^{ab}	2.68^{cd}	5.09^{a}	3.67^{bc}	4.56^{ab}	≤ 0.01
Ethoxy-quin	0.04^{b}	0.00^{b}	0.32^{a}	0.36^{a}	0.08^{b}	0.00^{b}	0.29^{a}	0.31^{a}	≤ 0.01

$^{a-d}$Within a row, means without a common superscript differ at $P \leq 0.05$.

were greater ($P \leq 0.05$) compared to the a* values from the rest of the steaks without E treatment after 7 d of the retail display.

For discoloration, the trend that separated out the steaks from E treatments and the steaks from treatments without E could clearly be seen on d 6 of retail display. At d 7 of the retail display period, all steaks from steers supplemented with E or the combination of E and AG were less discolored ($P \leq 0.01$) than steaks from steers not supplemented with E. The E+AG and E supplementation alone were effective in this study to maintain both a* values and discoloration scores in steaks from steers fed 0% WDGS or 30% WDGS diets. Reduction in steak discoloration rates due to AG supplementation was only observed when steers were on 30% WDGS diets.

A reduction in oxidation rates due to E and/or AG supplementation was observed at all three retail display periods only when steers were fed the 0% WDGS diets ($P \leq 0.01$; Table 3). The effect of E, AG or the combination of E and AG in reducing lipid oxidation for beef steaks from 30% WDGS treatment is likely diminished because of the already low level of lipid oxidation of the control diet. Comparing diet effects without any antioxidant supplementation, steaks from steers fed 0% WDGS had greater lipid oxidation values compared to steaks from steers fed 30% WDGS ($P \leq 0.01$). Feeding 30% WDGS did not increase lipid oxidation values compared to feeding 0% WDGS. Feeding WDGS may cause a vitamin E-sparing effect by synthesizing sulfur-containing antioxidant peptides and thus reducing lipid oxidation.

Finally, E supplementation increased ($P \leq 0.01$) muscle tissue E concentrations compared to muscle tissue from steers without E supplementation (Table 3). It is interesting to note that 30% WDGS+AG samples had greater ($P \leq 0.05$) muscle tissue E concentrations compared to samples from 0% WDGS+AG, which demonstrated a minor E-sparing effect. Diets with AG supplementation also increased ($P \leq 0.05$) muscle tissue ethoxyquin concentrations compared to diets without AG supplementation (Table 3). These results suggest that increased PUFA content in muscle tissue does not promote lipid oxidation and discoloration, and discoloration and lipid oxidation can be effectively suppressed by the combination of E+AG or E supplementation alone, while supplementing AG alone had minimal effects in improving lipid and color stability.

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