PERFORMANCE DURING RETAIL DISPLAY OF BEEF AND BISON STEAKS AFTER STORAGE UNDER VACUUM AND MODIFIED ATMOSPHERE PACKAGING

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Background

The colour of meat is the single most important factor that influences the buying decision of the consumer. Myoglobin, sometimes referred to as dexoymyoblogin (DOMB), is the main pigment of meat and has a purplish red colour. When a freshly cut surface of meat comes in contact with air, DOMB is oxygenated and converted to oxymyoglobin (OMB); this gives beef a bright cherry red appearance and this colour is normally used as an indicator of freshness by the consumer. If only small quantities of oxygen are present, such as in a partial vacuum or a sealed semi-permeable package, DOMB is converted to metmyoglobin (MMB) via oxidation giving the meat a brown appearance. Development of this brown pigment is a serious problem in merchandising meat, because most consumers associate it with a product that has been stored too long. Bison meat is traditionally viewed as having a dark red colour. This colour is not as acceptable to consumers who are conditioned to the bright cherry red colour of beef. The colour of the meat can be controlled, if the factors influencing it are better understood. In the meat industry, vacuum packaging (VP) is employed to maximize the shelf-life of meat, whereas modified atmosphere packaging (MAP), containing high levels of oxygen, is widely used to attain the bright red colour of meat through oxygenation of DOMB.

Objectives

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

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 was divided into as many steaks (2.54 cm 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 (n=48) for MAP were masterpacked in high oxygen using Cryovac B series bags. The headspace was evacuated, filled with a mixture of 70% O_2/30% CO_2 and then sealed. VP and MAP steaks were stored at designated temperatures for set periods. After removal from the main packaging following the designated storage interval, steaks were re-packaged on styrofoam trays over-wrapped with an oxygen permeable film and then placed in a retail display case (under 24 h fluorescent lighting with average light intensity of 975 lx) maintained at 3.0±1°C. Colour (L*, a* and b*) and absorbance was measured using a HunterLab Miniscan XE colorimeter daily for 5 days. Different forms of myoglobin (*i.e.*, OMB, MMB and DOMB) were calculated as described by Hunt *et al.* (1991).

Results and discussion

As is typical of most game animals, bison meat appeared darker than beef, yet was of similar initial pH (5.3). It has a negligible amount of intramuscular fat, which could be a possible reason for its darker appearance. 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 that of beef. The ability of different muscles to resist MMB formation during aerobic storage varies greatly and depends upon the species in question, anatomical location within the carcass and most importantly variations in the rate of DOMB oxidation and the ability of muscle to consume

oxygen; *i.e.*, muscles with high activities of oxygen-utilizing enzymes, that allow little penetration of oxygen into the tissue, tend to discolour more rapidly.

HunterLab colour values, particularly a* values, are a good indication of the redness of meat: the higher the a* value, the redder the meat. The change in colour of beef and bison steaks was monitored for 5 days. For beef, the decline in a* values was gradual and significant ($p<0.05$) between day 0 and day 5, whereas for bison the steaks held a bright red colour for only the first 2 days. After which, discolouration of bison steaks became evident; most of the steaks had to be discarded before the completion of the retail display study. As expected, steaks stored at the lower temperature (-1°C) held better colour than those stored at the higher temperature (+4°C). Because the maximum storage life of meat is attained at the lowest possible temperature, without freezing the meat (*i.e.*, between -1 and -1.5°C), any increase in this optimum storage temperature will result in a proportional decrease in the storage life (Gill and Shand, 1993). The rate of change in redness or discolouration increases with a rise in storage temperature (Jeremiah and Gibson, 2001). Injection had a beneficial effect on the colour stability of steaks during retail display; however, this positive effect was more pronounced for bison steaks compared to those of beef. Steaks stored overnight under MAP (MAP-OV) prior to retail display maintained the highest a* values (*i.e.*, a brighter red colour) for up to 5 days compared to those stored under vacuum (VP1, VP2 and VP3). Bison steaks stored for 2 weeks under MAP were grossly discoloured by the end of the storage period and were discarded from the retail display study (data not shown).

Figs. 1 and 2 depict the effects of injection treatment, temperature, packaging type and storage in the retail display case on the relative proportions of OMB. Beef steaks maintained significantly ($p<0.05$) higher proportions of OMB compared to bison steaks: darker and less redder bison steaks (*i.e.*, lower a* values) compared to beef ones complemented these results. Injected steaks and steaks stored at the lower temperature (-1°C) had significantly ($p<0.05$) higher OMB levels compared to non-injected steaks and those stored at the higher temperature (+4°C), respectively. Present results clearly show the detrimental effects of storage and display on OMB content: MMB formation increased, while OMB proportions decreased with increasing storage time in the retail display case and corresponded to the changes observed in HunterLab values. The decrease in proportions of OMB for steaks in the retail display case was dependant upon injection treatment and storage temperature, as injected steaks and those stored at -1°C were generally redder and contained more OMB. This clearly demonstrates the beneficial effects of a lower storage temperature and antioxidative properties of phosphates on muscle colour stability. MAP-OV steaks maintained the highest OMB content for up to 5 days during retail display compared to those stored under vacuum (VP1, VP2 and VP3). A continued supply of oxygen in the headspace was responsible for oxygenation of DOMB, hence, the bright red colour. Nevertheless, OMB levels were significantly ($p<0.05$) lower in bison steaks compared to those of beef irrespective of packaging treatments.

Conclusions

Marination had a beneficial effect on the colour stability of steaks during retail display, but this positive effect was more pronounced for bison steaks compared to those of beef. The results obtained from the present study support the view that MAP containing a high oxygen concentration is not suitable for long storage; however, such packaging is well suited for display applications when the time between packaging and display is short. High oxygen-containing modified atmospheres tend to stabilize the oxygenated state of DOMB for relatively short periods, whereas VP is a better option when prolonged storage is required.

References

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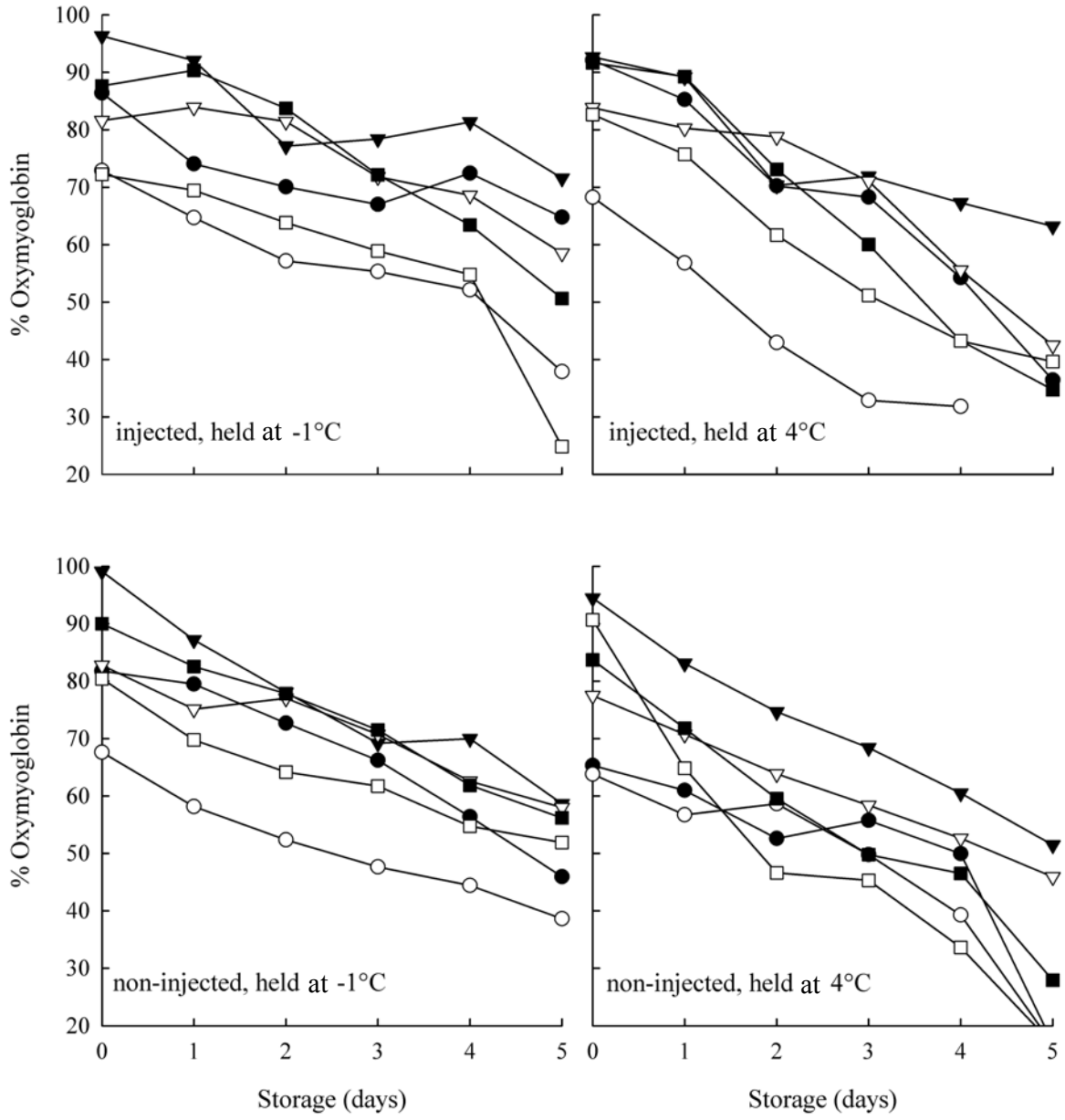

Fig. 1. Changes in surface oxymyoglobin content of beef steaks held under simulated retail display at 3°C following different conditions:

● MAP-1; ○ MAP-2; ▼ MAP-OV; ▽ VP-1; ■ VP-2; □ VP-3.

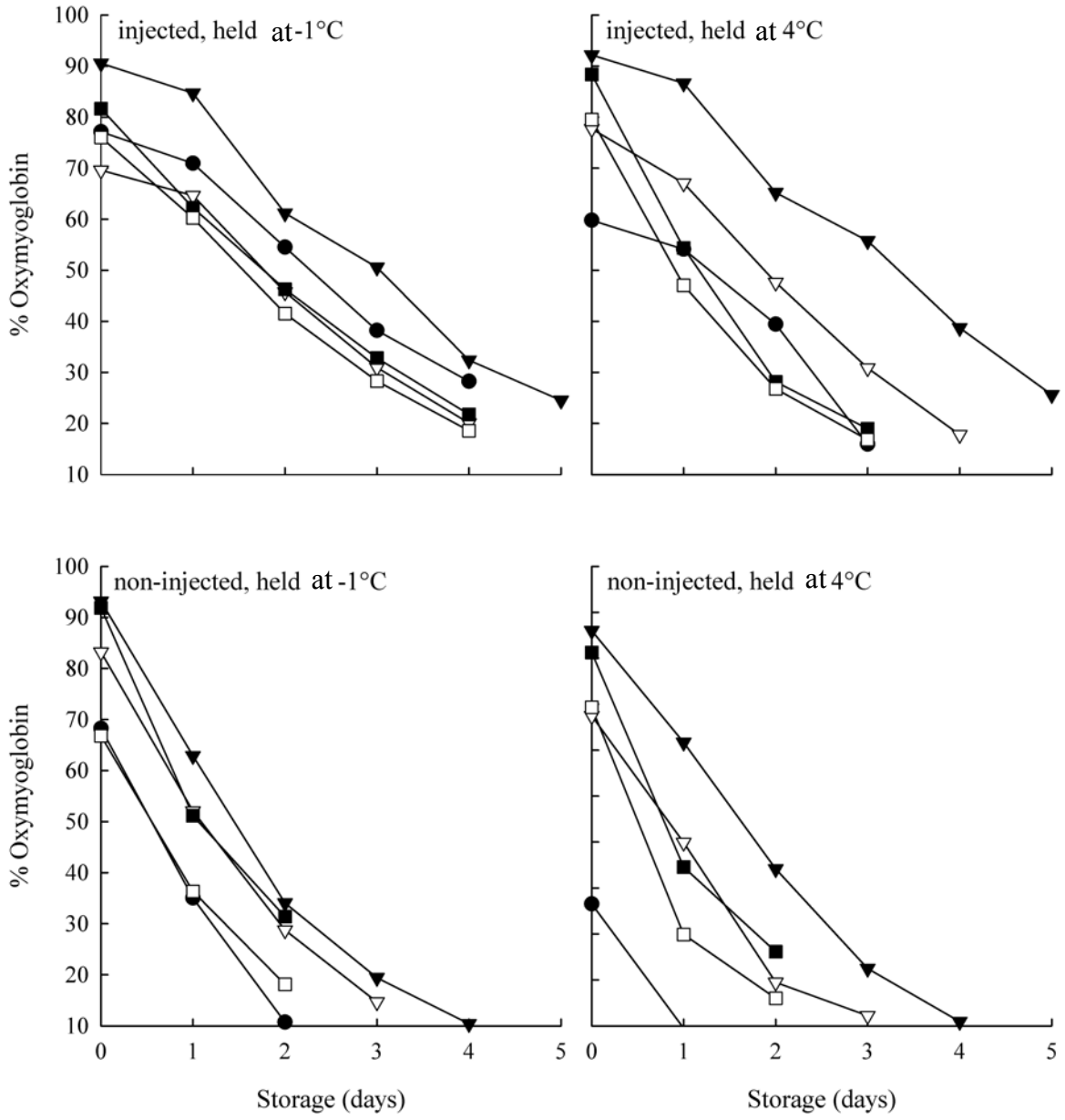

Fig. 2. Changes in surface oxymyoglobin content of bison steaks held under simulated retail display at 3°C following different conditions:

● MAP-1; ▼ MAP-OV; ▽ VP-1; ■ VP-2; □ VP-3.