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RETAIL BEEF IN DYNAMIC GAS EXCHANGE MODIFIED ATMOSPHERE PACKAGING WITH DIFFERENT DISTRIBUTION STORAGE TEMPERATURE

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INTRODUCTION

Centralized packaging of meat improves processing efficiencies, lowers store handling costs, increases product marketability and enhances product uniformity compared with in-store fabrication and packaging (Allen and Pierson, 1986). It has not been widely accepted for fresh beef because extended distribution time has not been combined with retail display of meat with a bloomed colour. Consumers are not familiar with the purple deoxymyoglobin appearance of fresh beef in vacuum packaging (VP) or modified atmosphere packaging (MAP) with nitrogen or carbon dioxide (Lynch *et al.*, 1986).

Distribution and retail shelf life of fresh meat are extended with MAP compared with air-permeable packaging or VP (Manu-Tawaih *et al.*, 1991; Fu *et al.*, 992). Gas exchange technology (Mitchell, 1990) has fresh meat in MAP with inert gases for distribution and gas exchange for oxygen which converts pigments from deoxymyoglobin to oxymyoglobin before retail display (McMillin *et al.*, 1992).

Previous reports of subfreezing temperatures are inconclusive for colour and microbial quality of subsequent refrigerated retail fresh beef. This study measured retail shelf properties of beef stored in MAP at different distribution temperature before gas exchange for retail display.

MATERIALS AND METHODS

Beef steers were slaughtered in the Louisiana State University Agricultural Center Laboratory after 24 days on feed (68.5% TDN, 10.5% CP). Boneless rib-eye steaks (*m.longissimus thoracic*) and oval ground beef patties from chuck (*infraspinatus* and *supraspinatus*) muscles (20% fat, 150g) were fabricated at 72 hours post-mortem and assigned to a MAP-storage treatment. Steaks and patties were weighed before packaging (Inpack, Ross Industries, Midland, VA) in barrier foam trays (Amoco Foam, Atlanta, Georgia). Samples with 80%N_2/20%CO_2 were stored in cardboard boxes to stimulate distribution at 4.4, -3.8 or -12.2°C before gas exchange for 80%O_2/20%CO_2 (Windjammer, Pakor, Inc., Livingston, TX) on day 14. Control packages with 80%O_2/20%CO_2 were stored in boxes at 4.4°C. All packages were displayed under simulated retail conditions of 4.4°C and 23 lux cool white fluorescent light. Duplicate packages were randomly tested 0, 7 and 14 days after packaging and at two days intervals after gas exchange.

Objective colour analyses of L (lightness), a (red/green) and b (yellow/blue) (LABSCAN-2 0/45, Hunter Laboratory, Inc., Reston, VA) were averaged on each steak or patty by rotating 90° between three readings for each sample. O_2 and CO_2 in packages were measured with a Food Package Analyzer (Series 1400, Servomex, Sussex, UK).

Weight loss was calculated as difference between weights of individual steaks and patties at initial packaging and at sampling divided by initial weight. Psychotrophic plate counts (PPC) were determined by "pour-plate" methods (APHA, 1976) with standard plate count agar (Difco) incubated at 6°C for eight to 10 days. Oxidative stability was determined by thiobarituric acid reactive substances values (TBARS) using distillation (Tarladgis *et al.*, 1960).

The split-plot design with main effects of animal source of meat temperature/package treatment and sub-plot of storage time was analyzed by analysis of variance using general linear models procedures (SAS, 1985). Treatment means were separated least squares means procedures at $P \leq 0.05$.

RESULTS AND DISCUSSION

ANOVA indicated no differences ($P<0.05$) due to animal source of steaks or patties. O_2 contents of steaks and patties were affected by treatment and storage time ($P<0.05$) (Figure 1). After gas-exchange, O_2 decrease and CO_2 increased with increased storage time. Gas exchange rate was less tan 65% which resulted in packages having less than 50% O_2 after gas exchange.

Weight loss of ground beef patties increased ($P<0.05$) with storage time (0.40, 0.84, 1.08, 0.77, 0.67 and 2.71% at 0, 7, 14, 16, 18 and 20 days) but was not influenced by distribution temperatures. Steak sample weights were not different ($P>0.05$) with distribution temperature treatments or storage time.

Oxidative stability (Table 1) was similar among different treatments with inert gas and increased slowly with storage. Control packages containing high oxygen has increased TBARS when compared with other treatments. Growth of psychotrophic microorganisms were affect ($P<0.05$) by treatment, storage time and treatment and time interaction. Psychotrophs were inhibited by lower distribution temperatures and inert gas atmospheres for distribution.

HunterLab L and b values (Figure 2) of patties and steaks were generally higher for controls while L, a and b values decreased with -12.2°C distribution compared with other temperatures.

CONCLUSION

Distribution storage at -3.8°C inhibited growth of psychotrophic microorganisms more than 4.4°C but after gas exchange colour and oxidative stability of ground beef patties and steaks were similar during simulated retail display at 4.4°C.

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Table 1. Oxidative stability and psychotrophic plant counts.

Beef type, trait, distribution treatment	Days after initial packaging 1	14	16	18	20
Steaks					
TBARS[b]					
4.4°C/N_2	0.47^{eg}	0.30^{g}	0.27^{g}	1.02^{ef}	0.75^{ef}
-3.8°C/N_2	0.27^{fg}	0.14^{g}	0.43^{fg}	0.80^{ef}	1.18^{e}
-12.2°C/N_2	0.47^{fg}	0.17^{fg}	0.25^{fg}	0.44^{df}	0.38^{f}
4.4°C/O_2	0.54^{ef}	0.99^{e}	1.05^{e}	0.70^{ef}	2.28^{d}
PPC[c]					
4.4°C/N_2	2.89^{h}	4.65^{egh}	5.65^{eg}	4.83^{dg}	5.67^{eg}
-3.8°C/N_2	0.93^{i}	2.81^{f}	1.97^{f}	3.21^{fg}	4.24^{e}
-12.2°C/N_2	0.69^{i}	2.94^{f}	2.23^{f}	2.81^{f}	2.68^{f}
4.4°C/O_2	0.69^{i}	5.65^{e}	5.30^{e}	6.23^{de}	7.23^{d}
Ground beef					
4.4°C/N_2	0.54^{g}	0.62^{g}	1.79^{g}	1.87^{g}	2.39^{g}
-3.8°C/N_2	0.48^{g}	0.33^{g}	2.21^{g}	1.93^{g}	2.49^{g}
-12.2°C/N_2	0.46^{g}	1.33^{g}	1.88^{g}	2.09^{g}	2.28^{g}
4.4°C/O_2	0.76^{g}	6.37^{de}	7.21^{d}	3.30^{f}	4.22^{ef}
PPC[c]					
4.4°C/N_2	3.06^{gh}	5.32^{f}	6.57^{e}	6.62^{e}	7.16^{de}
-3.8°C/N_2	2.78^{eh}	3.28^{hi}	2.76^{h}	4.30^{g}	5.39^{f}
-12.2°C/N_2	2.19^{e}	3.32^{gi}	3.44^{gh}	3.72^{g}	4.86^{fg}
4.4°C/O_2	2.45^{e}	7.37^{d}	7.81^{d}	7.30^{d}	7.48^{d}

[a] N_2 = 80%N_2/20%CO_2
O_2 = 80%O_2/20%CO_2
[b] TBARS = thiobarbituric acid reactive substances as mg/kg sample, SEM = 0.20 for steaks and 0.83 for ground beef.
[c] PPC = psychotrophic plate counts as log colony forming units/g, SEM = 0.48 for steaks and 0.22 for ground beef.
[d,e,f,g,h,i] least squares means for each traits in same row or column with same superscripts are not different ($P<0.05$).