INFLUENCE OF INJECTION, PACKAGING AND STORAGE CONDITIONS ON THE MICROBIAL AND COLOUR STABILITY OF BEEF AND BISON STEAKS

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Background

Maintaining quality and appearance is essential during the distribution and merchandising of perishable food products like meat. The only criterion consumers have at the point of purchase when selecting meat cuts is visual appearance. To prevent product shrinkage and to delay the onset of its deterioration, optimum storage temperature and appropriate packaging are necessary for retail display. There are many packaging choices available; however, knowledge of the physical characteristics of the materials and systems in question, along with other factors that influence the keeping quality of meat, is essential when selecting the appropriate packaging. Vacuum (VP) and modified atmosphere packagings (MAP, *i.e.*, with one or more gases) are being used by the industry to design different conditions so as to maximize the shelf-life of meat and to promote desired product attributes. The most commonly used gases for packaging of meat are carbon dioxide (CO_2), nitrogen (N_2) and oxygen (O_2). The O_2 in the package headspace enhances meat colour and extends the stability of oxymyoglobin, while CO_2 restricts the growth of aerobic spoilage bacteria (Jeremiah, 2001).

Objectives

The objective of this study was to assess the influence of injection, packaging and storage conditions on the microbial, oxidative and colour stability of beef and bison steaks.

Materials and methods

Fresh beef and bison loins (*longissimus lumborum*, LL - 4 each) were procured from local sources. Each LL was divided into two sections. One section was injected with brine containing NaCl and sodium tripolyphosphate (0.5% and 0.3%, respectively in the finished product) to achieve 20% extension by weight, while the other section was kept as a non-injected control. Then, each loin section was divided into as many steaks (1" thick) as possible. These steaks were randomly allocated to storage atmospheres (MAP and VP), storage temperatures (-1 and +4°C) and storage interval subgroups (overnight, 1 and 2 weeks; and 1, 2 and 3 weeks for MAP and VP, respectively). The steaks (n=48) for VP treatment were individually packaged in ethylene/vinyl acetate copolymer polyvinylidene-chloride (PVDC) laminate bags. After making 2 holes through the over-wrap film for free exchange of gases, the steaks (48) for MAP were transferred to Cryovac B series bags, the headspace was evacuated, filled with a mixture of 70% O_2/30% CO_2 and then sealed. After removal from the main packaging following the designated storage intervals, pH, 2-thiobarbituric acid reactive substances (TBARS), purge during storage and total aerobic plate counts were determined. Colour (L*, a* and b*) was measured using a HunterLab Miniscan XE colorimeter. The change in colour was calculated for each L*, a* and b* values; *i.e.*, ΔL^* ($L_x^* - L_0^*$), Δa^* ($a_x^* - a_0^*$) and Δb^* ($b_x^* - b_0^*$), where L_0^*, a_0^*, b_0^* were at time zero and L_x^*, a_x^*, b_x^* were at time x. For each type of meat (beef and bison), data were analyzed as a split-plot with two replications. Storage temperatures of -1 and +4°C were the main plot treatment. Sub-plot treatments included a factorial combination of 2 injection treatments, and 6 packaging-storage treatments. Least-squares means were calculated for all main effects or interactions that were represented by a significant *F*-test.

Results and discussion

As expected, the pH of injected steaks was significantly ($p<0.05$) higher than non-injected samples (Table 1). The pH of beef steaks remained constant in MAP but decreased in the third week in VP. For injected bison, the pH decreased from 5.74 to 5.49 over time in vacuum-packed systems but did not change significantly ($p<0.05$) in the non-injected counterpart. At the higher storage temperature, pH of the meat decreased with time. Owing to a high O_2 concentration and subsequent increased lipid oxidation, MAP beef steaks stored for 1 or 2 weeks exhibited higher TBARS values compared to VP steaks. In bison meat, lipid

oxidation was also significantly influenced by different packaging treatments; however, their effect on TBARS was strongly dependant on injection and temperature of storage, as indicated by the packaging *x* injection and packaging *x* temperature interactions (p=0.000 and p=0.007, respectively). TBARS values for steaks stored under MAP for 1 week were higher than those stored under vacuum, while TBARS values for steaks stored under MAP-OV were the lowest (p<0.01). In the present study, the interactions between injection and temperature were probably due to the magnification of the TBARS differences among packaging treatments within non-injected steaks and those stored at the higher temperature. Both beef and bison showed significant injection *x* storage treatments interactions for purge lost during storage. Except for MAP steaks stored overnight, injected steaks had significantly lower fluid loss compared to non-injected samples. Regardless of the injection treatment, steaks stored under vacuum had significantly higher fluid loss in comparison to MAP treatments. The differences in purge among the storage treatments were greater in the non-injected than in the injected meat.

Storage temperature has a major influence on the microbial quality of meat products. As expected, microbial loads of steaks that had been injected and the ones stored at +4°C were higher than non-injected steaks and those stored at -1°C, respectively (Fig. 1). Modified atmospheres around steaks delayed the time to spoilage, which was evident from the data obtained on microbial load in the present study. Aerobic counts for steaks stored under MAP were lower than those stored under VP; nevertheless, counts from both packaging atmospheres were in the acceptable range. In the present study, a mixture of 70% O_2 and 30% CO_2 was employed. The CO_2 in the package atmosphere restricts the growth of aerobic spoilage bacteria, while the elevated O_2 concentration enhances meat colour and extends the stability of oxymyoglobin (Jeremiah, 2001). Aerobic counts increased gradually with storage, but generally colour deterioration occurred in advance of significant changes in aerobic plate counts.

In the present study, bison meat bloomed quickly with a dark red colour, but it tended to loose its brightness readily on storage compared to beef. As expected, steaks stored at the lower temperature (-1°C) held better colour than those stored at the higher temperature (+4°C) (Fig. 2). It has been reported that a low storage temperature promotes oxygen penetration into meat surfaces and increases the solubility of oxygen in tissue fluids, which increases the depth of the oxymyoglobin layer on meat surfaces (Hood, 1984). At the time of storage, non-injected beef steaks had higher a* values than injected ones. However, after 3 weeks of storage marination had no significant (p>0.05) affect on the colour of beef steaks. While for bison steaks, the change in a* values during storage due to brine injection was dependant on storage time and type of packaging. There was a positive influence on the colour of steaks under MAP treatment after overnight and 1 week of storage, whereas the colour of steaks deteriorated (*i.e.*, decreased a* values) significantly (p<0.05) after vacuum packaging irrespective of the storage time. These changes in a* values were more pronounced in injected than non-injected bison steaks (Fig. 3).

The largest increase in a* value of beef and bison steaks was observed during overnight storage under MAP. A slight improvement of the colour was also seen in beef steaks stored under MAP for 1 week. The a* value remained constant in beef steaks held under MAP for 2 weeks and under vacuum for 1 week but decreased significantly after 2 and 3 weeks of storage under VP. Bison steaks held under MAP for 1 week retained a bright red colour only in injected treatments and those stored at the lower temperature. Regardless of storage temperature and injection, bison steaks held under MAP for 2 weeks were totally discoloured, so rendered as unacceptable and were discarded from further assessments.

Conclusions

Beef LL steaks were able to retain their bright red colour longer than bison steaks. However, the deterioration in colour of bison steaks occurred in advance of significant changes in aerobic plate counts. Bison appears to develop higher TBARS on storage, and this might have an influence on the resulting rapid loss of redness with bison. Storage at -1°C provided greater colour stability and longer storage life for both beef and bison meat. MAP is an excellent option for short-term storage due to its positive effects on meat colour, but for longer storage, VP may be necessary. Storing meat under vacuum and then placing it under MAP just before retail display might be another option to increase shelf-life.

References

Hood, T. 1984. The chemistry of vacuum and gas packaging of meat. In A.J. Bailey (Ed.), *Recent Advances in the Chemistry of Meat* (pp. 213-230). London, UK: Royal Society of Chemistry.

Jeremiah, L. E. 2001. Packaging alternatives to deliver fresh meats using short- or long-term distribution. *Food Research International*, 34, 749-772.

Table 1. Effects of marination, packaging and storage on pH, TBARS and purge of beef and bison steaks.

		pH		TBARS (mg malon-aldehyde eq./kg)		Purge (%)	
		Beef	Bison	Beef	Bison	Beef	Bison
Temperature							
-1		5.51	5.55	0.565	0.957	3.47	4.65
+4		5.39	5.43	0.553	1.164	3.71	5.10
p-value		*0.349*	*0.223*	*0.929*	*0.173*	*0.365*	*0.283*
Injection							
INJ		5.59a	5.66a	0.553	0.572b	2.69b	3.55b
NO		5.31b	5.32b	0.565	1.183a	3.86a	4.32a
p-value		*0.000*	*0.000*	*0.866*	*0.000*	*0.000*	*0.000*
Storage							
MAP-OV		5.48a	5.53ab	0.487bc	0.411b	0.97a	1.23a
MAP1		5.49a	5.55a	0.688b	2.529a	2.47b	2.99b
MAP2		5.45a		1.142a		2.65b	
VP1		5.53a	5.54a	0.362c	0.546bc	4.98c	5.54c
VP2		5.42ab	5.44b	0.390c	0.684c	5.73cd	6.32cd
VP3		5.32b	5.41b	0.410c	0.681c	6.20d	7.19d
p-value		*0.045*	*0.035*	*0.000*	*0.000*	*0.000*	*0.000*
Interactions							
INJ	MAP-OV		5.72a		0.265e	1.00h	1.03h
INJ	MAP1		5.78a		1.304b	2.03g	2.45g
INJ	MAP2					2.06g	
INJ	VP1		5.74a		0.464de	3.95de	4.68e
INJ	VP2		5.56b		0.516d	4.59cd	5.01de
INJ	VP3		5.49b		0.481d	4.98c	6.06cd
NO	MAP-OV		5.33c		0.575d	0.93h	0.93h
NO	MAP1		5.31c		4.404a	3.01f	3.64f
NO	MAP2					3.39ef	
NO	VP1		5.33c		0.632cd	6.29b	6.56bc
NO	VP2		5.33c		0.871c	7.14ab	7.96ab
NO	VP3		5.32c		0.908c	7.72a	8.54a
p-value		*0.372*	*0.017*	*0.736*	*0.000*	*0.004*	*0.000*
-1	MAP-OV				0.394c		
-1	MAP1				1.935b		
-1	VP1				0.578bc		
-1	VP2				0.703b		
-1	VP3				0.741b		
+4	MAP-OV				0.429c		
+4	MAP1				3.242a		
+4	VP1				0.514bc		
+4	VP2				0.666bc		
+4	VP3				0.623bc		
p-value		*0.117*	*0.061*	*0.749*	*0.007*	*0.968*	*0.585*

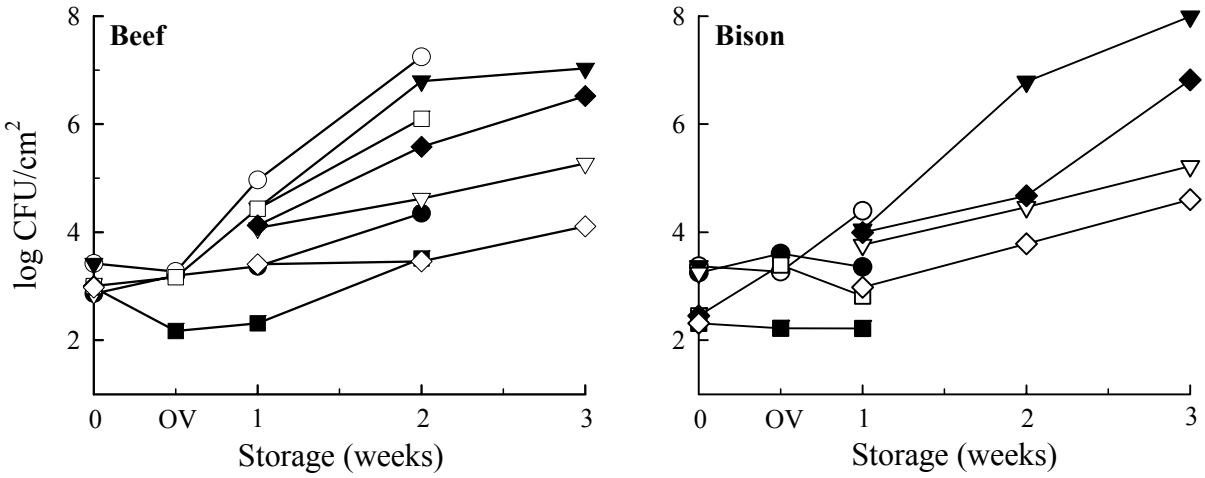

Fig. 1. Total aerobic plate count in beef and bison steaks.

● Inj, -1°C, MAP; ○ Inj, 4°C, MAP; ▽ Inj, -1°C, VP; ▼ Inj, 4°C, VP;
■ Non, -1°C, MAP; □ Non, 4°C, MAP; ◇ Non, -1°C, VP; ◆ Non, 4°C, VP.

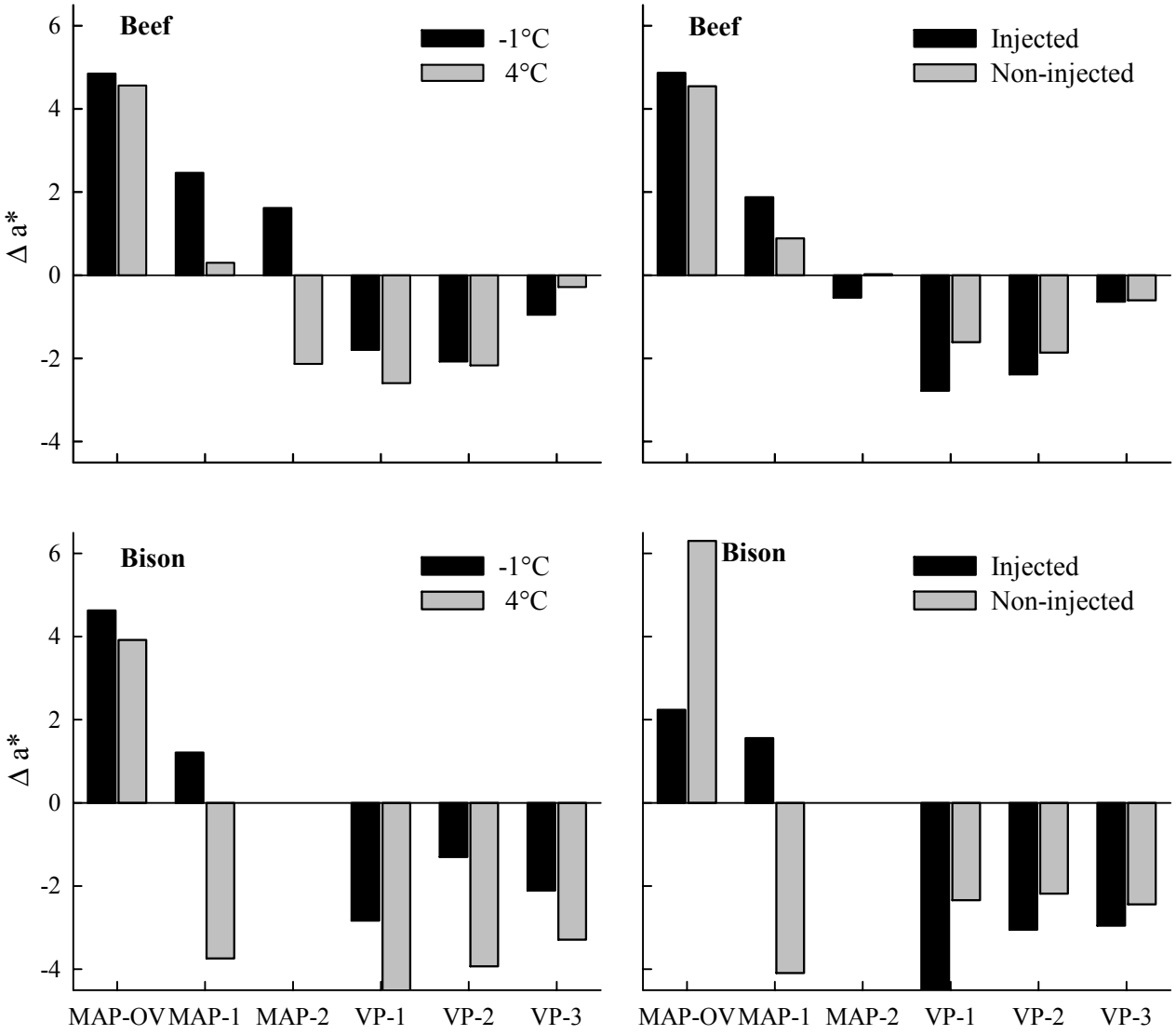

Fig. 2. Effect of temperature & packaging on change in a* during storage of steaks.

Fig. 3. Effect of injection treatment & packaging on change in a* during storage of steaks.