

# EFFECTS OF OXYGEN CONCENTRATION ON THE QUALITY OF BEEF STEAK PACKED UNDER MODIFIED ATMOSPHERE

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## Introduction

Over the past number of years much research has focused on the influence of modified atmosphere packaging (MAP) on meat quality attributes and the purchasing preferences of consumers (Jayasingh et al., 2002). MAP usually consists of a mixture of three gases: O<sub>2</sub> (to enhance colour stability), CO<sub>2</sub> (to inhibit microbiological growth), and N<sub>2</sub> (to maintain pack shape) (Sorheim et al., 1999). It is well established that packaging headspaces containing mixtures of these gases contribute to fresh red meat quality and extended shelf life (Gill, 1996). Beef steaks are commonly displayed under high O<sub>2</sub> concentrations in order to promote the oxymyoglobin cherry red form of myoglobin (O'Grady et al., 2000). High O<sub>2</sub> conditions impact negatively on the oxidative stability of muscle lipids and may lead to development of undesirable flavours. Recent studies have also suggested that storage under high O<sub>2</sub> atmospheres can result in a decrease in beef tenderness (Toerngren, 2003). As such, the requirements for colour stability must be balanced against the possible deteriorative reaction of lipid oxidation and/or other processes. The objective of the present study was to investigate the relationship between O<sub>2</sub> concentration of MA packaged beef muscle and a number of indicators of meat quality.

## Materials and Methods

Beef steak (*Longissimus dorsi*) muscle was obtained from a local slaughterhouse. Muscles were cut into 2.54 cm thick steaks. LD muscle steaks packed under MA were placed in polystyrene/EVOH/polyethylene trays and heat sealed with laminated barrier film with a polyolefin meat sealable layer (oxygen transmission rate of 3 cm<sup>3</sup>/m<sup>2</sup>/24h at STP). O<sub>2</sub> concentrations in MA packs ranged from 0 to 80%, CO<sub>2</sub> was 20% in all cases and N<sub>2</sub> made up the difference. MA packs were held at 4°C ± 1°C and 616 lux for 15 days to simulate commercial retail display conditions. Attributes measured included CIE colour analysis (Minolta CR 300 colorimeter), lipid oxidation (TBARS) (Siu and Draper, 1978), protein oxidation (PO) (Oliver et al., 1987), oxymyoglobin (OxMb) (Krzywicki, 1982), heme iron analysis (HI) (Schricker et al., 1982) and Warner-Bratzler shear force (WB) (Shackelford et al., 1991).

## Results and discussion

After 6 days storage steaks held under O<sub>2</sub> concentrations of 20, 50 and 80% showed significant (P<0.05) decrease in a number of quality indicators. Increasing O<sub>2</sub> concentration resulted in an increase in lipid oxidation (TBARS) (Figure 1) and concomitant decrease in a\* (redness) values (Table 1), HI, and oxymyoglobin (OxMb). Previous studies have shown that high O<sub>2</sub> atmospheres were associated with increased TBARS numbers and increased OxMb oxidation during storage (O'Grady et al., 2000). TBARS data correlated strongly with OxMb, HI, a\* with R values of -0.90, -0.63, -0.65, respectively (for samples held at 80% O<sub>2</sub>), (Table 2). HI decreased with O<sub>2</sub> concentration over time suggesting a possible lipid oxidation induced denaturation of muscle pigment. Objective analysis of tenderness showed an overall decrease in tenderness (P<0.05) with increasing O<sub>2</sub> concentration. It appeared that samples packed with 50 and 80% O<sub>2</sub> were tougher than low oxygen treated samples. This is supported by a previous study of Tornngren (2003), who reported that MA-packing with O<sub>2</sub> and CO<sub>2</sub> decreased tenderness.

**Table 1.** Effect of O<sub>2</sub> concentration on a\* values of beef stored under MAP conditions at 4°C.

O <sub>2</sub> conc.(%)	Storage Time (d)					
	0	3	6	9	12	15
0	22.65 <sup>a</sup>	18.14 <sup>ab</sup>	18.81 <sup>ab</sup>	17.67 <sup>ab</sup>	16.87 <sup>ab</sup>	15.64 <sup>bc</sup>
10	23.48 <sup>a</sup>	12.35 <sup>a</sup>	15.49 <sup>a</sup>	13.20 <sup>a</sup>	13.86 <sup>ab</sup>	14.85 <sup>bc</sup>
20	24.74 <sup>a</sup>	23.72 <sup>b</sup>	20.55 <sup>bc</sup>	15.80 <sup>ab</sup>	12.62 <sup>a</sup>	6.23 <sup>a</sup>
50	26.21 <sup>a</sup>	25.03 <sup>b</sup>	24.35 <sup>c</sup>	20.31 <sup>b</sup>	18.46 <sup>ab</sup>	5.97 <sup>a</sup>
80	28.35 <sup>a</sup>	26.79 <sup>c</sup>	19.96 <sup>ab</sup>	18.49 <sup>ab</sup>	nd	11.43 <sup>b</sup>

Means with the same superscripts within columns not significantly different (P<0.05); nd = not determined

**Table 2.** Effect of O<sub>2</sub> concentrations on correlation coefficients (R) of data from beef stored under MAP conditions at 4°C.

0% O <sub>2</sub>						
	TBARS	OxMb	HI	WB	PO	a*
OxMb	-0.76					
HI	0.42	-0.23				
WB	0.44	-0.02	0.71			
PO	0.84	-0.63	0.55	0.39		
a*	-0.32	-0.21	-0.60	-0.85	-0.50	
L*	0.16	-0.46	-0.43	-0.72	-0.07	0.83
80% O <sub>2</sub>						
	TBARS	OxMb	HI	WB	PO	a*
OxMb	-0.90					
HI	-0.63	0.47				
WB	0.62	-0.70	0.13			
PO	-0.04	-0.29	0.45	0.53		
a*	-0.65	0.82	0.55	-0.21	-0.13	
L*	0.06	-0.03	0.38	0.41	-0.21	0.25

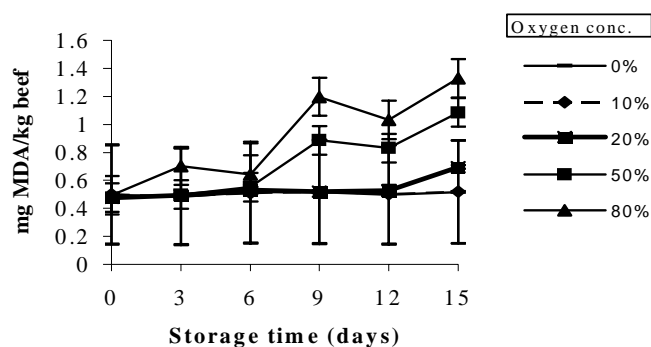


Figure 1. TBARS values of LD muscle stored under different MAP treatments at 4°C.

## Conclusions

Changes in OxMb, HI and a\* appeared to be driven by lipid oxidation and correlated strongly with TBARS data. In contrast, changes in tenderness did not appear to be related to lipid or protein oxidation, although this work needs to be investigated further. In general, O<sub>2</sub> associated decreases in beef quality occurred after 6 days storage. Objective suggested that the quality of steaks was best promoted by packaging under an atmosphere containing 50% oxygen.

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