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HIGH CARBON DIOXIDE, MODIFIED-ATMOSPHERE PACKAGING (MAP) FOR BEEF STEAKS

S. E. Luchsinger, M. C. Hunt, and D. H. Kropf

Summary

To determine the effects of storage in a high-carbon dioxide, modified-atmosphere package (MAP) on shelf life, beef strip steaks were packaged under 30% CO₂-70% N₂ and stored for up to 42 days at 30 or 38 °F. Aerobic plate counts (APC) and lactic acid bacteria (LAB) counts in these ExtendPak™ packages were well below the threshold of spoilage even after 42 days of MAP storage. After 28 days of storage, steaks stored in vacuum packages had APC counts 1.0 log₁₀ greater than steaks in MAP. APCs increased during a 5-day display period in steaks stored in vacuum packages, but no increases occurred with MAP. Repackaged steaks from vacuum packages bloomed to a brighter red color than steaks stored in MAP, but MAP steaks were more color stable through display. Microbial data indicated that steaks can be stored for up to 42 days using this promising MAP system. The long storage life of MAP steaks allows packers and retailers more flexibility to respond to variable consumer demand, without the threat of product spoilage.

(Key Words: Packaging, Beef Steaks, Shelf Life.)

Introduction

Annually in the United States, over 25 billion lb of fresh beef and other meats are vacuum-packaged, gas packed, or master packaged (several retail portions in a single gas package). Increasingly, packers/processors are using modified-atmosphere packaging (MAP) for case-ready retail cuts. MAP allows for packer or centralized retail cutting, thereby reducing labor costs and facilitating improved meat quality, decreased contamination, and an immediate response to consumer demands. A

high carbon dioxide (CO₂) atmosphere (>20-25%) with minimal to no oxygen reduces microbial growth during storage, allowing extended shelf life for both wholesale and retail cuts. This study determined the effects of MAP storage time (up to 42 days) and storage temperature (30 or 38 °F) on the shelf life of beef strip steaks packaged in the ExtendPak MAP system and then displayed for 5 days.

Experimental Procedures

Eight paired, vacuum-packaged, boneless strip loins (NAMP #180A) were obtained from a commercial processor. Twenty steaks per loin pair were cut 1 in. thick, trimmed to ≤.25 in. of fat, and assigned randomly to all combinations of two storage temperatures (30 and 38 °F); four MAP storage periods (21, 28, 35, and 42 days); two package types (ExtendPak MAP and vacuum packaging); and two display times (0 or 5 days). The ExtendPak system consists of two compartments: a tray holding the individual steak, which is covered by oxygen-permeable PVC film, and a dome that covers the tray. During packaging, the tray and dome areas are evacuated, flushed, and filled with a 30% CO₂/70% N₂ gas mixture, and the tray, PVC film, and dome are sealed into an integral MAP package. Four steaks per loin pair were vacuum-packaged.

Oxygen and CO₂ levels within the ExtendPak dome and tray were determined after storage. Aerobic plate counts (APCs), *Escherichia coli*/coliform counts, and lactic acid bacteria (LAB) counts were determined after steak cutting, after storage, and after display, using standard procedures. After MAP and ExtendPak storage, packages were opened and blooming ability was evaluated instrumentally. Vacuum-stored steaks were rewrapped onto an

ExtendPak tray covered with identical PVC film. Steaks then were displayed at 38 °F for 5 days under 150 foot candles of Deluxe Warm White fluorescent lighting. Steak color was analyzed instrumentally and by a trained panel at 0, 1, 2, 3, and 5 days of display. Visual color was scored as 1=very bright cherry red, 2=bright cherry red, 3=slightly dark red to brown, 4=moderate dark red to brown, and 5=dark red to brown, in .5 intervals. A score of ≥ 3.5 was considered unacceptable color. Steaks were scored for off-odor after storage and after display. The scale (.5 intervals) was 1=none, 2=slight off-odor, 3=small off-odor, 4=moderate off-odor, and 5=extreme off-odor.

Data were analyzed as two-way (gas composition), three-way (blooming ability and display color), or four-way (off-odor and microbial analysis) treatment structures. Animal served as a blocking factor. Least square means were determined, and the statistical significance level was set at $P < .05$.

Results and Discussion

Carbon dioxide levels in ExtendPak packages were maintained above 25% throughout 42 days of storage, and oxygen levels remained between .01 and .18%. Oxygen levels were greater after storage at 30 than at 38 °F. At 38 °F, oxygen-utilizing meat enzymes are more active and, thus, may have lowered the oxygen level.

The APCs were $2.0 \log_{10}$ and LAB counts were $1.9 \log_{10}$ cfu/cm² after steak cutting, well below the threshold for bacteria spoilage ($\text{APC} \geq 7.0 \log_{10}$). (cfu is "colony forming unit". $2.0 \log_{10} = 100$, $3.0 \log_{10} = 1000$.) *E. coli* and coliforms were not detected ($< 1.9 \log_{10}$ cfu/cm²). These results indicate that the product was essentially free of microbial contamination at the initiation of storage.

Within ExtendPak MAP storage, APCs or LAB counts did not increase during storage (Table 1). *E. coli* was not detected and coliform levels were maintained $< 1.9 \log_{10}$ throughout storage, regardless of storage temperature, package type, or display time. The APCs and LAB counts were greater at 38 than at 30 °F and

after display than after MAP (Table 1) but were maintained below the spoilage threshold. These results were expected, because microbial growth is faster at 38 °F and in the presence of oxygen. The APCs (Table 2) were greater in vacuum-packaged controls after 28 d of storage and after display than in ExtendPak samples. In addition, APCs increased by $2.4 \log_{10}$ in steaks stored in vacuum packages during display, whereas counts did not change during display for ExtendPak samples. Thus, residual antimicrobial effects of CO₂ carried over into the display of ExtendPak samples.

Off-odors were none to slight on steaks from ExtendPaks after MAP storage for 42 days, and odors increased only slightly during retail display. Steaks stored in vacuum packages had more off-odors after display than those in ExtendPaks.

Steaks stored for up to 35 days in ExtendPaks at 38 °F were more red, more vivid, and less discolored than steaks stored at 30 °F. This temperature effect was unexpected, because beef has been reported to tolerate residual oxygen levels of 400 ppm (.04%) or more without discoloration when stored at 30 °F but to discolor at temperatures greater than 35 °F. Visual color for steaks in ExtendPaks from both temperatures was described as slightly to moderately dark red or brown. Steaks stored under vacuum for 28 days were more red and less discolored after 2 days of display than ExtendPak samples. However, by 3 days display, ExtendPak steaks had color equal to or better than that of steaks from vacuum storage. ExtendPak samples were more color stable than vacuum-packaged controls throughout display.

Although microbial results indicate that the shelf life of steaks in this MAP system is at least 42 days, bloom and display color of beef steaks from MAP need improvement. Research continues on this problem. The long storage life of MAP steaks should allow packers and retailers more flexibility to respond to variable consumer demand, without product spoilage.

Table 1. Microbial Analyses ¹ as Affected by Evaluation Time and Days in MAP Storage for ExtendPak™ Containing Beef Strip Steaks

Attribute	Evaluation Time			MAP Storage, Days				
	After MAP	After Display	SE	21	28	35	42	SE
APC	2.5 ^b	3.4 ^a	.2	2.5 ^a	3.2 ^a	3.1 ^a	3.0 ^a	.2
LAB	2.1 ^b	2.5 ^a	.1	2.1 ^a	2.4 ^a	2.4 ^a	2.2 ^a	.2
<i>E. coli</i>	<1.9	<1.9	---	<1.9	<1.9	<1.9	<1.9	---
Coliform	<1.9 ^a	<1.9 ^a	.02	<1.9 ^a	<1.9 ^a	<1.9 ^a	<1.9 ^a	.04

¹APC=aerobic plate counts, LAB=lactic acid bacteria counts; Expressed as log₁₀ cfu/cm².

^{a,b}Means within a row within a variable with a different superscript letter are different (P<.05).

Table 2. Microbial Analyses ¹ as Affected by Evaluation Time, Storage Temperature, and Package Type for ExtendPak™ and Vacuum Packages Containing Beef Strip Steaks and Stored for 28 days

Attribute	Evaluation Time/ Temperature, °F	Package Type		
		ExtendPak	Vacuum	SE
APC	After MAP	2.8 ^{bx}	3.8 ^{ay}	.2
	After display	3.4 ^{bx}	6.2 ^{ax}	
LAB	After MAP	2.2 ^{ax}	2.8 ^{ay}	.2
	After display	2.6 ^{bx}	4.4 ^{ax}	
	30	<1.9 ^{ay}	2.3 ^{ay}	
	38	3.0 ^{bx}	4.9 ^{ax}	

¹APC = aerobic plate counts, LAB = lactic acid bacteria counts; Expressed as log₁₀ cfu/cm².

^{a,b}Means within a row within a variable with a different superscript letter are different (P<.05).

^{x,y}Means within an attribute within a column with a different superscript letter are different (P<.05).