

Effect of Salt, Trisodium Phosphate, Synthetic Antioxidants, and Conjugated Linoleic Acid on Instrumental Color Characteristics and Physical Characteristics of Beef Striploins of Different Quality Grades

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Story in Brief

USDA Select (n = 12) and Choice (n = 10) striploins were enhanced to examine the use of trisodium phosphate in combination with salt, synthetic antioxidants (butylated hydroxyl anisole/butylated hydroxytoluene; BHA/BHT), and conjugated linoleic acid (CLA). Treatments included: Choice control (n = 5, non-inject; CC), Choice inject (n = 5, 0.4% trisodium phosphate, 0.5% salt, and 0.006% BHA/BHT; CI), Select inject (n = 4, 0.4% trisodium phosphate, 0.5% salt, and 0.006% BHA/BHT); SI), Select inject + CLA (n = 4, 0.4% trisodium phosphate, 0.5% salt, 1.3% CLA, and 0.006% BHA/BHT; CL), and a Select control (n = 4, non-inject; SC). All injected treatments were injected at a pump rate of 10% of their original weight. No differences were found for a* (redness), b* (yellowness), hue angle (trueness of red), or saturation index (vividness). Steaks from treatments CI and SI had lower (P < 0.05) L* (lightness) values, and greater 630/580 nm ratios (oxymyoglobin proportion) than steaks from the other treatments. Retail purge was lower (P < 0.05) for enhanced treatments.

Introduction

The beef industry has for years sold steaks on a system that utilizes the amount of intramuscular fat (marbling) in the muscle to segregate carcasses based on palatability. In this system Prime is the highest quality followed by Choice, Select and Standard. Baublits et al. (2007) found that the addition of conjugated linoleic acid (CLA) could add artificial or what could be perceived as marbling to the meat. This is of great concern, not only due to the health benefits, but also due to the potential monetary benefits that it may have on the beef industry.

The benefits of phosphates and salt have been documented by many authors, showing that improvements in palatability and quality can be achieved. The high solution pH of trisodium phosphate could potentially stabilize color, and improve the water holding capacity of the muscle, which would improve the shelf life and yields respectively. The use of BHA/BHT (butylated hydroxyl anisole/butylated hydroxytoluene) to help stabilize color and retard oxidation may enhance the overall quality of the meat as well. Color is a very important factor of beef quality, and research efforts for maintaining and improving color are of great importance.

Therefore, the objectives of this trial were to examine effects of: 1) the use of trisodium phosphate and salt in combination with BHA/BHT, 2) the use of CLA to enhance marbling of Select steaks, and 3) directly compare enhanced steaks to Choice and Select control.

Experimental Procedures

Muscles. Beef striploins (IMPS 180; n = 22) were obtained from a commercial packing plant and transported to the University of Arkansas Red Meat Abattoir and aged for 14 days. Total make-up of the muscles was 10 Choice muscles and 12 Select muscles. Muscles were then frozen until use. Upon time of use, muscles were allowed to thaw for 5 days in a cooler at 33.8°F. Muscles were then removed from their vacuum packages and external fat and adjacent

muscles were removed. The 10 Choice muscles were randomly assigned to one of two treatments, while the 12 Select muscles were assigned to one of three treatments.

Treatments and solutions. The Choice muscles were assigned to either the Choice control (CC) treatment or the Choice inject (CI) treatment. The Select muscles were assigned to one of three treatments. Treatments included; Select control (SC), Select inject (SI) or Select inject plus CLA. The 2 control treatments were not injected and were used to compare within quality grade and also as a standard for between quality grades. The Select inject (SI) and Choice inject (CI) were injected at the same time with the same brine to examine effects of phosphate, salt, and BHA/BHT on differing quality grades. The 2 treatments were injected to a final product weight of 0.4% trisodium phosphate, 0.5% salt, and 0.0006% BHA/BHT. The Select inject plus CLA (CL) treatment group was injected with a solution containing 0.4% trisodium phosphate, 0.5% salt, 0.0006% BHA/BHT, and 1.3% CLA to examine the effects of CLA on the muscle. All treatments were injected to 110% of their original weight (10% pump).

Sample processing. After enhancement, muscle sections were then taken and cut into 1 in steaks for their respective analysis. Four steaks were placed on foam trays with absorbent pads and over-wrapped with polyvinyl chloride film with an oxygen transfer rate of 14,020 cc O₂/m²/24h/atm-60 gauge (Prime Source®, Koch Supplies, Inc., Kansas City, Mo.). Those steaks that were over-wrapped and designated for instrumental color, and TBARS (thio-barbituric reactive substances; an oxidation measure) were placed in display cases for simulated retail conditions (4°C; deluxe warm white fluorescent lighting, 1600 lx, Philips, Inc., Somerset, N.J.) for 7 days.

TBARS. Thiobarbituric acid reactive substances assays were performed on days 0, 3, and 6 (n = 22) using the method described by Jimenez-Villarreal et al. (2003). In brief, 2 mg of meat was homogenized with 8 ml of cold (2°C) 50 mM phosphate buffer mix standardized to a pH of 7 and containing 0.1% EDTA and 0.1% propyl gallate and 2 ml of trichloroacetic acid (Sigma, St. Louis, Mo.). This was followed by filtration through Whatman No. 4 filter

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paper. Then, 2 ml of clear supernatant was transferred in duplicate into 10 ml borosilicate tubes, 2 ml of 0.02 M 2-thiobarbituric acid reagent (Sigma, St. Louis, Mo.) was added, and then boiled for 20 min. Upon cooking completion, tubes were placed in an ice bath for approximately 15 min and allowed to cool. Samples were read using a spectrophotometer (Shimadzu Scientific Instruments, Inc., model UV-12015, Japan) at 533 nm. The absorbency was then multiplied using a factor of 12.21 to attain the TBARS value (mg malonaldehyde/kg of meat).

Instrumental color and purge. Instrumental color readings of steaks placed under retail display conditions were measured using a Hunter Miniscan XE (Model 45/0-L, Hunter Associates Laboratory, Inc., Reston, Va.). The CIE L*, a*, and b* were determined from 3 random readings from the surface of each steak using Illuminant A and a/10° standard observer. Hue angle was calculated using $\tan^{-1}(b^*/a^*)$, and saturation index was calculated by square root ($a^{*2} + b^{*2}$).

Purge was calculated taking the initial weight of the steak before being placed on the tray. After 7 days of display (0 – 6), steaks were reweighed. The weight was then subtracted from the original weight, divided by the original weight, and multiplied by 100 to represent percent purge during days of retail display.

Statistical analysis. All data were analyzed using PROC MIXED of SAS (SAS Inst., Inc., Cary, N.C.). The model included muscle, treatment, day, and treatment by day interaction. Treatment and day were considered fixed, and muscle was a random effect. Least squares means were generated using the LSMEANS / PDIF option of SAS, and main effect means are presented.

Results and Discussion

Retail purge. Means for retail purge are presented in Table 1. Steaks from treatments CC and SC were not different ($P > 0.05$) from each other as expected, and steaks from treatments CI, SI, and CL were not different from each other as expected. However, steaks from enhanced treatments were different ($P < 0.05$) from steaks from the 2 controls. Pietrasik et al. (2006) found that injected beef and bison steaks had significantly less purge than control non-injected steaks.

TBARS. Least squares means for TBARS are presented in Table 1. There were no treatment differences for TBARS, however, day was a significant effect with days 0 and 3 not being different ($P > 0.05$) from each other and day 6 being different ($P < 0.05$) from the other 2 days. The day effect is due to the increased storage time increasing the amount of oxidation within the meat. The absence of treatment differences is most likely due to the fact that all injected treatments had an antioxidant, which helps to reduce oxidation. Additionally, the added phosphate most likely helped to stabilize the complex and keep the injected treatments closer to the control.

Instrumental color. Means for instrumental color characteristics are presented in Table 2. There were no differences ($P > 0.05$)

among treatments for b* (yellowness) values, a* (redness) values, hue angle and saturation index. This is attributed to the ability of phosphates and antioxidants preserving color within the muscle. There were differences in day, however, for all color measures. There were general declines in b*, a*, saturation index, and 630/580 nm ratio with all days within an effect being different ($P < 0.05$). Hue angle had a general increase in value, which is expected, with all days being different ($P < 0.05$) from each other.

There were differences for L* (lightness) values and 630/580 nm ratios. In regards to L* values, steaks from treatments CI, SI, and SC were not different ($P > 0.05$); steaks from SC, CC, and CI were not different; and steaks from CC, SC, and CL were not different ($P > 0.05$). Steaks on treatment CL did differ ($P < 0.05$) from steaks on treatments CI and SI for these traits. This is thought to be the action of CLA adding artificial marbling to the muscle, lightening the appearance, and increasing the reflectance. Day was also a significant effect, with steaks on day 0 being different ($P < 0.05$) from steaks on the other days, and steaks on day 6 being different ($P < 0.05$) from steaks on the other days. Steaks on days 2 and 4 were the same ($P > 0.05$) for these traits, but differed ($P < 0.05$) from steaks on the other 2 days. The 630/580 nm ratios for steaks from treatments CC, SC and CL were not different ($P > 0.05$), and steaks from treatments CI and SI were not different ($P > 0.05$). Baublits et al. (2006) found that the salt and phosphate combination allowed for similar a* values, saturation index, and 630/580 nm ratios, but different L* values, b* values, and Hue angle.

The reasoning for the treatments remaining similar to the control for instrumental color could be the action the BHA and BHT in the solutions. The two antioxidants are free radical scavengers and help to stabilize the meat/lipid/myoglobin complex that can help to maintain color.

Implications

Inclusion of trisodium phosphate, salt and CLA with BHA/BHT has the ability to increase L* values of the meat without increasing oxidation or retail purge. Enhancement in general from this trial did not affect oxidation, and did decrease purge while in display. Enhancement did not have adverse effects on the color characteristics of the beef.

Literature Cited

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Table 1. Least squares means ± standard error for physical characteristics of beef striploins.

Treatment	TBARS ¹	Retail purge (%)
Choice control ²	0.28 ± 0.020	5.98 ^a ± 0.29
Choice inject ³	0.26 ± 0.020	4.02 ^a ± 0.29
Select + CLA ⁴	0.24 ± 0.022	4.14 ^a ± 0.32
Select inject ²	0.25 ± 0.022	3.69 ^a ± 0.32
Select control ¹	0.26 ± 0.022	5.66 ^a ± 0.32
Day	L*	Hue angle ²
0	44.38 ^{ab} ± 1.14	41.45 ^{ab} ± 0.98
3	41.49 ^c ± 1.14	40.69 ^{bc} ± 0.98
6	45.83 ^a ± 1.27	41.09 ^{abc} ± 0.42
	40.35 ^c ± 1.27	40.44 ^c ± 0.42
	43.67 ^a ± 1.27	41.66 ^a ± 0.42

¹TBARS: Thiobarbituric acid reactive substances (TBARS); units of measures are presented as ppm malonaldehyde/wet tissue.

²Controls – non-injected controls; no solutions added.

³Steaks were injected to a final weight of 0.4% trisodium phosphate, 0.5% salt, and 0.0006% BHA/BHT (butylated hydroxyl anisole/butylated hydroxytoluene).

⁴Steaks were injected to a final weight of 0.4% trisodium phosphate, 0.5% salt, 0.0006% BHA/BHT and 1.3% conjugated linoleic acid (CLA).

^{a,b}Means, within column and effect, with no superscript in common differ (P < 0.05).

Table 2. Least squares means ± standard error for instrumental color characteristics of enhanced beef striping steaks¹.

Treatment	b*	a*	L*	Hue angle ²	Saturation index ³	630/580nm ⁴
Choice control ⁵	21.00 ± 0.40	24.21 ± 0.64	44.38 ^{ab} ± 1.14	41.45 ^{ab} ± 0.98	32.20 ± 0.73	3.80 ^b ± 0.12
Choice inject ⁶	20.84 ± 0.40	24.62 ± 0.64	41.49 ^c ± 1.14	40.69 ^{bc} ± 0.98	32.30 ± 0.73	4.38 ^a ± 0.12
Select + CLA ⁷	21.19 ± 0.43	24.57 ± 0.69	45.83 ^a ± 1.27	41.09 ^{abc} ± 0.42	32.48 ± 0.79	3.90 ^b ± 0.13
Select inject ⁶	20.83 ± 0.43	24.71 ± 0.69	40.35 ^c ± 1.27	40.44 ^c ± 0.42	32.35 ± 0.79	4.40 ^a ± 0.13
Select control ⁵	21.13 ± 0.43	24.00 ± 0.69	43.67 ^a ± 1.27	41.66 ^a ± 0.42	32.00 ± 0.79	3.75 ^b ± 0.13
Day	b*	a*	L*	Hue angle ²	Saturation index ³	630/580nm ⁴
0	23.56 ^a	29.51 ^a	44.43 ^a	38.60 ^d	37.77 ^a	5.75 ^a
2	21.98 ^b	25.56 ^b	42.62 ^b	39.92 ^c	33.33 ^b	4.33 ^b
4	20.24 ^c	23.02 ^c	42.33 ^b	71.35 ^b	30.65 ^c	3.50 ^c
6	18.97 ^d	19.60 ^d	43.18 ^b	44.40 ^a	27.31 ^d	2.60 ^d
SEM	0.33	0.56	0.674	0.355	0.62	0.113

¹a*: -60= green, +60 = red; b*: -60= blue, +60= yellow; L*: 0= black, 100= white; Saturation index: higher values indicate greater vividness of red; 630/580 nm: oxymyoglobin to metmyoglobin proportion, Hue angle is the trueeness of red with lower values indicating a truer red color.

²Hue angle calculated as: $\tan^{-1}(b^*/a^*)$.

³Saturation index calculated as: $\sqrt{a^{*2} + b^{*2}}$.

⁴Oxymyoglobin to metmyoglobin ratio calculated as: 630/580 nm.

⁵Controls – non-injected controls; no solutions added.

⁶Steaks were injected to a final weight of 0.4% trisodium phosphate, 0.5% salt, and 0.0006% BHA/BHT (butylated hydroxyl anisole/butylated hydroxytoluene).

⁷Steaks were injected to a final weight of 0.4% trisodium phosphate, 0.5% salt, 0.0006% BHA/BHT and 1.3% conjugated linoleic acid (CLA).

^{a,b,c} Within a column, within an effect, means with no superscript in common differ (P < 0.05).