Topical Application of Rosemary can alter the Surface Color Characteristics of Beef Strip loins during Simulated Retail Display Conditions

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Abstract

*Beef striploins (NAMP 180) were purchased from a commercial processor3 d post fabrication and assigned to a storage temperaturefor 7 d. Following storage,subprimalswere cut into equal halves and allotted to either control (0%) or test (0.25% Rosemary). A 25% solution of water and rosemary was applied topically to steaks at 0.25% of steak weight.The application of rosemary did not alterTBAR values (P> 0.05)following altered storage temperatures. Steaks treated with rosemary were less red (a * values) and contained less surface discoloration (P < 0.05). There were no differences (P > 0.05) in b* values across treatments. Whereas, oxymyoglobin decreased (P < 0.05) throughout the retail display period, but no differences across treatments occurred after d 0. The topical addition of rosemary created limited effects on surface color of beef striploin steaks following altered storage temperatures during a simulated retail display period.*

Keywords: beef, striploin, antioxidant, sensory color, instrumental color,TBARS

1.0 Introduction

Oxidative deterioration is a significant factor contributing to the limited shelf life of foods and is of great economic concern to the meat industry. As lipid-containing foods are stored, oxidation causes the development of objectionable colors and therefore, decreases acceptability of the products over time (Cottone, 2009). Herbs and spices have been used for many centuries to improve sensory characteristics and to extend the shelf life of fresh meat products (Shahidi et al., 1992). Presently, retail consumers do not have methods to estimate tenderness, juiciness or flavor of meat products at the time of purchase (Kropf, 1993). Therefore, the utilization of herbs and spices can further delay the rate at which oxidation occurs. Many herbs and spices contain antioxidantcomponents which limits the rate at which lipid oxidation occurs (Fennema, 1996). Within the past ten years, the use of natural antioxidants has grown significantly due to the overwhelming decreasein consumer acceptability of synthetic antioxidants (Mielche, 1994).

Rosemary and vitamin C have altered metmyoglobin formation and lipid oxidation, as well as microbial growth further extending the retail display period of products from ten to twenty days (Djenane et al., 2003). Other spices are used primarily for their flavoring properties (Chipault et al., 1956). Recent applications bySebranek et al. (2005), in raw frozen sausage with a rosemary extract was more effectivethan BHA/BHT for preventing increases in TBAR values or loss of red color (lower instrumental a*values). Therefore, the objectives of this study were to investigate the topical application of Rosemary to beef striploin steaks following a temperature abusive storage period (0.55 °C and 6.1 °C).

2.0 Materials and Methods

2.1Muscle Fabrication

Vacuum-packaged beef subprimals, (LongissimusLumborum, LL North American Meat Processors Association Number, NAMP 180) were purchased from a major beef packing facility (Tyson Foods Inc., Springdale, AR, USA) and transported to the Tarleton State University Meat Laboratory, where the box date was recorded, and subprimals cut into equal halves. Striploin sections were vacuum packaged, and placed into the respective storage temperatures (0.55 °C or 6.1 °C) for 7 d in the absence of light to stimulate a traditional distribution process.

At the end of the 7 d storage period, striploin sections were removed from their respective packages and weighed. Beef striploinsubprimals (N=20) were fabricated into six 2.54-cm-thick steaks (n=60/trt) using a Hobart meat slicer (Model 3818, Troy, OH, USA) , placed onto a styrofoam tray (# 2, Sealed Air Corp, Cryovac Food Packaging Division, Duncan, SC, USA)with a soaker pad.Steaks assigned to treatment with topical rosemary received 0.25% of steak green weight of a 25% rosemary solution applied with a hand-held sprayer to the steak surface, over-wrapped with a poly-vinyl chloride film (O_2 transmission rate= 14,000 cc $O_2/m^2/24h/atm$; Koch Supplies Inc, Kansas City, MO, USA) and individually identified. Steaks were randomly allotted to laboratory analysis, and analyzed for instrumental and visual color, moisture retention, and thiobarbaturic reactive acid substances (TBARS). Steaks were placed into a three-tiered retail display case set at 2 ºC and under 1,600 lux deluxe warm white fluorescent lighting (Philips Inc., Somerset, NJ, USA).

2.2 Sensory Visual Color

A six member, trained sensory panelwas used to evaluate the surface color of steaks at 1800 hours on d 0, 3, 5, and 7of simulated retail display. Panelists were given a formal ballot with color anchors and instructed to record their color evaluations using the following anchors for lean color, amount of browning, surface discoloration, fat discoloration, and overall color using AMSA (1991) color panel evaluation guidelines.

2.3 Instrumental Color

Instrumental color readings (L*, a*, and b*), were determined from a mean of 3 random readings on the surface of each steak taken once daily at 1800 hours on d 0, 3, 5, and 7 of simulated retail display using a Hunter MiniScan XE (Mo. 45/0-L. Reston, VA, USA.). Additionally, instrumental color values were used in the calculation of hue angle as: $\tan^{-1}(b^*/a^*)$, and chroma$(a^{*2}+b^{*2})^{1/2}$ (AMSA,1991). The colorimeter was calibrated each day before data collection against a standard white tile and a standard black tile.

2.4Thiobarbaturic Acid Reactive Substance

Steaks assigned to measure purge loss and 2- thiobarbituric acid reactive substance (TBARS) were removed from retail display on d 0, 3, 5, and 7, weighed and purge loss calculated as: (d 0 weight – final day weight (3, 5, or 7) ÷ d 0 weight × 100))). Immediately after measuring steaks for purge loss, each steak was individually identified, vacuum packaged, and frozen at -20 °C until TBAR analysis could be completed. On the day of analysis, steaks were thawed at 4 °C for 16 hours.TBAR samples were analyzed using procedures outlined by Beuge&Aust (1978) with absorbance measured at 533 nm using a spectrophotometer (Thermo Fisher Scientific., model Genesys 10 UV, Waltham, MA, USA) and values multiplied using a factor of 12.21 to obtain the TBARS mg malonaldehyde/kg of meat.

2.5Statistical Analysis

Data were analyzed using the Mixed procedures of SAS (SAS Institute, Inc. Cary, NC). All data were analyzed as a completely randomized design with striploin section serving as the experimental unit. The analysis of variance was generated using the mixed models procedure, with treatment as the lone fixed effect and replication as the lone random effect in the model for instrumental color, TBARS, and purge loss. Sensory session and day were included in the model and fit with all main and interactive effects for sensory color variables, whereas panelist was also included in the model as a random effect for all visually evaluated variables to account for panelist variation. Least squares means were generated, and, when significant F-values were observed ($P < 0.05$), least squares means were separated using pair-wise t-test (PDIFF option).

3.0 Results and Discussion

3.1 Visual Color

A 2-way interaction occurred ($P < 0.05$) for surface discoloration, overall color, and lean color sensory ratingsof steaks (Table 1). Despite slight improvements in surface color, control steaks stored at 6.1 ºC were the least discolored when compared to all other steaks and treatments ($P < 0.05$) throughout the retail display period. Discoloration occurred on the rosemary treated and steaks stored at colder temperatures that resulted in ratings equal to 60% or more discoloration often indicative of total consumer discrimination.Rosemary improved ($P < 0.05$) surface discoloration ratings from d 3 through d 5 of the retail display period. Whereas, overall color ratings were greater ($P < 0.05$) for steaks treated with Rosemary on d 7 of the retail display period. Moreover, it appears that the colder storage temperatures and rosemary resulted in greater overall color scores by sensory panelists.However, lean color ratings by sensory panelists indicated control steaks stored at 6.1 °C were brighter ($P < 0.05$) throughout the entire retail display period regard of Rosemary application or storage temperature.

A two-way interaction ($P < 0.05$) occurred for sensory color ratings of surface browning and fat discoloration (Table 2). Steaks originating from sub-primals stored at colder temperatures had more ($P < 0.05$) surface browningfrom d 5 through d 7 of the retail period. Similarly, steaks receiving a topical application of rosemary were browner ($P < 0.05$) than control steaks from d 3 through d 7 of the simulated retail period.

The comparison byJeremiah et al. (1972) of visual sensory and consumer desirability suggeststhat steaks with greater sensory ratings by visual sensory panelists are also rated more desirable by consumers.It is possible that rosemary treated steaks stored in a warmer (6.1 ºC) storage temperature may have allowed for greater exposure of the steak surface to the rosemary application where by allowing the ingredient to penetrate the muscle surface. Therefore, the antioxidant properties of Rosemary interacted with myoglobin allowing for less oxidation and less surface discoloration ratings by sensory panelists. Increasing surface discoloration throughout the retail displayperiod occurred regardless of rosemary application, traditional applications (i.e. marination) are perhaps preferred for limiting lipid oxidation through the use of rosemary. Moreover, sensory ratings of surface discoloration and color of steaks from the current study tend to agree with Jakobsen et al. (2000), in as much that warmer temperatures (>8°C) have less color stability than product stored at chilled temperatures (< 4 °C).

Kropf (1980) reported temperatures in retail display cases can often vary by 4.5 °C from the air inlet to the air discharge. Higher shelves are frequently warmer than those lower in multiple shelf display cases. This could provide a greater understanding of the sensory color ratings panelists recorded in this experiment. In using a three-tiered display case, the air flow or temperature differences within the display case might have caused steaks to appear more discolored on the shelves farther from the air inlets, whereas the steaks on shelves closer to the cooler air could have kept the steak colder whereby the surface color could remain brighter.

3.2 Instrumental Color

Total color (chroma) of striploin steaks was not altered (P > 0.05) by the addition of rosemary to the surface of the steak at the time of cutting and packaging (Table 3). However, steaks from subprimals stored at colder (0.55 °C) distribution temperatures had greater chroma values during the initial days of the retail display period (d 0 through 3, Table 4). The greater chroma values after d 3 for steaks from colder subprimals decreased quickly on d 5 and the steaks from warmer stored subprimals resulted in greater chroma values for the remainder of the display period (d 5 through 7, Table 4). Largerchroma values are indicative of a greater amount of color on the meat surface and it is plausible that as the display period lengthened steak temperature increased causing a greater loss of myoglobin and a subsequent decrease in chroma values.

Hue angles for steaks increased from d 3 to d 5 of simulated retail display indicating a shift from the true red color of the steak's surface (Table 3). Furthermore, rosemary application did not alter the steak surface as indicated by no difference (P > 0.05) in hue angles instrumental values. However, hue angle increased (P < 0.05) for steaks from subprimals stored in colder temperatures during the 7 d abuse period (0.55 °C).

The interaction between treatment and day of retail display on a* are reported in Figure 1.Redness values (a*) which inherently decrease overtime, control steaks were redder on d 0 (P < 0.05) and again on d 7, than steaks receiving topical Rosemary throughout the retail display period. Rosemary application in fresh meats can limit the surface color deterioration (i.e. stabilize redness values), however the method utilized during this experiment appears to limit the effectiveness of the ingredient. Rennere et al. (1993) concluded that the application of rosemary and vitamin C can lower formation of metmyoglobin which gives meat a brown color. When considering storage temperature and day of simulated retail display, a decrease in a* values can also be seen. Jakobsen et al. (2000) also reports a decrease in a* values with increasing temperatures. Initially, (d 0 through 3) there were difference (P > 0.05) in a* values for the interactive effects of temperature and day of retail display. However, from d 5 through d 7, steaks abused at 6.1°C prior to retail display had greater a* values (Figure 2).Larger instrumental a* values are indicative of a redder color on the steak surface and could influence consumer purchase intent to an even greater extent.

There were no (P > 0.05) differences in yellowness (b*) values across treatments during the retail display period (Figure 3).However, oxymyoglobin (spectral ratio of 630:580) values were greater (P < 0.05) on d 0 for control steaks but values did not differ from d 3 to the end of the retail period(Figure 4). It appears that on d 0 the topical application of rosemary hindered the rate at which myoglobin binding with oxygen could occur (hence lower oxymyoglobin values). Moreover, with polyvinyl chloride packaged meat, oxymyoglobin can be completely oxidized to metmyoglobin in less than 4 d leaving a brown color for the remainder of retail display (Pierson et al., 1970). Rosemary, can be influential in prolonging the surface color of fresh meats as evidence of its wide use throughout the retail sector within today's industry. However, during this study the implications of rosemary on surface color improvements were minimal. The minimal effects could be attributed to the application of the ingredient as a topical solution instead of a solution enhancement within the muscle fibers. Whereby, the active mechanisms of the ingredient could not fully reach the myoglobin molecule and provide a positive influence on the meat surface color.

Storage of boxed beef subprimals has been noted to occur in temperatures from 1°C to 10°C (Gill et al., 2002). Many other authors agree that storing beef cuts at warmer temperatures can elicit changes in shear force values (Minks and Strinker 1972; Pierson and Fox 1976; and Herrera-Mendez et al., 2005). It has been suggested by King et al. (2009) that a tremendous amount of protelytic degradation can occur when beef samples are stored in warmer temperatures. Ultimately these temperatures can lead to a greater improvement in mechanical tenderness assessment. Extensive efforts have viewed beef subprimal storage from the proteolytic implications, however, the extent of the surface color changes that occur is quite limited. It is plausible that the warmer temperatures cause a greater effect on the moisture loss of the subprimal during storage. Whereby causing a greater percentage of myoglobin to lost in the purge at the time the package is opened and prepared for cutting.

3.3Purge Loss (%)

The interaction between distribution temperature and day of retail display for percent purge loss is reported in Figure 5. Purge values increased ($P < 0.05$) with increasing day of retail display. Strikingly, it was the steaks from subprimals stored at 6.1 °C that ultimately had the greatest ($P < 0.05$) percent of moisture loss during the display period. These increases in moisture loss could be attributed to higher temperatures causing the muscle to accelerate the aging process whereby creating a greater amount of purge during the abusive temperature storage that is lost during steak fabrication or the combination of warmer storage and fluctuating retail display temperatures. There were no differences ($P > 0.05$) in either control or rosemary treated steaks for purge loss that occurred during the retail display period (Figure 6). The addition of rosemary to the steak surface accounted for only a 0.25% increase in steak weight.

3.4Thiobarbaturic Acid Reactive Substances (TBARS)

TBAR values increased throughout the retail display period and were greater ($P < 0.05$) for steaks from subprimals stored at 6.1 °C (Table 5).The application of rosemary at the time of steak fabrication resulted in less lipid oxidation as evident by fewer mg of maldonaldehyde($P < 0.05$; Figure 7). Notably, the detectable threshold of maldonaldehyde for rancid odors appears at 2 mg/kg (Green and Cumuze, 1981). It is apparent that these thresholds were not met during the current study, however, rosemary can account for a 20% reduction in the lipid oxidation which suggests that the antioxidant properties of the ingredient provided some support in reducing lipid oxidation. Altering the delivery could enhance the rosemary's effectiveness whereby eliciting an improvement in the surface color regardless of storage temperature.

The TBAR results agree with Jakobsen et al. (2000) in as much that an increase in TBAR values can occur with increasing storage or display temperatures and duration.Ahn et al. also report that the used of grape seed (ActiVin) can effectively reduce lipid oxidation. Rosemary has been applied and investigated in meat systems as a means to reduce the lipid oxidation that can occur during storage shelf-life. This technology has been found to contain carnosal, rosmanol, isorosmanol and epirosmonal (Namiki, 1990). As the exact mechanism of rosemary influence on lipid oxidation continues to be investigated, it is believed that the flavonoids within the rosemary ingredient can provide some thermal stability and antioxidative properties (Cuvelier et al., 1994).

4.0 Conclusions

Results from this study indicates that storing beef striploins at warmer temperatures prior to retail display can lead todeterioration of the surface color at a rate much faster than steaks stored in conventional temperatures between 0 and 4 °C. Ultimately, these changes in the surface color could impact consumer purchases and lead to an increasein retail setting markdowns and throwaways. The addition of arosemary solutiondid not prolong the surface redness to the extent of adding additional days in the retail setting. However, it is plausible that a more concentrated rosemary solution or delivery method within the steak could lead to greater surface color improvements.

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Table 1. Interactive Effects for Color Traits of Beef Striploin Steaks after 0% and 0.25% application of Rosemary under simulated retail display

Trait	Day	Control[1]		Rosemary[1]	
		0.55 °C	**6.1 °C**	**0.55 °C**	**6.1 °C**
Surface Discoloration[2]	0	1.00^{k}	1.00^{k}	1.00^{k}	1.00^{k}
	3	1.98^{gh}	1.31^{ijk}	2.08^{g}	2.18^{g}
	5	5.10^{cd}	3.35^{f}	6.03^{ab}	4.72^{de}
	7	6.23^{a}	5.06^{cd}	6.53^{a}	6.10^{a}
SEM*		**0.17**	**0.17**	**0.17**	**0.17**
Overall Color[3]	0	1.00^{l}	1.00^{l}	1.00^{l}	1.00^{l}
	3	2.18^{i}	1.69^{jk}	2.03^{i}	2.02^{i}
	5	3.86^{ef}	2.80^{h}	4.40^{bcd}	3.52^{g}
	7	4.33^{cd}	3.70^{fg}	4.93^{a}	4.61^{abc}
SEM		**0.11**	**0.11**	**0.11**	**0.11**
Lean Color[4]	0	6.67^{a}	6.63^{a}	6.53^{ab}	6.35^{abc}
	3	4.48^{e}	5.09^{d}	4.55^{e}	4.63^{e}
	5	2.52^{hi}	3.36^{fg}	2.40^{hi}	2.68^{h}
	7	1.52^{k}	2.09^{ij}	1.27^{k}	1.52^{k}
SEM		**0.27**	**0.27**	**0.27**	**0.27**

[1]Treatment is defined as steaks receiving 0% or 0.25% topical application of rosemaryafter simulated distribution periods at 0.55 °C or 6.1 °C.
[2] Surface Discoloration Score: 1 = No discoloration (0%); 7= Total discoloration(100%).
[3] Overall Color: 1 = Bright purple-red; 5 = Brown
[4] Lean Color:1= Extremely dark red; 7= Extremely bright cherry-red.
[a-l]Means within a trait lacking a common superscript letter differ (*P < 0.05)*.
*SEM is defined as Standard Error of the Mean.

Table 2. Mean Color Traits for Beef Striploin Steaks after storage temperature abuse and under simulated retail display (Exp. 3)

Trait	Day	Temperature[1]		Treatment	
		0.55°C	**6.1°C**	**Control**	**Rosemary**
Amount of Browning[2]	0	1.00^{e}	1.00^{e}	1.00^{h}	1.00^{h}
	3	1.88^{d}	1.66^{d}	1.51^{g}	2.03^{f}
	5	4.53^{b}	3.07^{c}	3.54^{e}	4.06^{cd}
	7	4.96^{a}	4.54^{b}	4.59^{b}	4.92^{a}
SEM*		**0.13**	**0.13**	**0.13**	**0.13**
Fat Discoloration[3]	0	1.00^{g}	1.00^{g}	1.00^{e}	1.00^{e}
	3	2.23^{e}	1.94^{f}	1.99^{d}	2.17^{c}
	5	3.36^{c}	2.92^{d}	3.09^{b}	3.19^{b}
	7	3.84^{a}	3.66^{b}	3.75^{a}	3.75^{a}
SEM		**0.09**	**0.09**	**0.09**	**0.09**

[1] Temperature is defined as storage temperature of striploin sections during a simulated distribution period.
[2] Amount of Browning: 1 = No evidence of browning; 6= Dark brown.
[3] Fat Discoloration: 1= No discoloration;4= Extremely discolored.
[a-h]Means within a trait with a different superscript letter differ(*P< 0.05*).
*SEM is defined as Standard Error of the Mean.

Table 3. Mean Chroma and Hue Angle values for Beef Striploin Steaks after temperature abuse and under simulated retail display conditions

Treatments[3]	**Chroma**[1]	**Hue Angle**[2]
Control	31.86[a]	41.64[a]
Rosemary	30.64[a]	42.24[a]
SEM	**0.45**	**0.61**
Distribution Temperature		
0.55 °C	-	43.10[a]
6.1 °C	-	40.79[b]
SEM	-	**0.87**
Day of retail display		
0	-	39.28[b]
3	-	39.12[b]
5	-	43.90[a]
7	-	45.47[a]
SEM	-	**0.61**

[1] Chroma is a measure of the total color (larger value indicates more total color).
[2] Hue Angle represents the change from the true red axis (greater angle indicates a greater shift from the true red color axis).
[3] Treatment is defined as steaks receiving 0% or 0.25% topical application of rosemaryafter simulated distribution periods at 0.55 °C or 6.1 °C.
[a-b] Means lacking a common superscript letter differ (P < 0.05).
*SEM is defined as Standard Error of the Mean.

Table 4. Distribution temperature by day of retail display interaction on beef striploin steaks after temperature abuse and under simulated retail display

		Temperature[1]	
Chroma[2]	**Day**	**0.55 °C**	**6.1 °C**
	0	42.46[a]	40.71[a]
	3	34.66[b]	32.58[b]
	5	25.79[d]	28.56[c]
	7	22.20[e]	23.03[e]
SEM		**0.90**	**0.90**

[1] Temperature is defined as storage temperature of striploin sections during a simulated distribution period.
[2]Chroma is a measure of the total color (larger value indicates more total color).
[a-e] Means lacking a common superscript letter differ ($P < 0.05$).
*SEM is defined as Standard Error of the Mean.

Table 5. Thiobarbaturic Acid Reactive Substances (TBARS) [1]
Interactive effects of temperature and day on beef striploins after simulated retail display.

Day	**Temperature**	
	0.55°C Storage Temperature	**6.1 °C Storage Temperature**
0	0.30[ef]	0.19[f]
3	0.50[de]	0.47[def]
5	0.81[bc]	1.15[a]
7	0.67[cd]	1.03[ab]
SEM	**0.07**	**0.07**

[1] 2- Thiobarbaturic acid reactive substances (TBARS) is a measure of lipid oxidation with a larger value indicating a greater amount of oxidation.
[a-f]Means lacking a common superscript differ ($P < 0.05$).

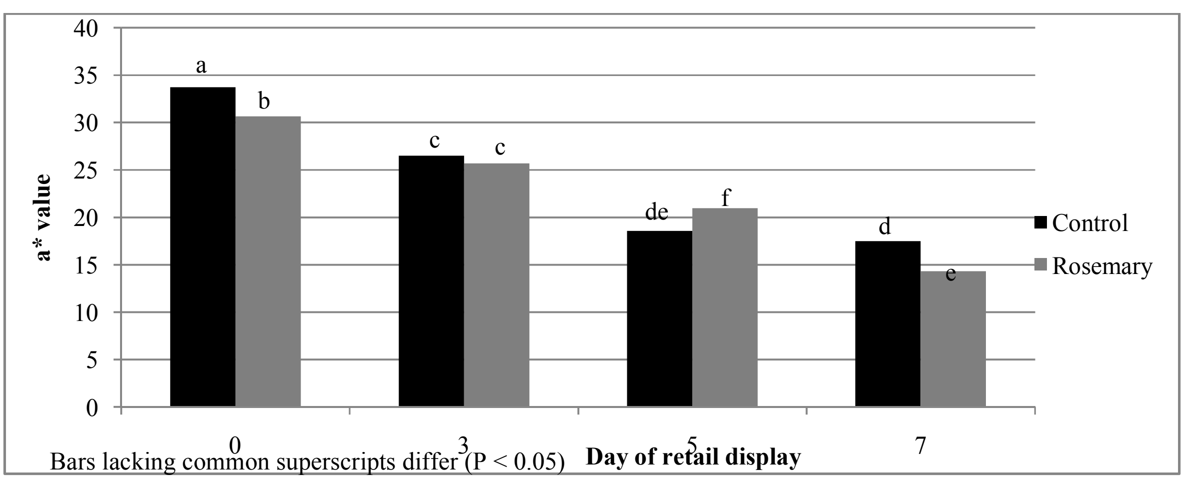

Figure 1. Interactive effect of treatment and day of display on instrumentl a* values ofbeef striploin steaks throughout a simulated retail display period at 2 °C.

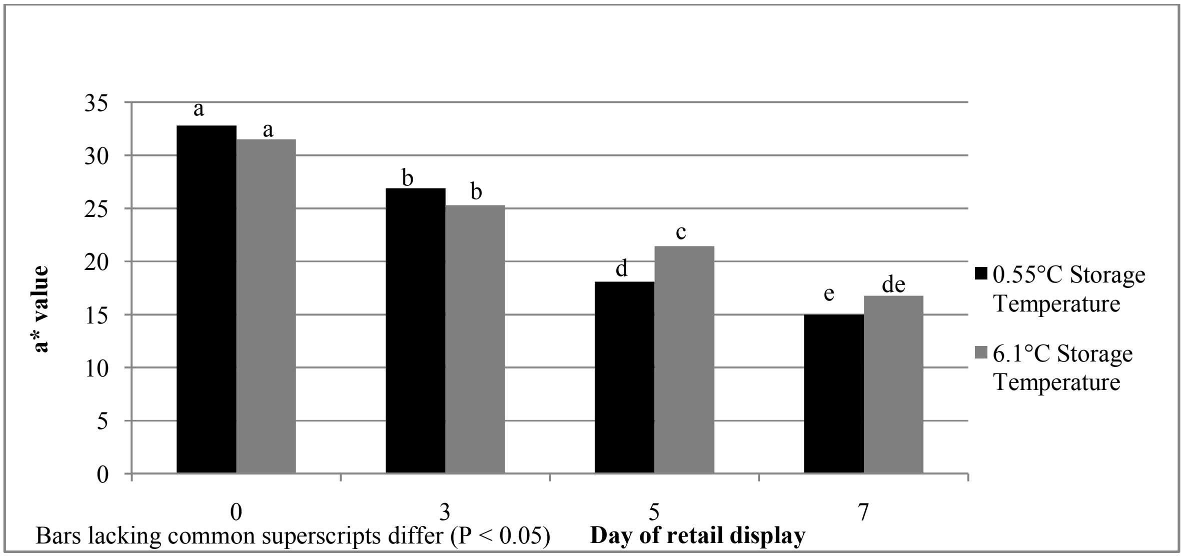

Figure 2. Interative effects of temperature by day effects on a* values of beef striploin steaksthroughout a simulated retail display period at 2 °C

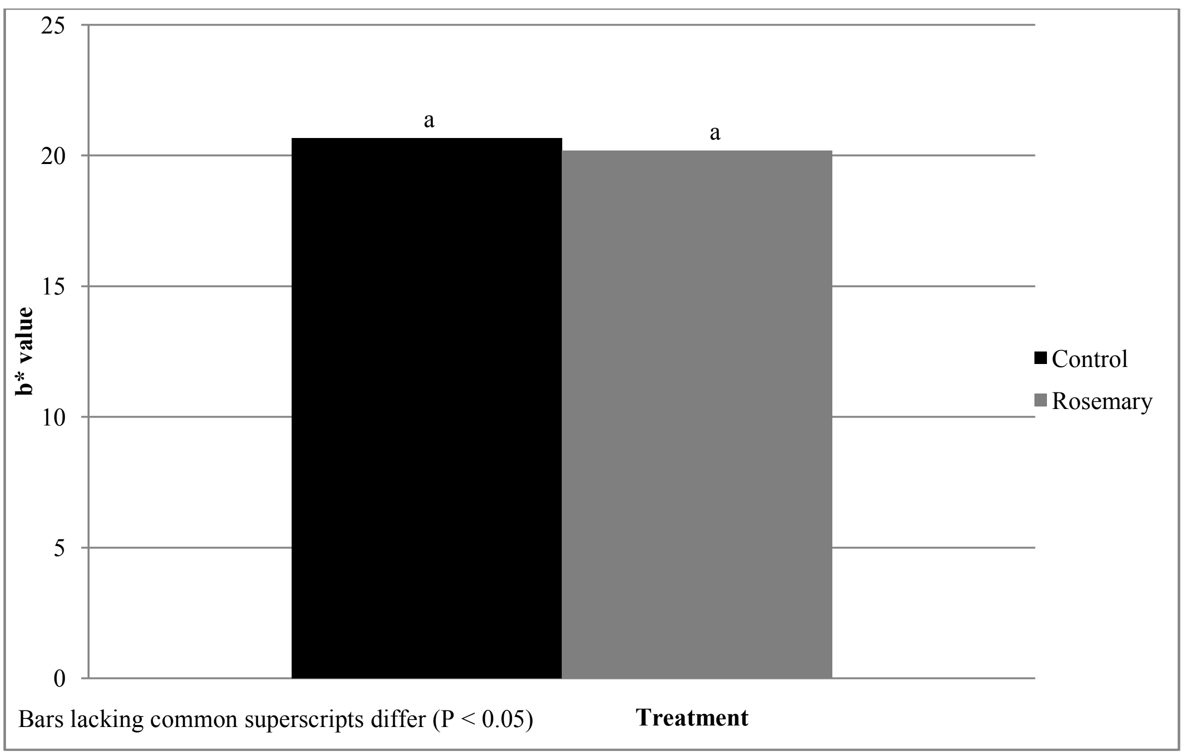

Figure 3.Main effects of treatment on b* (yellowness) values of beef striploinssteaks throughout a simulated retail display period at 2 °C.

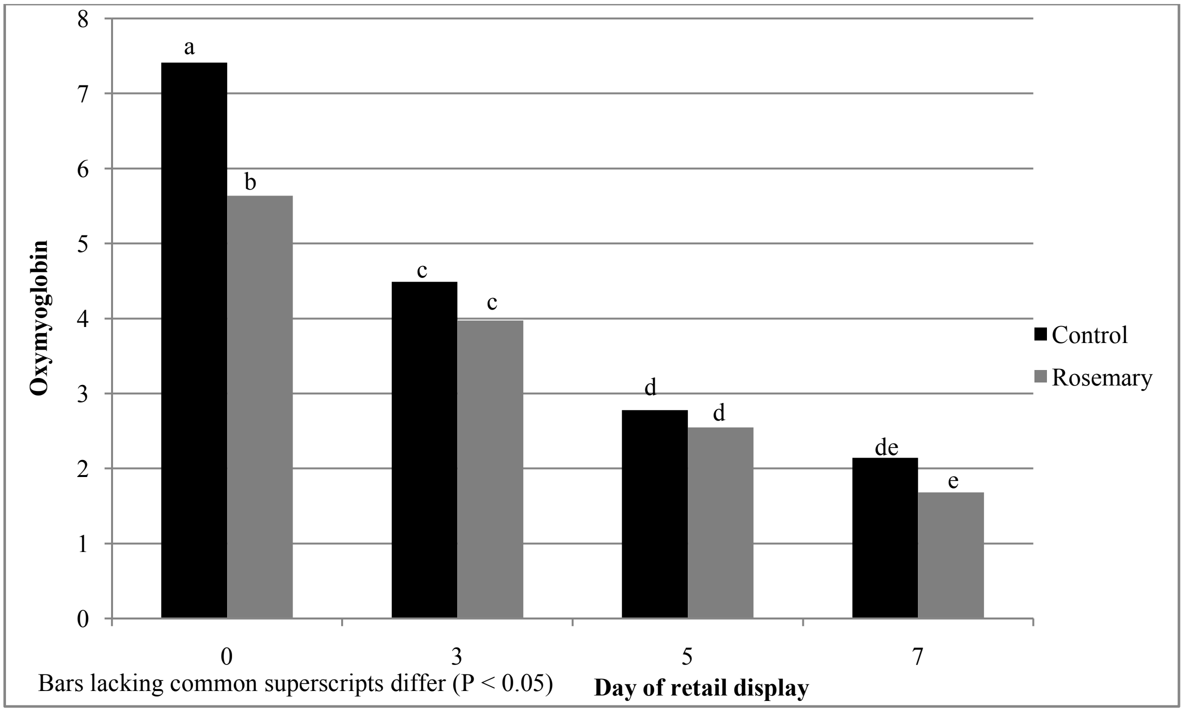

Figure 4. Interactive effect of treatment and day of retail display on Oxymyoglobin (630:580) instrumental values of beef striploin steaks after 0% (Control) or 0.25% application of Rosemary.

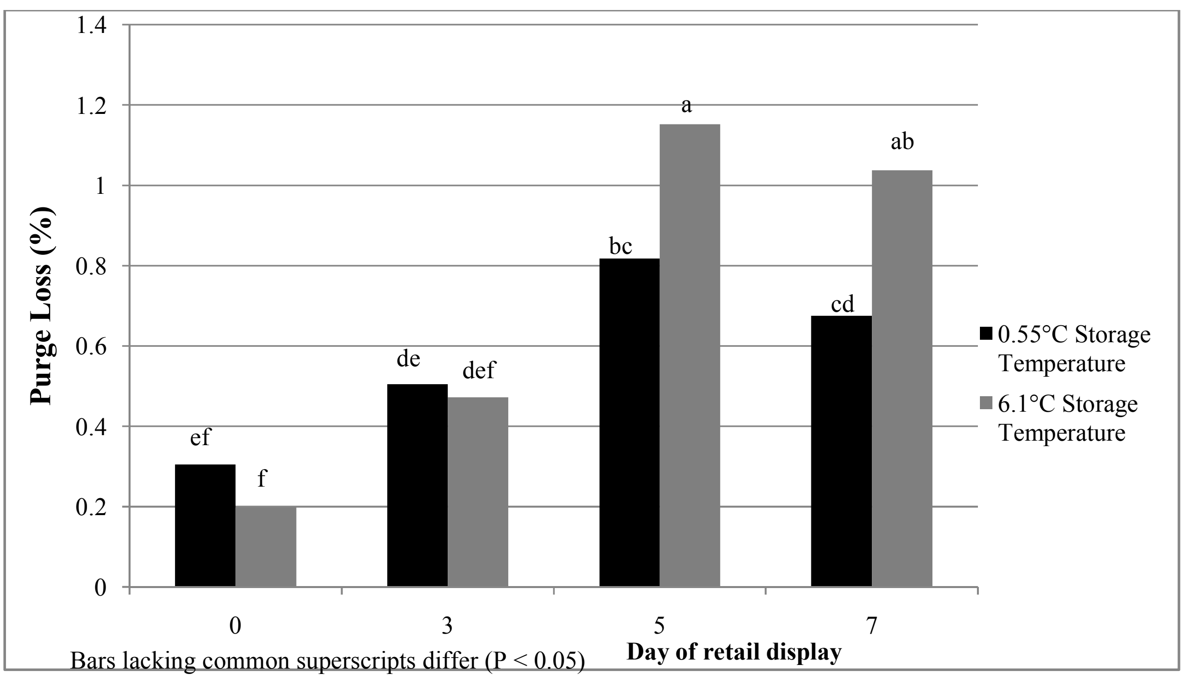

Figure 5.Interactive effects of storage temperature and day of retail display onpurge loss (%) of beef striploin steaks throughout a simulated retail display period at 2 °C.

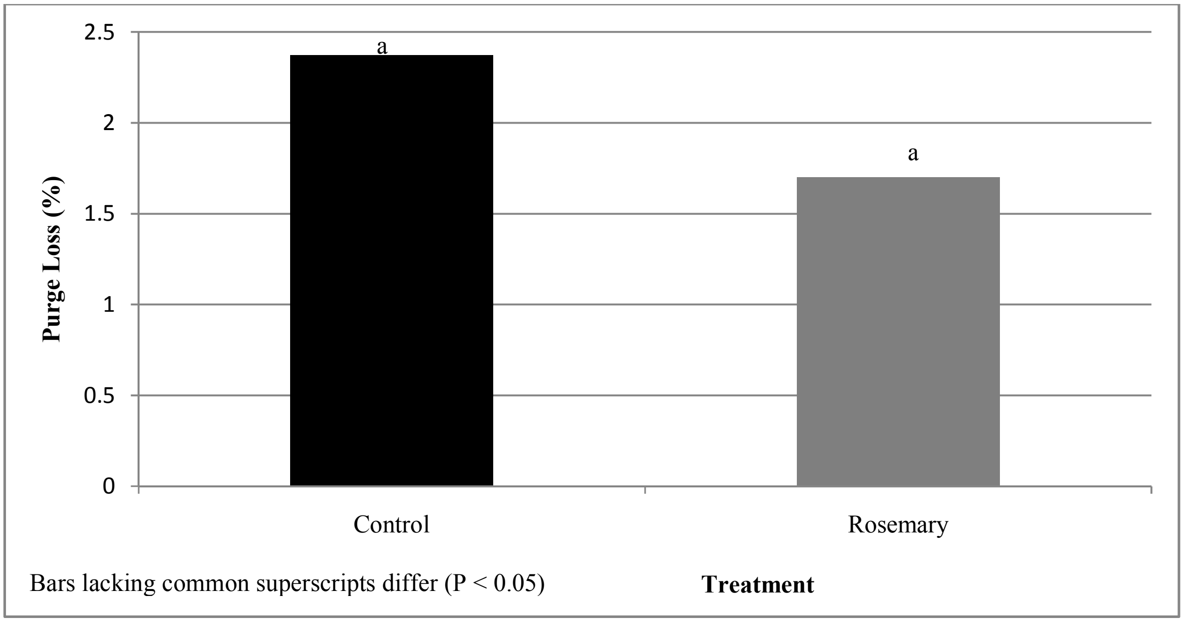

Figure 6.Main effect of treatment on Purge Loss (%) of beef striploin steaks throughout a simulated retail display period at 2 °C.

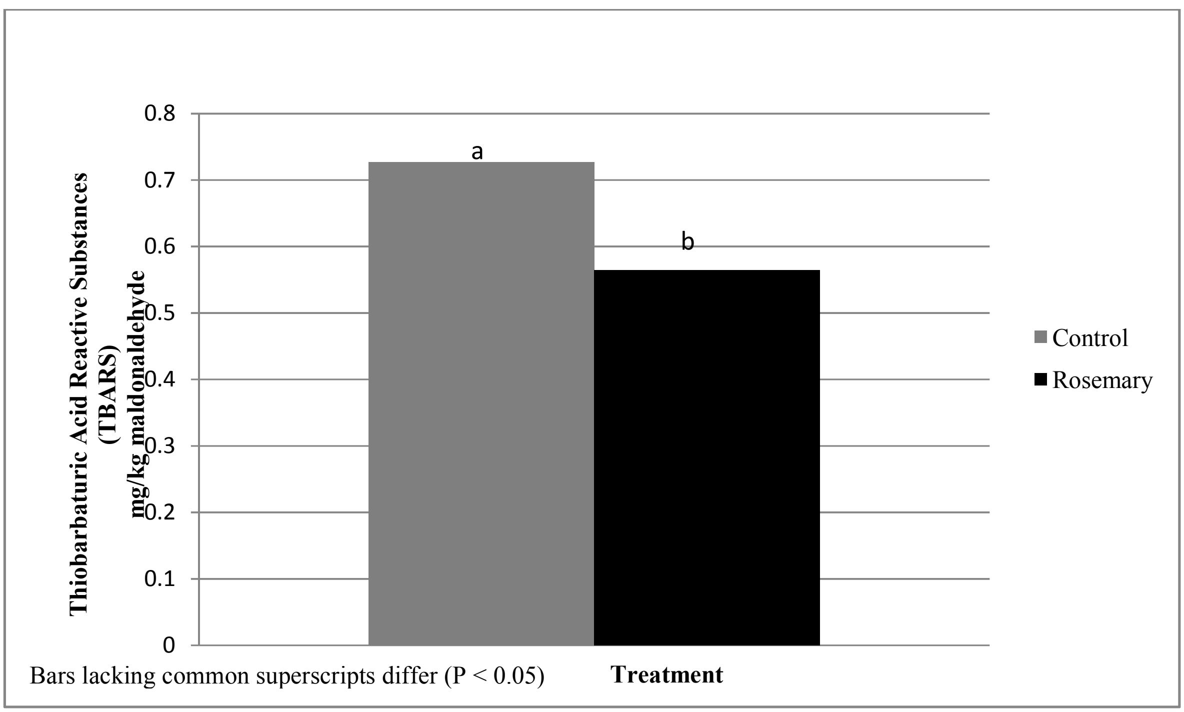

Figure 7.Main effect of treatment on Thiobarbaturic Acid Reactive Substances (TBARS) of beef striploin steaksthroughout a simulated retail display period at 2 °C.