The effect of modified atmospheres and oxygen scavengers on the colour stability of fresh beef.

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Introduction

New consumer trends are increasing the demand for refrigerated foods with extended shelf-life (Labuza and Breene 1988). One of the most important factors involved in consumer acceptance of meat is colour (Manu-Tawiah et al 1991). The principal pigment of fresh meat is myoglobin. It can exist in three forms - red oxymyoglobin, purple reduced myoglobin and brown metmyoglobin . Meat colour depends on the relative amounts of these three pigments (Hood and Mead 1993).

Packaging atmospheres can effect the colour of meat. Atmospheres containing 60-80% oxygen and 20-30% carbon dioxide are considered high oxygen systems. The red colour of the meat is enhanced due to the higher than normal levels of oxygen. (Bell and Bourke 1995). Carbon dioxide included in the atmosphere will inhibit the growth of spoilage organisms (Haines 1933). An initial oxygen concentration of at least 60% maintains the red colour of fresh beef for at least one week, stored at 1^0 C (Taylor and MacDougall, 1973). If meat is stored under anaerobic conditions, the colour is maintained in the purple reduced form of myoglobin. However optimum conditons for metmyoglobin formation occur at low partial pressures of oxygen. Therefore in anoxic packages when the air has been largely displaced by a CO2/N2 mixture, red meats will discolour because of the small amount of residual oxygen in the pack (Gill 1990). Oxygen scavengers are a means of reducing the oxygen to below the critical level for discolouration (Labuza and Breene 1988).

The objective of this study was to use MAP and oxygen scavengers to extend the storage life of fresh beef so as to facilitate the export of retail cuts of beef from Ireland.

Material and Methods

Meat was obtained from 6 heifers. The animals were slaughtered in a pilot scale abbatoir and hung at 4 ^{0}C. Six muscles - two of which were *Longissimus dorsi* (LD) and *Gluteus medius* (GM) -were examined.

At 6 days postmortem steaks, approximately 12mm thick, were cut from each muscle, placed in clear plastic trays (approx. 20cm × 11cm × 2.5cm) containing a 200cc oxygen scavenger (ss-200, Ageless, Mitsubishi) and overwrapped with clear plastic film (oxygen transmission rate 20,000 cm^3/m^2/24hrs/1 atm) . One sample of each muscle was then placed randomly in a mother pack containing one 2000cc oxygen scavenger (z-2000,Ageless) and packaged in an atmosphere of 50% CO_2 : 50% N_2 using a 'triple vacuum-flush'cycle on a gas flushing machine (A300, CVP systems Ltd., England). Control packs without oxygen scavengers were also packaged the same way. All Packs were stored in a chill in the dark at 0 ^{0}C for 2, 4 or 6 weeks. Six replicates were carried out, one animal being used per replicate.

The ph of all muscles was taken to ensure that the meat was of normal ph, suitable for packaging (<5.8).

After storage, packs were removed from the chill. The atmosphere in the mother packs was analysed using gas chromatography (Gow-Mac Spectra 250, Gow-Mac Instrument Company, Ireland). The carrier gas was helium at a flow rate of 50 ml/min.The column temperature was 50 ^{0}C, the detector temperature was 77 ^{0}C and the injection port temperature was 50 ^{0}C.

After gas analysis the mother packs were opened and the trays placed on display in an illuminated (fluorescent) retail display cabinet at 4^0C ± 1^0C for 96h. Using a spectrophotometer (Hunterlab - UltraScan XE, Hunter Associates laboratory Inc., U.S.A.) Hunter l, a, b reflectance values were obtained at 0, 2, 24, 48, 72 and 96 h of retail display. The average of 6 readings was recorded for each sample. The reflectance port size was 25 mm. The illuminant was D65, the observer angle was 10^0 and the specular component was excluded.

At time of packaging 12 fresh steaks(2 from each muscle, 1 from each side of the animal) were placed in the same retail display cabinet as a control for the packaged beef. Colour measurement was carried out as above. Analysis of the data was carried out using one-way analysis of variance.

Results and Discussion

Results from the gas analysis showed that the average oxygen content of packs stored with oxygen scavengers for 2, 4 or 6 weeks was less than .05%. Packs stored without scavengers had an average oxygen content of > 1.1%. Gill and McGinnis (1995) found in beef an oxygen content of < 600 ppm or .06% prevented colour deterioration of muscle of high colour stability stored at sub-zero temperatures. The oxygen scavengers are therefore an essential part of the system, keeping residual oxygen below the critical level and thereby retarding metmyoglobin formation.

The mean 'hunter a' values for the muscles LD and GM after storage with and without scavengers for 2, 4, or 6 weeks are shown in figures 1a and 1b.Both muscles stored with scavengers bloomed to a bright red colour between 2 and 24h while the control packs failed to bloom. As expected the redness of both muscles decreased with display time.The LD and the GM responded to the mother pack and scavenger system with varying degrees of success. Table 1. summarises the results of the ANOVA for the redness of steaks (LD and GM) stored with scavengers for 2,4 or 6 weeks compared to the fresh steaks at 2, 24, 48, 72 and 96 hours of retail display. The system was, as expected, most successful for the LD muscle. Steaks from packs stored with scavengers were compared with fresh steaks displayed for 96h. For the LD there were no significant differences at any display time after the 2, 4 or 6 week storage with the exception of the 2h, 6wk readings ($p<.01$). There were significant differences ($p<.05$%) between fresh and stored at 2, 24, and 48h - 4wk readings and at 24h - 2wk readings. However these differences occurred due to the stored muscle being significantly better than the fresh. The least successful muscle was the GM. Significant differences occurred between fresh and stored from 48h onwards for 2 week storage, 24h onwards for 4 week storage and at all display time for 6 weeks storage. In general the trend is that of increasing differences between the fresh muscle and that stored with scavenger as the storage period increases.

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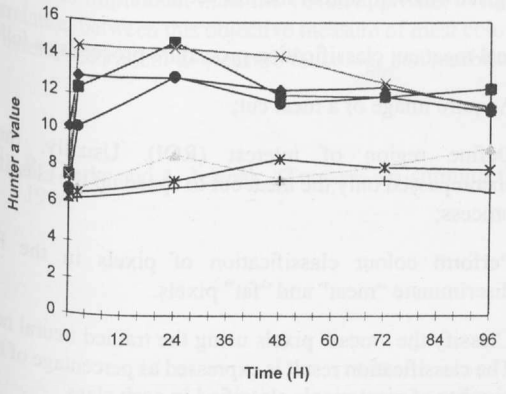
Table 1. Redness of steaks stored with oxygen scavengers for 2, 4, or 6 weeks compared to the redness of fresh steaks. P<.05 *, P<.01 **, P<.001, ns non-significant.

Muscle	Storage (wk)	Display (h)				
		2	24	48	72	96
LD	2	ns	ns	ns	ns	ns
	4	*	*	*	ns	ns
	6	**	ns	ns	ns	ns
GM	2	ns	ns	**	***	*
	4	ns	*	*	***	***
	6	*	*	**	**	**

Fig. 1 Hunter a values (redness) for (a) LD and (b) GM during retail display, stored with and without oxygen scavengers for 2,4, or 6 weeks.

(a)



(b)