Project Title: The Effects of Fresh and Frozen Storage on Palatability, Oxidative Rancidity and Color of Packaged Beef Steaks

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Background

Case ready packaging is rapidly becoming the preferred method for retailers to display their meat products. The American Meat Institute estimated that in 2000, retailers sold 1.2 billion packages of case-ready product, which is more than double the number sold in 1997. A 2004 Food Marketing Institute survey found that approximately one-half of all retail beef is sold in a modified atmosphere packaging (MAP) system.

Case-ready packaging systems generally come in one of two major forms:

- Vacuum packaged product with a tightly fitted impermeable plastic packaging
- Modified atmosphere packaging, which typically employs plastic trays, impermeable film and a combination of nitrogen, carbon (monoxide or dioxide) and oxygen gases

Beef products packaged in either of these systems have advantages over traditional packaging such as a foam tray with an air permeable polyvinyl chloride overwrap, which was typically applied in store. Some of those advantages include:

- Reduced labor costs in-store
- Fewer out-of-stock items
- More consistent product for consumers from purchase to purchase
- Reduced liability risks in the event of a food safety issue
- Extended shelf life

Modified atmosphere packaging was designed to present fresh meat attractively with the intent that consumers would take product home and prepare it soon thereafter, however surveys are indicating that consumers are freezing a large majority of fresh beef purchases. There is relatively little information about how beef products in modified atmosphere packaging perform after being frozen.

The objective of this project was to determine the quality attributes of beef steaks when placed in popular retail or case-ready packaging systems and then subjected to several different fresh or frozen storage periods in home refrigerator or freezer storage temperatures.

Methodology

Twenty pairs of USDA select ribeye rolls (IMPS 112A) and twenty pairs of inside rounds (IMPS 169A) were randomly selected at 48 hours postmortem from a commercial beef processing facility. These subprimals were vacuum packaged and shipped to the Food and Agricultural Product Center (FAPC) at Oklahoma State University.

Half of the subprimals were enhanced with a solution designed to distribute .25 percent salt, .35 percent phosphate and .10 rosemary oleoresin using a Metalquimia (Model

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120/3000CR) multi-needle spray injector. Both the enhanced and non-enhanced subprimals were fabricated into 2.54 centimeter steaks and were assigned to one of three package treatments:

- Modified atmosphere packaging (MAP), which consisted of Cryovac® polypropylene trays (Model CS977), flushed with an 80 percent O2, 20 percent CO2 gas and sealed with a high barrier film with a G. Mondini® MAP machine (Model CVS 0.1-S).
- Polyvinylchloride overwrap (PVC) over Cryovac® polystyrene foam trays
- Vacuum packaging (VP) with heat shrink storage bags and sealed using an Ultravec® vacuum packaging machine

Packaged steaks were then randomly assigned to one of five storage periods, so that all packaging systems were equally represented within each storage period:

- Refrigeration for 30 days (2.2° C)
- Frozen for 15 days (-14.4° C)
- Frozen for 30 days (-14.4° C)
- Frozen for 60 days (-14.4° C)
- Frozen for 90 days (-14.4° C)

Refrigeration and freezing were performed in walk-in coolers and freezers, which were adjusted to simulate household storage conditions. After undergoing the appropriate storage periods, a percentage of steaks were set aside for initial objective color analysis (L*, a*, b*) and thiobarbituric acid (TBA) analysis samples to determine lipid oxidation estimates. Additionally, Warner-Bratzler shear force (WBSF) values were obtained for a percentage of the steaks to determine tenderness.

Sensory analyses were also conducted with trained panelists who evaluated steaks for tenderness, juiciness, off-flavor (i.e. oxidative rancidity), saltiness and overall acceptability. Panelists also took part in an odor analysis of uncooked steaks from all packaging systems and storage variations.

Packaged oxygen concentration was monitored in a percentage of randomly selected MAP and PVC packages. These steaks, along with ones from the vacuum packaged group, were also evaluated for purge loss.

Findings

Objective Tenderness

Enhanced beef steaks had lower, more desirable shear force values after three days of refrigeration and throughout the frozen storage periods compared to non-enhanced steaks. Longer storage times for MAP and VP steaks seemed to enhance tenderness while all nonenhanced steaks and the PVC packaged steaks only became more tender during the first 30 days of frozen storage, and then increased in shear force values after that time. Overall, short term refrigeration or longer term frozen storage had no significant effects on shear force values of retail beef cuts.

Lipid Oxidation

Non-enhanced steaks had higher thiobarbituric acid reactive substance (TBARS) measurements, an objective measure of lipid oxidation, than enhanced steaks. All enhanced steaks, as well as non-enhanced VP steaks shared common TBARS values indicating a similarity in oxidative properties. Elevated levels of TBARS became apparent when non-enhanced steaks were packaged in MAP and PVC. On the third day of refrigeration, the non-enhanced MAP steaks possessed significantly higher TBARS values, which was likely due to the high level of oxygen in the packaging system, the lack of antioxidant and the refrigerated rather than frozen storage.

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Generally, extreme off-flavors seemed to result in modified atmosphere packaged steaks when exposed to high oxygen conditions for as few as three days in refrigeration conditions. Additionally, it appears that in order to slow down oxygenation, vacuum packaging or incorporation of an antioxidant (via enhancement) should be used.

Overall Sensory Acceptability
After three days of refrigeration, all steaks were similar in perceived tenderness as rated by the trained sensory panelists. Subtle differences were observed in frozen steak tenderness. Enhanced beef steaks from all packaging systems appeared to be acceptable throughout all storage periods for both refrigeration and freezing. The only exception to this rule of thumb is modified atmosphere packaged steaks, which did not appear to handle long-term frozen storage (i.e. greater than 30 days) as well as the other tested packaging systems.

Purge Loss
Non-enhanced modified atmosphere packaged and polyvinyl chloride overwrapped steaks had more purge loss than their enhanced counterparts. For the vacuum packaged steaks, the opposite was true as the enhanced steaks showed more purge loss than non-enhanced steaks.

Purge loss also seemed to be influenced by cut. Frozen storage was detrimental to the purge loss experienced by vacuum packaged *Longissimus* steaks. Modified atmosphere packaged *Longissimus* steaks experienced more purge loss only when subjected to long-term storage. Frozen storage for any enhancement and package system combination was disadvantageous to *Semimembranosus* from the standpoint of purge loss.

Implications

This project helped determine the effect of frozen storage times on different packaging systems and should help provide scientific recommendations for acceptable storage periods. This information can be used to help retailers educate consumers and aid home use of product, which should help maintain a high level of beef quality through correct handling.

Based on this study, the following recommendations can be made to help ensure overall sensory acceptability:

- Non-enhanced modified atmosphere packaged steaks should be used quickly by consumers for the best eating experience.
- Polyvinyl chloride overwrapped steaks should be used quickly, or if need be frozen for a short period by consumers for the best eating experience
- Non-enhanced modified atmosphere packaged steaks should not be refrigerated for a short period, nor frozen for a long period, to avoid oxidative rancidity.

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