Beef Quality following Prolonged Aging after Supplementing High Levels of Vitamin E

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Summary with Implications

Increased postmortem aging of beef can accelerate discoloration, shortening retail display time, inducing oxidation of lipids and proteins, and generating negative flavor attributes. This study was conducted to evaluate supplementation of high levels (2,200 International Units/head/day for 100 d) of Vitamin E (α-tocopherol) when feeding cattle as a strategy to sustain meat color quality in beef strip loins after prolonged aging. Results showed significantly less discoloration in loins from animals fed high levels of Vitamin E across 3, 6, and 9 weeks of aging. In addition, loins from cattle fed high levels of Vitamin E exhibited significantly greater redness (a) values across 3, 6, and 9 weeks of aging. Lastly, cattle fed Vitamin E exhibited significantly less lipid oxidation compared to control fed cattle at 3, 6, and 9 weeks of aging. Feeding high levels of Vitamin E to cattle sustains meat color and oxidative stability following prolonged aging, like what may occur during export.*

Introduction

Acceptable color of fresh beef in the retail case is major factor used by consumers when making purchasing decisions. In commodity export products, which undergo multiple weeks of vacuum-packaged aging, fresh beef is susceptible to accelerated discoloration and oxidation of lipids. This can result in reduced shelf life for fresh beef to be sold at its peak quality. Previous research has reported that daily supplementation of vitamin E (α —tocopherol) at 300 international units (IU) to feedlot cattle is an effective method to delay oxidative reactions in fresh beef. However, there is limited information on the impact of supplementing high Vitamin E (2,200 IU/head/day) on the quality of beef after prolonged aging like what occurs with exported products. Therefore, an investigation into cattle supplemented with levels of Vitamin E, across beef aged moderate to long periods of time may increase the understanding of meat quality as it relates to retaining ideal meat color in commodity export products.

Procedure

Cattle (n=150; 10/pen) across 15 pens were grain-finished and supplemented with 2,200 IU per day of Vitamin E as a dietary treatment for the final 100 days on feed. One Low-Choice strip loin (*Longissimus Lumborum*) was selected from a carcass from each pen along with fifteen Low-Choice strip loins selected from commercial packing plant production as a control treatment, totaling 15 loins per treatment (n = 30). Loins were split into three equal portions and sections were randomly assigned to 3, 6, or 9 weeks of wet aging using vacuum-packaging. After aging, loin sections were opened, and fabricated in the following manner. One, 1-inch thick steak was cut for instrumental color and subjective color analysis during 7 days of retail display. Fat caps from the 1-inch steaks were trimmed off, vacuum-packaged, and evaluated for fatty acid analysis. Two, half-inch steaks were also fabricated and cut in half [one half section for laboratory proximate analysis and three half sections for lipid oxidation after 0, 4, or 7 days of retail display]. After fabrication, all steaks to be used for retail display were placed on foam trays, overwrapped with oxygen permeable film, and placed under simulated retail display conditions up to 7 d at 37°F. The same fabrication scheme was used for all aging periods. Fatty acid profile was measured via gas chromatography. Proximate composition, including moisture and ash (%), were measured via Thermogravimetric Analyzer. Fat content was measured via ether extraction, and protein content was calculated by difference. Lipid oxidation was measured on steaks held at 0, 4, and 7 days of retail display (37°F with continuous florescent lighting) using Thiobarbituric acid reactive substance values (TBARS) methodology, calculated by the amount of mg of malonaldehyde per kg of muscle tissue. Instrumental color was measured using a colorimeter to record L* (lightness), a* (redness), and b* (yellowness) on steaks held for 7 days of retail display. Instrumental color was recorded daily. Delta E (overall color change over time) values were calculated using the following equation: $\Delta E=[(\Delta L^{*2})+(\Delta a^{*2})+(\Delta b^{*2})]^{0.5}$. Delta E was used to determine the overall color change from the initial (day 0) to the final (day 7) day of retail display. Subjective discoloration was also evaluated daily during retail display by a panel of five trained panelists using a percentage scale where 0% meant no discoloration and 100% meant complete surface discoloration.

Lipid oxidation (TBARS) data were analyzed as a split-split plot design with dietary treatment as the whole- plot, aging period as the split-plot and day of retail display as the split-split plot. The L*, a*, b* values and subjective discoloration data were analyzed as a split-split-plot design with day of retail display considered as a repeated measure. Fatty acid profile and proximate composition were analyzed as a completely randomized design. Loin was considered the experimental unit. Data were analyzed using the PROC GLIMMIX procedure of SAS with the LS MEANS statement. Statistical significance was determined at $P < 0.05$ with trends discussed when the P-value was between 0.051 and 0.10.

Results

Differences in subcutaneous fatty acid content (Table 1) were found ($P < 0.05$). Of interest, control loins had greater branched chain fatty acids (BCFA), cis-monounsaturated fatty acids (cis MUFA),

Table 1. Analysis of Proximate Composition and Subcutaneous fat of strip loins from cattle fed commercial diet with or without 2,200 IU of Vitamin E.

Variable	Treatment		SEM	*P*-value
Proximate Composition	Control	Vitamin E		
Protein	20.76[b]	23.43[a]	0.27	<.0001
Moisture	70.23	68.40	0.65	0.07
Fat	7.84	7.00	0.65	0.38
Ash	1.18	1.17	0.03	0.92
Fatty Acids Composite, %				
SFA	40.91[b]	43.52[a]	0.65	.008
BCFA	1.16[a]	0.96[b]	0.04	.0013
cis MUFA	48.41[a]	45.42[b]	0.83	.0168
t16:1	0.36[a]	0.32[b]	0.01	.0019
t18:1	3.30	4.10	0.31	.08
Atypical Dienes	0.48[a]	0.40[b]	0.02	.002
CLA	0.62[a]	0.50[b]	0.02	.0011
n-6 PUFA	2.83[a]	2.33[b]	0.13	.0096
n-3 PUFA	0.23[a]	0.19[b]	0.01	.0066

[a-b] Means within the same row with different superscripts denote dietary treatment differences ($P < 0.05$).

SFA: Saturated Fatty Acids

BCFA: Branch-Chained Fatty Acids

cis MUFA: cis-Monounsaturated Fatty Acids

t16:1: Trans isomers of 16:1—Palmitoleic Acid

t18:1: Trans isomers of 18:1—Oleic Acid

CLA: Conjugated Linoleic Acid

n-6/n-3: omega-6/omega-3

PUFA: Polyunsaturated Fatty Acid

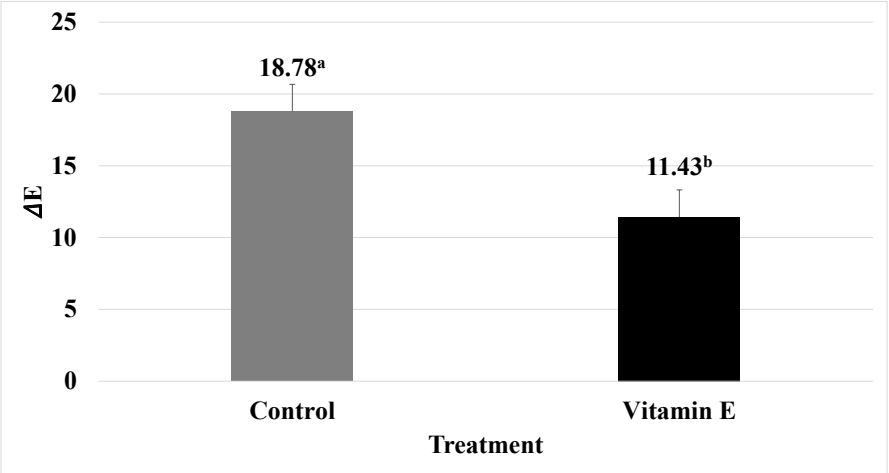

Figure 1: Delta E (ΔE) values of loins from cattle fed with or without Vitamin E [SEM: 1.89].

trans isomers of palmitoleic (16:1) and oleic (18:1) acid, atypical dienes, conjugated linoleic acid (CLA), and omega-6 and omega-3 polyunsaturated fatty acids (n-6/n-3 PUFA). Loins from cattle fed Vitamin E had greater saturated fatty acid (SFA) content. The increase in unsaturated fats in meat can increase the rate of oxidation of lipids and discoloration in meat. In addition, there was a significant difference ($P < 0.05$) in protein content (Table 1), as samples from cattle fed Vitamin E had greater protein composition compared to controls (23.43 and 20.76, respectively). While protein content was significant, it was calculated using the overall means of moisture, fat, and ash, and is of little practical significance to the overall scope of the study. Differences in fatty acid and proximate composition might be related to the different cattle populations sampled, as all control samples were randomly chosen by quality grade at the packing plant and the vitamin E-fed cattle were selected from a controlled population of cattle given their known dietary treatment.

Examining meat color, there were no differences ($P > 0.05$) in lightness (L*) values (Table 2). A dietary treatment x day of retail display interaction ($P < .0001$) in redness (a*) value was found, as steaks from Vitamin E-fed cattle exhibited greater, more acceptable red color throughout retail display compared to control samples. These data were supported by a significant difference ($P = .0008$) in delta E values, as Control loins had a larger delta E values compared to Vitamin E samples (18.78 and 11.43, respectively; Figure 1). Larger delta E values indicate a larger change in overall color over time. A dietary treatment x days of aging x days of retain display interaction ($P < .0001$) was found for subjective discoloration. In general, percent discoloration gradually increased as aging period and retail display increased, regardless of treatment type. Loins from cattle fed high levels of Vitamin E had significantly lower percent discoloration in steaks across 3, 6, and 9 weeks of aging. Given that meat is typically discounted when reaching 20% of discoloration, it was interesting to see that beef fed Vitamin E only surpassed this threshold after 6 days of retail display following 6 and 9 weeks of aging. The threshold was not exceeded for vitamin E samples

Table 2. Analysis of Objective Redness (L*, a*, b*) scores and Subjective Discoloration during Retail Display.

Variable	Treatment	Days of Retail Display								SEM	*P*-Value
		0	1	2	3	4	5	6	7		
L*[1]	Control	45.75	44.90	44.68	44.29	43.51	43.63	43.40	44.10	.89	.5708
	Vitamin E	46.70	45.84	45.45	45.54	45.00	44.40	44.15	43.83		
a*[1]	Control	20.51^{a}	20.21^{a}	18.77^{bc}	17.77^{d}	15.90^{e}	13.16^{f}	11.12^{g}	9.59^{h}	.31	<.0001
	Vitamin E	20.65^{a}	20.39^{a}	19.30^{b}	18.18^{cd}	17.39^{d}	15.64^{e}	13.15^{f}	11.98^{g}		
b*[1]	Control	9.30	9.48	8.88	8.68	8.13	7.97	7.88	7.81	.38	.10
	Vitamin E	10.14	10.24	9.65	9.34	9.12	8.78	8.32	7.82		

	Treatment	Age	Days of Retail Display								SEM	*P*-Value
			0	1	2	3	4	5	6	7		
Percent Discoloration (%)	Control	3	0.51^{E}	0.60^{E}	0.60^{E}	1.47^{E}	5.60^{E}	23.13^{CD}	29.71^{CD}	39.31^{C}	7.54	<.0001
	Vitamin E	3	0^{F}	0^{F}	0^{F}	0.04^{F}	0.38^{E}	0.56^{E}	3.71^{E}	13.22^{D}		
	Control	6	0^{F}	0^{F}	0.36^{F}	0.96^{E}	14.31^{D}	55.44^{B}	81.58^{A}	87.60^{A}		
	Vitamin E	6	0^{F}	0^{F}	0^{F}	0.13^{F}	1.18^{E}	8.69^{DE}	29.11^{CD}	52.89^{B}		
	Control	9	0^{F}	0.04^{F}	0.20^{F}	0.93^{E}	4.38^{E}	35.80^{C}	77.53^{AB}	95.29^{A}		
	Vitamin E	9	0.04^{F}	0.04^{F}	0.04^{F}	0.04^{F}	0.67^{E}	13.00^{D}	34.27^{C}	59.73^{B}		

[a-g] Means within the same variable with different superscripts denote treatment*day interactions ($p < 0.05$).[1 A-F] Means within the same variable with different superscripts denote dietary treatment x age x day differences ($p < 0.05$).

[1] L*: Black to white color space; 100 = light (white), 0 = dark (black); a*: Red to Green color space; + value (red),—value (green); b*: Yellow to blue color space; + value = yellow,—value = blue.

[2] SEM: Standard error of the Mean

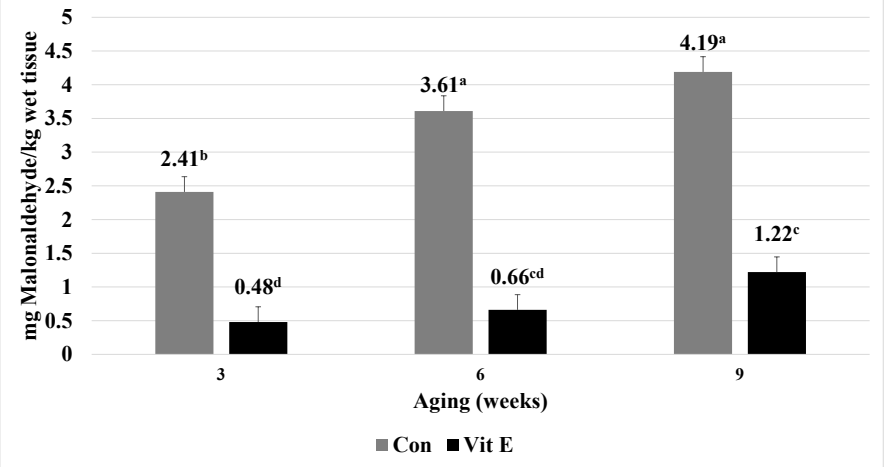

Figure 2: Thiobarbaturic Acid Reactive Substances (TBARS) of loins from cattle fed with or without Vitamin E [SEM (mg Malonaldehyde/kg wet tissue: 0.2263)].

with 3 weeks of aging. For comparison, control steaks surpassed 20% discoloration after 5 days of retail display regardless of aging period. Furthermore, a treatment x age interaction ($P = 0.03$) was found for lipid oxidation (Figure 2). Regardless of treatment, lipid oxidation increased as aging time increased. Beef from cattle supplemented with Vitamin E had less than one third the malonaldehyde content compared to control samples (1.22 and 4.19 mg per kg of wet tissue, respectively) after 9 weeks of aging.

Conclusions

Overall, supplementing high levels of Vitamin E to cattle maintained meat color and oxidative stability, as shown by greater redness (a*) scores, lower percentage discoloration and total color change (delta E), and reduced lipid oxidation. The results from this study provide an industry application for product which undergoes prolonged aging, as occurs during export, to be retain ideal meat quality.

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