RETAIL CASELIFE AND BACTERIAL GROWTH ON THE SURFACE OF GROUND BEEF IN PVC FILM, IN A MODIFIED ATMOSPHERE PACKAGE OR IN A MASTER PACKAGE

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Summary

Polyvinyl chloride (PVC) film, modified atmosphere packaging (MAP) and master packaging (MP) were evaluated to determine their effects on subsequent retail display life of ground beef produced at a centralized packaging facility. Ground beef packaged in MAP or MP remained acceptable in appearance longer ($P < .05$) than that packaged in PVC, and use of MAP resulted in a longer caselife than use of MP. Packaging type did not have an effect on microbial growth on the surface of ground beef ($P > .05$). Microbial contamination of the raw materials influenced the contamination and subsequent caselife of the ground beef.

Key Words: ground beef, packaging, raw materials, caselife

Introduction

Case-ready fresh meats have a growing presence in retail cases throughout the country, as many meat suppliers turn to centralized packaging of fresh red meats. With this emergence comes an increasing focus on modified atmosphere packaging (MAP) and master packaging (MP), as well as concerns of contamination and growth of bacteria.

Modifying meat package atmospheres involves inclusion of carbon dioxide which inhibits bacterial growth and extends caselife of meat (Baran et al., 1970; Huffman et al., 1975; Seideman et al., 1979). Ground beef can be produced in centralized packaging facilities with low microbiological contamination (Shoup and Oblinger, 1976) and with a retail caselife equal to or greater than that for ground beef produced at the retail level (Worobo et al., 1997).

This study identified the average caselife of and bacterial growth on ground beef packaged at the retail level in PVC film and displayed immediately, or packaged at a centralized facility in MAP or MP, stored for 2 or 5 days, and then displayed.

Materials and Methods

Raw Materials

At a centralized meat packaging facility, five core samples were obtained from each of four combo-bins of raw materials used in the production of 27%, 20% and 9% fat blends of ground beef from a single day's production. The core samples were ground and analyzed for aerobic plate counts (APC) and lactic acid bacteria counts (LAB).

PVC, Modified Atmosphere and Master Packaged Ground Beef

Thirty-five packages of ground beef, each weighing .45 kg, were randomly selected from each of the fat percentage blends and assigned to the polyvinyl chloride (PVC) film treatment group. All packages were immediately placed in a retail display case.

One-hundred sixty packages of ground beef, each weighing .45 kg, were selected randomly from the 27%, 20% and 9% fat blends and assigned to either the MAP (n=80) or MP (n=80) treatment groups. MAP ground beef was packaged, as single units, in coextruded ethyl vinyl acetate and nylon pouches into which an atmosphere of 80% O_2 and 20% CO_2 was introduced. MP ground beef was packaged, as single units, in PVC film, and five such units

were then placed in nylon and polyethylene bags into which an atmosphere of 70% O_2 and 30% CO_2 was introduced.

Within each packaging group, ten packages were used to determine initial APC and LAB counts and two subgroups were selected (n=35 per subgroup) to be evaluated for caselife following two pre-display storage periods, 2 or 5 days, to simulate transportation and distribution time. The MAP and MP ground beef were stored at 0 to 2°C and were not exposed to light for 2 or 5 days, and then the MAP ground beef and MP ground beef (after removal of the outer nylon and polyethylene bag) were placed in the retail display case.

Due to mechanical complications, three combo-bins of raw material and random selection of all ground beef packages stored for 2 days was repeated and reflected production on a different day compared to the PVC packages and the MAP and MP packages stored for 5 days.

Retail Display

Packages of ground beef were placed in a coffin-style retail case at 0 to 2°C under lighting conditions recommended by AMSA (1992). For each treatment group, five packages were sacrificed upon initial placement in the retail display case and at each subsequent 12 h interval for a period of 3 days for evaluation of APC and LAB counts, CIE L*, a* and b* values, and overall appearance scores.

Aerobic Plate Counts and Lactic Acid Bacteria Counts

For all APC and LAB evaluations, a 25-g sample from each package was diluted to a 10^{-1} dilution with sterile peptone water and then stomached for 2 min. Serial dilutions were prepared, plated on trypticase soy agar (Difco) for APC and on MRS agar (Difco) for LAB, incubated for 48 h at 25°C, and colonies were counted using a laser colony counter (Model 500A, Spiral Biotech, Inc.) and a CASBA data processor (Model 800, Spiral Biotech, Inc.). All counts were reported as log CFU/g.

Color Evaluation and Overall Appearance Scores

Measurements of ground beef color were collected using a portable spectrophotometer (MiniScan XE; HunterLab Associates Laboratory, Inc., Reston, VA.). Color was measured in L* (psychometric lightness; black = 0, white = 100), a* (red = positive values, green = negative values) and b* (yellow = positive values, blue = negative values) values. All CIE values were the average of three independent and randomly placed measurements of the exposed surface of the ground beef. Overall appearance scores (7 = extremely desirable; 1 = extremely undesirable) were averages of scores assigned to each package by three to six trained panelists following procedures similar to those used by Lavelle et al. (1995).

Statistical Analysis

Data were analyzed separately for each percent fat blend using general linear model (GLM) and regression procedures of SAS (SAS, 1988) and means were separated using the least squares means method. Treatment (packaging type by storage time before retail display) and retail display time were analyzed as fixed main effects. An analysis of covariance was conducted to adjust the treatment means for variation in initial plate counts, but the covariates did not test significant ($P > .05$) and adjusted means were not different from the true means, indicating analysis of covariance was not effective in adjusting means to the average initial APC level.

Results and Application

Aerobic Plate Counts and Lactic Acid Bacteria Counts of Raw Materials

APC and LAB for the raw materials used to produce PVC, MAP and MP ground beef ranged from 3.4 to 6.3 log CFU/g and 2.9 to 5.5 log CFU/g, respectively (data not presented in tabular form). The raw materials used to produce the ground beef stored for 2 days had higher initial microbial counts than those used in the production of the PVC packaged ground beef and the ground beef stored for 5 days. It was evident that the 27% fat ground beef stored for 2 days contained the highest proportion of this highly contaminated raw material as it had the highest initial microbial counts. However, it is expected that centralized meat packaging facilities should be able to expect greater control over contamination of raw materials than can retail stores as they should obtain fresh raw materials and utilize them more quickly.

Caselife and Shelflife of Ground Beef in PVC Film

Overall appearance scores and CIE a* values decreased with increased display time ($P < .05$) (Table 1). Mean overall appearance scores fell below the slightly undesirable score (3.0) after 12, 36, and 24 h of retail display for the 9% fat, 20% fat, and 27% fat PVC ground beef, respectively (Table 1). This would indicate that the 27% fat ground beef remained acceptable in appearance longer than the 20% fat ground beef, followed by the 9% fat ground beef. Aerobic plate counts increased with display time ($P < .05$) for all fat blends of PVC ground beef. The bacterial growth on the ground beef was not affected by the fat percentage of the blend.

Packaging Type Effects on Caselife and Bacterial Growth of Ground Beef

Mean caselife for PVC ground beef was 28.8 h, 31.2 h and 19.2 h for 27%, 20% and 9% fat ground beef, respectively (Table 2). Mean caselife was determined by computing the amount of display time (h) required before overall appearance scores declined to below a score of 3.0 (slightly undesirable), or the point at which product would be discounted in price for quick sale at the retail level.

Both MAP and MP ground beef had advantages in caselife over the ground beef packaged in PVC, even after 2 and 5 days of storage, and ground beef packaged in MAP had a longer caselife than that packaged in MP ($P < .05$) (Table2). This strongly favors centralized packaging of ground beef in modified gaseous atmospheres over packaging of ground beef in PVC film overwrap at the retail level.

MAP ground beef stored for 5 days had a longer caselife than MAP ground beef stored for 2 days, and MP ground beef stored for 5 days had an advantage in caselife over MP ground beef stored for 2 days within the 20% fat blend (Table 2). It was assumed that caselife would be longer for the ground beef stored for 2 days than for that stored for 5 days, but in this study, the initial microbial loads of the two sources of raw materials were not the same. Gill and McGinnis (1993) demonstrated that increased storage time leads to inadequate stability when displayed in a retail case and showed that an increase in storage time leads to increased surface discoloration.

Table 1. Means for overall appearance scores, CIE a* values, aerobic plate counts (APC) and percent of packages discounted for ground beef of different fat levels displayed in polyvinyl chloride (PVC) film

Display (h)	Overall Appearance	CIE a*	APC (log CFU/g)	% Packages Discounted[a]
27% fat				
0	7.0[b]	12.9[b]	4.3[e]	0
12	6.3[b]	13.8[b]	4.6[de]	0
24	4.3[c]	11.1[c]	5.0[d]	0
36	2.9[d]	12.0[bc]	6.1[c]	0
48	1.6[e]	8.4[d]	6.5[b]	80
60	1.1[e]	6.2[e]	6.4[b]	80
72	1.0[e]	5.8[e]	6.3[bc]	100
20% fat				
0	6.6[b]	15.4[b]	4.3[d]	0
12	5.3[c]	14.6[bc]	4.5[d]	0
24	4.5[c]	12.9[c]	5.2[e]	0
36	3.1[d]	12.9[c]	5.6[d]	0
48	1.5[e]	9.6[d]	6.5[c]	60
60	1.5[e]	7.5[d]	7.0[b]	60
72	1.7[e]	7.7[d]	6.3[c]	80
9% fat				
0	6.6[b]	14.7[b]	4.0[e]	0
12	5.3[c]	13.5[bc]	4.1[e]	0
24	2.8[d]	11.4[cd]	5.1[d]	20
36	1.7[e]	10.0[d]	5.3[d]	60
48	1.0[e]	7.0[e]	5.8[c]	100
60	1.0[e]	5.7[e]	6.4[b]	100
72	1.0[e]	5.9[e]	6.3[b]	100

[a]Overall appearance scores declined to below a score of 3.0 (slightly undesirable, point at which product would be discounted in retail price for quick sale).

[bcde]Means within columns and within percent fat blends that do not share a common superscript letter differ (P < .05).

Table 2. Effect of package type and previous storage time on caselife[a] of ground beef of different fat levels

	27% Fat		20% Fat		9% Fat	
	Display	Gain (h)	Display	Gain (h)	Display	Gain (h)
PVC, 0 day storage[b]	28.8[e]	-	31.2[f]	-	19.2[f]	-
MAP[c], 2 day storage	40.8[de]	12.0	48.0[e]	16.8	60.0[d]	40.8
MAP, 5 day storage	50.4[d]	21.6	67.2[d]	36.0	57.6[d]	38.4
MP[c], 2 day storage	38.4[de]	9.6	43.2[e]	12.0	57.6[d]	38.4
MP, 5 day storage	31.2[e]	2.4	60.0[d]	28.8	38.4[e]	19.2

[a]Mean display time (h) before overall appearance scores fell below 3.0.

[b]Control.

[c]MAP = modified atmosphere packaging; MP = master packaging.

[def]Means within columns that do not share a common superscript letter differ (P < .05).

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Mean CIE a* values (not presented in tabular form) and mean overall appearance scores (Table 3), decreased as display time increased across all packaging types and storage times. Ground beef packaged in MAP and stored for 5 days had the highest numerical overall appearance scores from 48 through 72 h within the 27% fat blend and from 12 through 72 h of retail display in the 20% fat blend (Table 3).

Table 3. Effect of package type and previous storage time on mean overall appearance of ground beef of different fat levels displayed in polyvinyl chloride (PVC) film, modified atmosphere packaged (MAP) and master packaged (MP)

	Display time (h)						
	0	12	24	36	48	60	72
27% fat							
PVC, 0 day storage	7.0^{a}	6.3^{a}	4.3^{c}	2.9^{b}	1.6^{c}	1.1^{c}	1.0^{a}
MAP, 2 day storage	6.9^{a}	5.9^{a}	5.6^{ab}	3.9^{a}	2.5^{bc}	1.5^{c}	1.1^{a}
MAP, 5 day storage	6.6^{a}	6.7^{a}	5.9^{a}	3.7^{ab}	3.6^{a}	4.0^{a}	1.4^{a}
MP, 2 day storage	6.8^{a}	5.3^{b}	5.2^{ab}	3.7^{ab}	1.8^{c}	1.1^{c}	1.0^{a}
MP, 5 day storage	6.3^{a}	6.2^{ab}	4.9^{bc}	3.3^{ab}	2.8^{ab}	3.0^{b}	1.2^{a}
20 % fat							
PVC, 0 day storage	6.6^{a}	5.3^{b}	4.5^{b}	3.1^{c}	1.5^{d}	1.5^{c}	1.7^{b}
MAP, 2 day storage	7.0^{a}	6.3^{a}	5.4^{a}	4.6^{b}	4.0^{b}	2.5^{b}	1.0^{b}
MAP, 5 day storage	6.9^{a}	6.8^{a}	6.1^{a}	5.5^{a}	5.2^{a}	5.1^{a}	3.5^{a}
MP, 2 day storage	6.9^{a}	6.2^{a}	5.8^{a}	4.7^{ab}	3.1^{c}	1.7^{bc}	1.0^{b}
MP, 5 day storage	6.4^{a}	6.2^{a}	5.6^{a}	4.7^{ab}	5.0^{a}	4.4^{a}	1.9^{b}
9% fat							
PVC, 0 day storage	6.6^{a}	5.3^{a}	2.8^{c}	1.7^{c}	1.0^{d}	1.0^{b}	1.0^{b}
MAP, 2 day storage	7.0^{a}	6.4^{a}	6.0^{a}	5.3^{a}	4.9^{a}	3.0^{a}	3.5^{a}
MAP, 5 day storage	6.5^{a}	6.2^{a}	5.9^{a}	4.7^{bc}	3.7^{bc}	3.6^{a}	1.6^{b}
MP, 2 day storage	6.4^{a}	6.1^{a}	5.7^{a}	5.0^{a}	4.2^{ab}	3.8^{a}	1.4^{b}
MP, 5 day storage	6.0^{a}	5.8^{a}	4.4^{b}	3.4^{b}	3.1^{c}	3.1^{a}	1.3^{b}

^{abcd}Means within columns and within percent lean blends that do not share a common superscript letter differ ($P < .05$).

n = 5 for all mean.

APC and LAB counts increased throughout the 72 h of retail display for all packaging types and storage periods within the three percent fat blends (data not presented in tabular form). Initial APC and LAB counts of the MAP and MP ground beef stored for 2 days were significantly higher ($P < .05$) than initial counts for MAP and MP ground beef stored for 5 days and PVC ground beef at all three fat percentage levels. This was attributed to the elevated microbial loads of the raw materials.

At 0 h display time, ground beef packaged in PVC had significantly lower ($P < .05$) APC and LAB counts than MAP and MP ground beef (data not presented in tabular form). MAP ground beef stored for 5 days had significantly lower plate counts at 0 h display than MP ground beef stored for 5 days within the 27% and 20% fat blends. Within the 9% fat blend, no differences in APC at 0 h display were evident for the ground beef stored for 2 and 5 days, but the ground beef stored for 2 days had significantly lower ($P < .05$) LAB counts than did that stored for 5 days (data not presented in tabular form). Aerobic plate counts should have been lower at 0 h retail display time for the packages

stored for two days than for the packages stored for five days, but use of different raw materials resulted in different initial microbial loads.

This study determined that ground beef in modified atmosphere packaging or master packaging results in a longer caselife than ground beef in PVC film, and that modified atmosphere packaging results in a longer caselife than master packaging. Also, it is well established that increased microbial loads of raw materials result in decreased caselife of ground beef. It can be expected that centralized meat packaging facilities could better control contamination of raw materials when compared to retail stores, as they could utilize them more quickly to supply a greater number of consumers. These results strongly favor centralized packaging of ground beef in a modified gaseous atmosphere over packaging of ground beef in PVC film at the retail level.

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