The Effect of Fresh and Frozen Storage on Palatability, Oxidative Rancidity and Color of Modified Atmosphere Packaged Beef Steaks

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Story in Brief

Research was conducted to evaluate the effects of refrigerated and frozen storage of beef ribeye steaks in modified atmosphere packages on meat quality. Beef ribeye rolls were enhanced with a solution containing salt, sodium tripolyphosphate, and rosemary oleoresin prior to fabrication into steaks for modified atmosphere packaging. Packages were assigned randomly to the following storage treatments: 3 d at refrigerated temperatures of 2.2 ºC, 15, 30, 60 or 90 d at freezer temperatures of –14.4 ºC. Steaks were evaluated for purge, weight loss, percent O_2 in the package, objective lean color values oxidative rancidity, sensory attributes, and odor. Packages stored in the freezer for 90 d had more purge and weight loss ($P<.05$) compared to other storage times. The percentage of O_2 in packages increased for steaks stored in the freezer vs the refrigerator, but changed little during frozen storage. Objective color scores revealed that steaks became redder in color once packaged, but the red color began to fade for steaks stored more than 30 d in the freezer. No significant differences in oxidative rancidity were seen. Storage had no effect on the tenderness and flavor of cooked steaks, but juiciness scores were significantly lower for steaks stored for 60 and 90 d in the freezer compared to other storage times. Odor was not a concern until packages had been stored in the freezer for 90 d. These data reveal that packages of ribeye roll steaks can be stored at refrigerated temperatures for 3 d or frozen for up to 30 d without having detrimental effects on palatability, odor, purge and weight loss.

Key Words: Modified Atmosphere Packaging, Storage, Beef, Case-ready

Introduction

Modified atmosphere, case-ready packaging has gained acceptance from retailers in recent years. Many companies are turning to modified atmosphere packaging to increase the shelf life and appearance of their products. According to Luño et al. modified atmosphere packaging (MAP) is well-known as a method for extending shelf life of a variety of foods, including fresh meat. MAP systems also reduce product handling, which reduces the possibility of microbial contamination. Moreover, MAP is more convenient, and easily reveals product tampering.

According to Ken Parnell, approximately 80% of Wal-Mart's case-ready MAP product goes directly into the freezer. A majority of Wal-Mart costumers purchase their products fresh and then freeze the samples until ready to prepare meals. However, MAP was designed for fresh meat products. Thus, the effects of freezing on meat quality has not been investigated. Therefore, the objective of this project was to determine the effect of refrigerated and frozen storage on palatability, oxidative rancidity, and color of modified atmosphere packaged beef steaks.

Materials and Methods

Ribeye rolls (IMPS # 112A; n=10) were obtained from USDA Select carcasses and injected with a solution of salt, phosphate, and rosemary oleoresin. Ribeye rolls were pumped to 110% of their original weight with a brine solution designed to deliver .25% salt, .35% phosphate, and .1% rosemary oleoresin in the final product. Ribeye rolls were injected using a Reiser® multi-needle injector. The enhanced ribeye rolls were allowed to equilibrate for approximately 12 h before each was fabricated into 2.54 cm steaks. Steaks were then assigned randomly to one of five storage treatments: 3 d in a household refrigerator, 15, 30, 60, or 90 d in a household freezer. Refrigerated samples were stored in a household Maytag® refrigerator at 2.2 °C, whereas the frozen samples were stored in a household Kenmore® freezer at -14.4 °C. One steak was also retained for initial Thiobarbituric acid (TBA) analysis, as a measure of lipid oxidation. Each steak was weighed individually, and L* a* b* color scores were taken using a Hunter colorimeter. Steaks (n=20 per treatment) were packaged (n=2 per package) using a modified atmosphere packaging machine (G. Mondini). Packages were comprised of #10 lidded plastic trays, flushed with an 80% O_2 and 20% CO_2 gas, and sealed with a high barrier film. The amount of oxygen in the packages was monitored for each storage time. Oxygen concentration was measured using a MOCON® HS-750 analyzes and expressed as percentage O_2.

Odor panel was performed on each package by five panelists. Panelists ranked each package using a six point scale with 1= “odor not detected” and 6= “odor present, which is strong, overpowering, and intolerable and easily produce physiological effects.” The higher barrier film was cut with a knife, and the panel immediately evaluated the odor of the package.

Objective color scores were measured on each steak using Hunter® Colorimeter and expressed in CIE values (L* a* b*). Following color measurement individual steaks were weighed, and the volume of purge was measured. Purge was removed from each package by pipetting the fluid into a graduated cylinder. CIE values were also obtained on each sample once the designated storage time was complete. Frozen samples were thawed for 24 h at approximately 4 °C before measurements were taken.

Thiobarbituric acid (TBA) assays were performed according to Buege and Aust (1978) with modifications. A 10-g sample was weighed, and homogenized with 30 ml of cold deionized water for 15 s using a Waring® commercial blender. The homogenate was then centrifuged at 2000 X g for 10 min at 4 °C. The supernatant (2 ml) was combined with 4 ml trichloroacetic acid (TCA)/thiobarbituric acid (TBA) reagent, which consisted of 15% TCA and 20 mM TBA reagent in deionized water. Then 100 µl of butylated hydroxyanisole was added, mixed and heated for 15 min in a boiling water bath. The mixture was then cooled for 10 min in cold water, vortexed, and centrifuged at 2000 X g for 10 min at room temperature. Finally, absorbance was read at 531 nm using a Beckman® DU 7500 spectrophotometer.

Trained sensory panelists (n=7) evaluated steaks from each treatment. Panelists were recruited from a group of individuals that had participated in previous research. Steaks were cooked to an internal temperature of 70 °C using an impingement oven. Samples were cut into equal serving portions (1 cm^3), and served to panelists in individual booths, under red light. Panelists were provided an expectorant cup, as well as a cup of water and unsalted crackers to cleanse their palates. Panelists were asked to evaluate steaks for tenderness and juiciness using an eight point scale (1=extremely tough, dry; and 8=extremely tender, juicy); uncharacteristic flavor using a four point scale (1=extremely uncharacteristic and 4=none); along with salty flavor and soapy flavor using a three-point scale (1=not detectable and 3=strong). The panel was conducted over a 2-d period, serving 15 samples per session.

Data were analyzed using least squares analysis of variance (GLM, SAS Institute, Cary, NC). The model included storage treatment. Means were separated using least significant differences (PDIFF, SAS Institute, Cary, NC).

Results and Discussion

The effects of storage on purge, weight loss, and amount of O_2 in packages are shown in Table 1. Storage had a significant effect on purge, weight loss, and amount of O_2. The amount of O_2 present in the packages tended to increase as frozen storage increased, but there were no significant difference among frozen storage treatments. However, 3-d refrigerated packages had significantly less O_2 than their 15, 60, and 90 d frozen counter parts. Storage did have an affect on weight loss. Generally, longer storage times resulted in more loss. Samples stored frozen for 60 d and 90 d had higher weight loss compared to all other treatments. Weight loss and purge amounts were similar for samples stored in the refrigerator and freezer for 15 and 30 d.

Table 1. The effect of storage treatment on purge, weight loss, and oxygen in package atmosphere

	Fresh storage		Frozen storage			
	3 d		15 d	30 d	60 d	90 d
Purge, mL	.56^{a}		2.44^{ab}	3.32^{ab}	5.10^{bc}	8.31^{c}
% O_2	72.27^{a}		73.57^{b}	73.27^{ab}	74.22^{b}	74.08^{b}
Weight loss, g	.36^{a}		.88^{ab}	1.20^{ab}	1.78b^{c}	2.20^{c}

$^{a, b, c}$ Least Square Means in a row lacking a common superscript letter differ ($P<.05$)

The effects of storage on the CIE color values are shown in Table 2. Values were taken at fabrication and at each storage time. The L* represents lightness-darkness, the a* value represents red-green and the b* value represents yellow-blue. The CIE L* values varied among treatments without trend. CIE a* values at fabrication were similar to those of steaks stored in the freezer for 90 d. There was a drastic increase in a* values after products were enhanced and packaged, indicating a more red color. Steaks stored in the refrigerator were similar to those stored in the freezer for 15 d. After 30-d of storage in the freezer, a* value declined significantly. The same phenomenon was observed for steaks stored in the freezer for 60 d, compared to their 30-d counterparts. CIE b* values were significantly lower at fabrication compared to all other storage treatments. Storage in the refrigerator for 3 d, in the freezer for 15 d or in the freezer for 30 d, had no effect on b* values. However, there was a significant decline in b* values as frozen storage was carried out to 60 and 90 d, when compared to other fresh and frozen storage treatments.

Table 2. The effects of storage on objective CIE color values

		Fresh storage	Frozen storage			
	At fabrication	3 d	15 d	30 d	60 d	90 d
L*	35.89^{a}	36.54^{a}	34.48^{ab}	33.70^{b}	35.83^{ab}	37.04^{a}
a*	17.68^{a}	25.20^{b}	24.99^{b}	22.75^{c}	18.79^{d}	17.26^{a}

b*	16.36[c]	21.46[a]	22.22[a]	21.48[a]	19.79[b]	19.47[b]
[a, b, c] Least Square Means in a row lacking a common superscript letter differ (P<.05)						

Least squares means for thiobarbituric acid (TBA) analysis values are shown in Table 3. TBA values had a tendency to increase as storage time increased, however, storage treatment had no significant effect on TBA values. This is probably due to the addition of rosemary oleoresin (a powerful antioxidant) and the storage of products at frozen temperatures.

Table 3. Effect of storage treatment on thiobarbituric acid (mg/kg) values[a]

		Fresh storage		Frozen storage			
	At fabrication	3 d		15 d	30 d	60 d	90 d
TBA, mg/kg	.18	.40		.23	.37	.58	.62

[a] No significant effects observed.

The effects of storage treatment on sensory properties are shown in Table 4. Storage had no effect on tenderness, uncharacteristic flavor, salty flavor and soapy flavor for all storage treatments. However, storage significantly impacted sensory juiciness scores. Juiciness scores were similar for products stored in the refrigerator for 3 d, in the freezer for 15 d, and in the freezer for 30 d, but were significantly more favorable than those for samples stored for 60 and 90 d in the freezer. The effect of decreased juiciness could have negative impacts on the palatability of steaks consumed by consumers. More research is needed to determine if decreased juiciness could significantly lower customer satisfaction.

Table 4. Effect of storage on trained sensory characteristics

	Fresh storage		Frozen storage			
	3 d		15 d	30 d	60 d	90 d
Tenderness[1]	6.00		5.83	5.90	5.64	5.32
Juiciness[2]	5.50[a]		5.08[a]	5.10[a]	4.42[b]	4.26[b]
Uncharacteristic flavor[3]	3.13		3.25	3.48	3.35	3.22
Salty flavor[4]	1.69		1.54	1.54	1.49	1.55
Soapy flavor[5]	1.25		1.14	1.15	1.18	1.26

[a, b] Least Squares Means in a row lacking a common superscript letter differ (P<.05)
Tenderness[1]: 5= Slightly tender; 6= Moderately tender
Juiciness[2]: 4= Slightly dry; 5= Slightly juicy
Uncharacteristic flavor[3]: 3= Slight
Salty Flavor[4]: 1= Not detectable
Soapy Flavor[5]: 1= Not detectable

Odor panel scores are presented in Table 5. Results showed that there were no differences in product odor for samples stored in the refrigerator and up to 60 d in the freezer. However, odor was significantly detected after steaks had been stored frozen for 90 d. These data suggest that frozen storage of steaks beyond 90 d could have detrimental effects on odor.

Table 5. Effects of storage on odor characteristics of modified atmosphere packages

	Fresh storage		Frozen storage			
	3 d		15 d	30 d	60 d	90 d

Odor[1]	2.14[a]		2.6[b]	2.24[a]	2.2[a]	3.65[c]

[a, b, c] Least Square Means in a row lacking a common superscript letter differ ($P<.05$)
Odor[1]: 2= Odor present, which activates smell but is not distinguishable; 3= Odor present, which activates smell, is distinguishable, not necessarily objectionable in short periods

Implications

This research revealed that storage of modified atmosphere packaged beef ribeye steaks can have detrimental effects on purge, weight loss, sensory panel juiciness scores, and odor of packages. However, these effects are only an issue if the packages are stored for longer than 60 d at freezer temperatures.

Literature Cited

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