VERY LOW OXYGEN MAP PACKAGING FOR RETAIL BEEF CUTS

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Background

Beef on retail display should have a bright red colour otherwise consumers will reject it. The red colour, which is due to the oxygenation of the myoglobin pigment near the surface, is unstable and continuous exposure to oxygen leads to the formation of brown metmyoglobin. An oxygen-rich atmosphere results in a very deep layer of oxymyoglobin and therefore delays discoloration. MAP packs flushed with 70-80% oxygen are therefore used to give retail cuts of beef an extended colour display life of up to 8 days. There is commercial interest in packaging systems for retail cuts that could be stored for several weeks prior to retail display. Such systems must guarantee an acceptable colour during display for up to four days. Isdell et al (1999) used a mother pack system and oxygen scavengers to achieve a virtually oxygen-free atmosphere during storage for up to 4 weeks. When packs were taken out of the mother pack and placed in a retail display cabinet the steaks quickly developed a bright red colour since the overwrap film was highly permeable to oxygen. Retail MAP packs are now preferred to overwrapped trays by many retailers. If very low residual oxygen levels in packs could be achieved then such packs could be stored for several weeks without adverse effects on the colour display life provided oxygen entered the packs rapidly at the beginning of the display period. These conditions could be met by storing MAP packs with a highly permeable top film in a mother bag containing a CO_2/N_2 mixture. Preliminary work showed that very low residual O_2 levels could be achieved in MAP packs, but films with a high oxygen transmission rate were not sufficiently strong to be used with the MAP machine. To test whether a system would be successful if a sufficiently strong film with a high OTR could be found, a trial was carried out using a film with low permeability. These were stored for 3 weeks then the film was punctured to simulate a high OTR. The colour display life was compared with overwrapped steaks that had also been stored for 3 weeks either in identical MAP packs or in vacuum packs.

Objective

To compare the colour stability of beef steaks stored in a virtually oxygen-free atmosphere for 3 weeks either in MAP or vacuum packs.

Methods

Striploin (*Longissimus dorsi*), topside (M. *semimembranosus*), rump (M. *gluteus medius*) and fillet (M. *psoas major)* primals were removed from 2-year old heifers at 72 hours post mortem. These were chosen to represent a range of colour stability, from the most colour stable *Longissimus dorsi* to the least stable *psoas major* (Mac Dougall & Taylor, 1975). Ten steaks of approximately 25mm thickness were cut from each primal and placed individually in polystyrene trays. These were flushed with 60% N_2 and 40 % CO_2 and lidded with a film of low permeability (OTR = 15 cm^3/m^2 / 24 hrs at 1 bar, at 23°C) using a Ross Reiser Junior (Reiser UK, Milton Keynes). This machine was capable of reducing the residual oxygen concentration of each pack to below 0.1%. The remainder of each primal was vacuum packed. The retail MAP packs and the vac-packs were stored in the dark at 0°C for 3 weeks. The MAP packs were then either (A) perforated 4 times with a small needle, (B) opened and the steak was placed in a tray and rewrapped with a highly permeable cling film or (C) left intact. The vacuum packed primals were opened and individual steaks were cut and overwrapped in cling film (D). All packs were then placed in a retail display cabinet at an average temperature of 3.7°C. Colour was measured after 4, 24, 48 and 72 hours of display. Meat colour was monitored using a portable spectrophotometer (Minolta Scan XE Plus, Hunter Associates Laboratory Inc., Virginia, USA.). Hunterlab *L* (lightness), *a* (redness) and *b* (yellowness) values were measured through the film at 5 locations on each steak and averaged. The hue angle (arctan *b*/*a*) and Saturation $((a_2 + b_2)^{0.5})$ were calculated.

Results and discussion

The mean oxygen content of the MAP packs was 0.07% immediately after packing and 0.05% after storage for 3 weeks. This indicated that the expectations of the packaging machine and the barrier trays and film were fulfilled. The change during four days retail display in the mean redness (HunterLab a) of four types of steak for each of the packaging types is shown in Figure 1. All muscles in the non-perforated packs failed to bloom. This was due to the low OTR of these packs, which prevented ingress of oxygen. Blooming occurred to some degree in all the other packs, though there were differences between the pack types and between the muscles. For the *longissimus dorsi* steaks blooming was most rapid in the steaks that had been stored in vacuum packs and then overwrapped, slowest in those that had been stored in MAP packs and then perforated and intermediate in those that had been stored in MAP packs and rewrapped prior to display ($p<0.05$). On days 2 and 3 there were no differences between these three pack types. However, the redness of vac-packed steaks declined steadily from day 1 onwards while that of the other two pack types increased from day 1 to day 3 and by day 4 the redness of steaks in the perforated packs was higher than those that had been stored in vac-packs ($p<0.05$). For *semimembranosus* steaks storage in vac-packs prior to display resulted in higher redness than storage in MAP packs but the difference was significant only at days 1 and 2. *Semimembranosus* steaks that had been stored in MAP packs failed to bloom to an acceptable degree of redness regardless of whether they were perforated or rewrapped. This would suggest that some metmyoglobin formation had occurred during storage in this muscle even at the low residual oxygen level (<0.1%). The same was true of the *gluteus medius and psoas major* steaks that had been stored in MAP packs. Both of these failed to bloom during display. The relatively poor

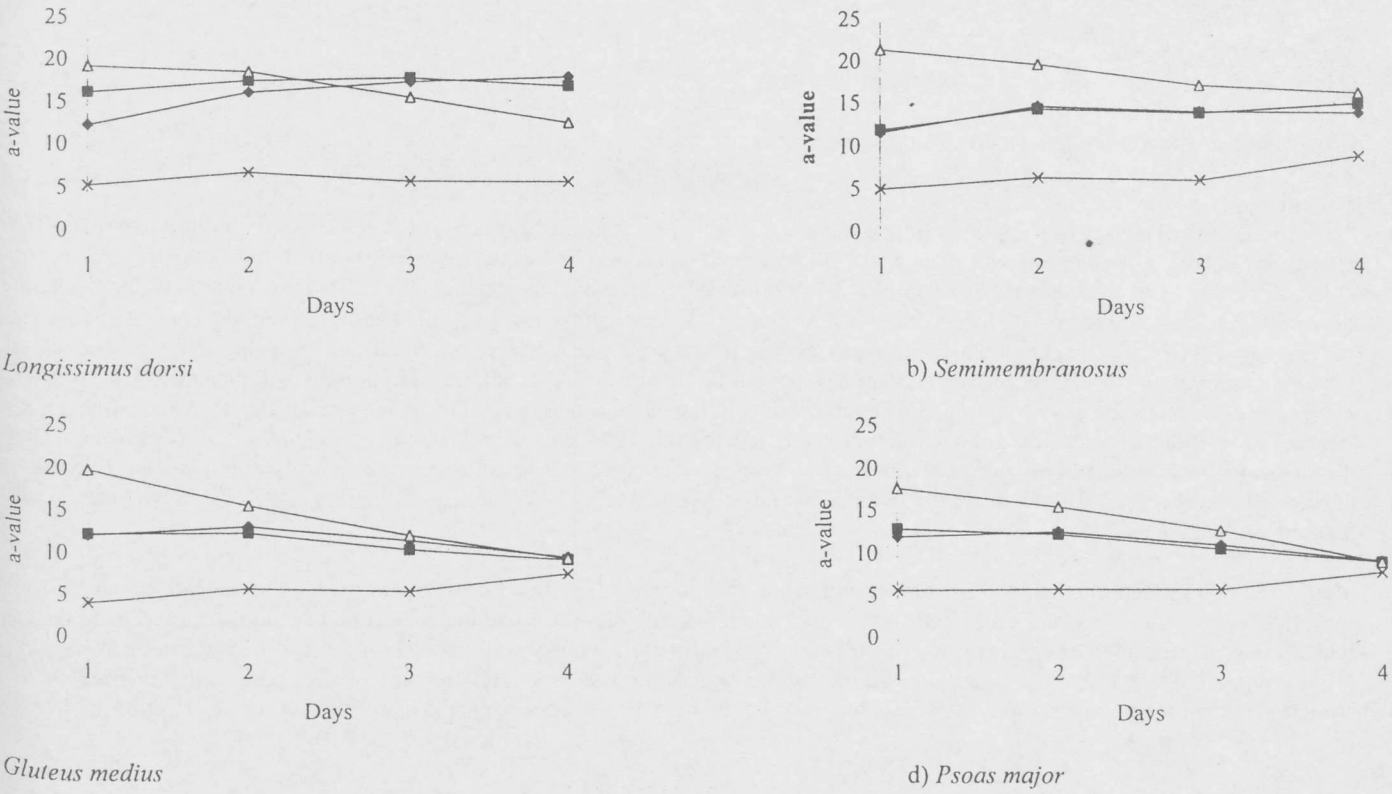

Figure 1 Effect of packaging system (♦ = Perforated, ■ = Rewrapped, △ = Vac-packed, ✕ = Non-perforated) on redness of beef steaks

colour stability of these muscles compared to the *longissimus dorsi* is illustrated by the rapid decline in redness of steaks of these two muscles that had been stored in vacuum packs. For both of these muscles the redness of steaks of the vac-pack treatment was not significantly different from those that had been stored in MAP packs on all days after day 1.

With the exception of the non-perforated packs, there were generally no differences between the pack types in the lightness (HunterLab L) of steaks at all display times. Lightness has been found by others to be a poor indicator of colour stability (e.g. Renerre, 1984, Bell *et al.* and 1996). The yellowness (HunterLab b) also changed little during display and generally did not differ between the pack types, excluding the non-perforated packs and this is in agreement with Renerre and Mazuel (1985). The results for saturation closely mirrored those described above for redness. MacDougall (1977) suggested that saturation was a good indicator of blooming and used a scale of saturation to describe the degree of discoloration. Hue angle results also folowed a similar pattern to redness, but there were fewer significant differences between the pack types, excluding the non-perforated packs. This suggests that hue angle is less sensitive to treatment differences than either redness or saturation.

Conclusions

These results indicate that storage of retail ready steaks in a low oxygen MAP pack for 3 weeks resulted in an acceptable colour display life only for the *longissimus dorsi* (striploin steaks). The colour stability of the less colour stable muscles was adversely affected by storage in an atmosphere with a residual oxygen content as low as 0.07%. For these muscles oxygen scavengers would be needed to absorb all the residual oxygen.

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