THE EFFECT OF DIFFERENT OXYGEN CONCENTRATIONS ON THE BLOOMING ABILITY OF M. *LONGISSIUMS DORSI* STEAKS.

M. Beggan[1], P. Allen[1], and F. Butler[2]
[1]Teagasc, The National Food Centre, Dunsinea, Castleknock, Dublin 15, Ireland.
[2] Department Of Agricultural and Food Engineering, University College Dublin, Earlsfort Terrace, Dublin 2, Ireland.

Keywords; Beef, modified atmosphere packaging, meat blooming

Background

The cherry red appearance of beef steaks at retail display is an appealing factor, which influences the consumers purchasing decision. Oxygen is required to convert the purple, myoglogin of the freshly cut beef surface to the cherry red oxygenated state. It is widely known that steaks packed in high oxygen MAP concentrations (80%) can maintain the red oxygenated appearance for 6-7 days (Bell & Bourke, 1995 & Sorheim *et al.*, 1999). However, the presence of oxygen at low concentrations (approx. < 1%) causes rapid oxidation at the meat surface resulting in a browning effect (Penney & Bell 1993). Beef packaging methods involve a storage period, usually for 3-4 weeks, followed by a display period. Most beef processors store beef as primals in vacuum packs. Vacuum packaging involves the removal of 97-99.7% of the atmospheric gases from a high barrier pouch, followed by sealing. The meat remains in its purple, myoglobin state during storage due to the lack of oxygen. For the display period, the primal is cut into steaks and either placed in a tray and overwrapped with highly oxygen permeable film (1-2 days display life) or packed under a modified atmosphere containing high oxygen (approx. 80%) (6-7 days display). Research had been carried out on the storage of beef in the retail steak form (3-4 weeks) using a modified atmosphere of high carbon dioxide (CO_2) and nitrogen (N_2) (Beggan *et al.,* 2001, Isdell *et al.*, 1999). In Isdell`s work, steaks are over wrapped with a highly oxygen permeable film and gas flushed with a low oxygen mixture. These packs were further packed in an outer barrier bag, which was gas flushed with the same mixture. Prior to display the outer bag was removed and the exposure of the steaks to oxygen caused the meat to bloom. Beggan *et al.*, (2001) investigated this method of beef packaging using the more popular lidded polystyrene tray. Problems were encountered trying to source a lidding film with sufficient oxygen permeability at low display temperatures that was suitable for use with a commercial packaging machine. It was found that many of the available films of high OTR were too weak for use on the packaging machine and did not seal properly. Most of the lidding films had insufficient oxygen permeability at display temperatures (0-4°C). The minimum oxygen concentration required for optimum blooming of aged beef steaks, i.e. bloomed to the same degree as those exposed to air, has not been clearly defined. This information along with the volume of the retail tray can be used to calculate the oxygen permeability of the film required for the successful blooming of steaks using this packaging method.

Objective

To determine the effect of oxygen concentration on the blooming ability of M. *longissiums dorsi* (LD) retail packed steaks.

Methods

Bovine M. *longissiums dorsi* (LD) muscles were excised from steers at 48hrs post mortem. The LD primal was immediately vacuum packed and stored for 2 weeks at 0°C. 21 steaks (approx. 25mm in thickness) were then cut from each LD and gas flushed (CVP A300, CVP Systems Ltd., Middlesex, England) as follows: 2%, 5%, 10% or 20% O_2 / 50% CO_2 / balance N_2. 5 packs were made per treatment. One steak was placed in a tray and overwrapped in a highly permeable film and display in air. This was used as the control. MAP packs were displayed in a display cabinet for 30mins, 1hr, 2hrs, 4hrs & 24hrs prior to analysis. The temperature of the display cabinet was monitored every 15 minutes using a temperature logger (Squirrel Meter 1200, Grant Instruments Ltd, Cambridge, England). The average display cabinet temperatures was 2.3°C. After each display time one pack from each treatment (2%, 5%, 10% & 20%) was sacrificially analysed for gas composition (Gow-Mac Spectra 250, Gow-Mac Instrument Company, Co Clare, Ireland). These steaks were then removed from the bag and analysed for colour (CIELab L*, a* b* from which saturation and hue angle were calculated) using a HunterLab UltraScan spectrophotometer (UltraScan XE, Hunter Associates Laboratory Inc., Virginia, USA). Colour analysis was carried out on the control at 0 mins and at the display times stated above. Colour results were analysed using one way analysis of variance within display time using Anova. The trail was replicated 6 times using a different animal each time. Calculations were made using the volume of the pack, volume of meat to be packed, the area of the film and the minimum percentage O_2 required for blooming, to determine the permeability of the film required for successful blooming.

Results and Discussion

Blooming is perceived as an increase in bright redness (Ledward, 1992). CIELab redness (*a*) values, saturation and hue angle values are given in Table 1, 2 & 3. Redness for the 2% & 5% treatments was consistently lower than the other three treatments at all display periods. No differences were found between the 10%, 20% and the control at 30mins and 24hrs display but small differences were noted in the intervening period. A similar trend was found for saturation. It was generally found that the 2% and 5% had lower saturation than the other treatments and no lasting differences were found between the 10%, 20% and the control. Differences in hue angle were apparent only at 24hrs, with the 2% and 5% being higher than the control.

The redness and saturation of the 10% and the control were similar after 30mins, however the 20% and control had higher *a* and saturation values after 1 hr display ($P<0.001$), indicating faster blooming for these steaks. Young *et al.,* (1999) reported that blooming in stored meat (2 & 8 weeks) should be complete within 4 hrs. By 4 hrs display the redness and saturation values for the 20% treatment and the control had reached their peak level, however the redness and saturation values for the 10% treatment continued to increase until 24 hrs display.

After 24hrs display the saturation and *a* values for the 2% & 5% treatments decreased indicating the formation of metmyoglobin on the surface of the steaks. This suggests that an O_2 concentration of 5% or lower is insufficient for adequate beef blooming.

A linear increase in the saturation (S) ($P< 0.01$), redness (a*) ($P< 0.001$) and yellowness (b*) ($P<0.05$) of the steaks was found with increased oxygen concentration in the MAP treatments over all display periods. Increased oxygen concentration resulted in a linear increase in lightness (L*) ($P<0.05$) after 1hr display time only and an decrease the hue angle ($P<0.05$) after 4 & 24 hrs display.

From these findings it is clear that the hue angle is not as good an indicator of beef blooming as saturation and redness, which agrees with previous work (Beggan *et al.*, 2001). Lightness and yellowness (b*) generally did not show significant differences between treatments. Previous work has reported that yellowness is not an important indicator for meat blooming (Renerre & Mazuel, 1985). Young *et al.*, (1999) reported that both *a** and b* values increase during blooming, and for that reason blooming is well represented by saturation ($\sqrt{(a^{*2} + b^{*2})}$ and that the a* value was a more important determinant of the changes in saturation than b*.

Conclusions

The minimum concentration of O_2 required for blooming was 10%. If 10% O_2 is required to permeate through the pack within 1 hr, then the film permeability required for successful blooming is approx. 30,000cc of O_2 / m^2/ 24hrs / 1 atm. Films of this permeability are available but their effective permeability at refrigerated temperatures is much reduced.

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Table 1: CIELab a* values for LD steaks packed under 2%, 5%, 10% & 20% O_2 concentrations and in air after various display times.

Display time	% Oxygen						
	$2\%O_2$	$5\%O_2$	$10\%O_2$	$20\%O_2$	Air (control)	SED	Significance
30 mins	14.2^{c}	14.1^{c}	16.5^{b}	17.3^{a}	16.8^{ab}	0.66	P<0.001
1hr	14.7^{c}	15.4^{c}	17.0^{b}	18.4^{a}	18.3^{a}	0.76	P<0.001
2 hrs	15.6^{d}	17.1^{c}	18.6^{ab}	20.1^{a}	18.5^{b}	0.89	P<0.001
4 hrs	16.3^{d}	17.2^{c}	18.8^{b}	20.6^{a}	19.8^{a}	0.74	P<0.001
24hrs	15.0^{b}	15.7^{b}	19.3^{a}	20.1^{a}	19.5^{a}	1.23	P<0.01

Table 2: CIELab Saturation values for LD steaks packed under 2%, 5%, 10% & 20% O_2 concentrations and in air after various display times.

Display time	% Oxygen						
	$2\%O_2$	$5\%O_2$	$10\%O_2$	$20\%O_2$	Air (control)	SED	Significance
30 mins	17.6^{b}	17.6^{b}	20.3^{a}	21.0^{a}	20.7^{a}	0.96	P<0.01
1hr	18.3^{c}	19.2^{c}	21.0^{b}	22.4^{a}	22.5^{a}	1.02	P<0.01
2hrs	19.2^{d}	21.3^{c}	22.8^{b}	24.4^{a}	22.3^{bc}	1.10	P<0.01
4hrs	20.2^{c}	21.3^{c}	22.8^{b}	24.8^{a}	23.8^{ab}	0.95	P<0.001
24hrs	18.7^{b}	19.7^{b}	23.7^{a}	24.3^{a}	23.5^{a}	1.5	P<0.01

Table 3: CIELab Hue angle values for LD steaks packed under 2%, 5%, 10% & 20% O_2 concentrations and in air after various display times.

Display time	% Oxygen						
	$2\%O_2$	$5\%O_2$	$10\%O_2$	$20\%O_2$	Air (control)	SED	Significance
30 mins	35.8	36.6	35.6	34.5	35.6	1.41	NS
1 hr	36.4	36.4	35.8	34.8	35.3	1.13	NS
2 hrs	35.8	36.4	35.1	34.4	34.0	1.03	NS
4 hrs	36.0	35.6	34.6	33.7	33.7	1.10	NS
24hrs	36.7^{ab}	37.4^{a}	35.5^{bc}	34.3^{cd}	34.1^{d}	1.02	P=<0.05