

## EFFECTS OF PACKAGING GASES ON THE COLOUR OF BEEF

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## INTRODUCTION

Commercial modified gas atmospheres for long time storage of beef and other meats usually consist of carbon dioxide ( $\text{CO}_2$ ) or carbon dioxide/nitrogen ( $\text{N}_2$ ). Extending the microbiological shelf life of meat with atmospheres containing  $\text{CO}_2$  is beneficial, provided that the meat does not discolour. Traces of residual oxygen ( $\text{O}_2$ ) in the atmospheres can be detrimental to the colour of beef by formation of gray or green metmyoglobin, in levels as low as less than 0.1 % (Gill & McGinnis, 1995). Residual  $\text{O}_2$  in the atmospheres can be removed by inserting  $\text{O}_2$  scavengers in the packages (O'Keeffe & Hood, 1980). While  $\text{N}_2$  is regarded as an inert gas not affecting meat colour, conflicting data exist on  $\text{CO}_2$  (Renerre & Labadie, 1993).  $\text{CO}_2$ , particularly in levels above 20 %, was claimed to discolour meat (Cole, 1986).

The aim of the present study was to compare the colour stability of beef loin sections packaged in different  $\text{CO}_2/\text{N}_2$  atmospheres and vacuum during chilled storage.

## MATERIALS AND METHODS

**Meat samples.** Both loins from 5 beef carcasses were obtained at a commercial abattoir 3 days after slaughter. The carcasses of Norwegian Red Cattle had been electrically stimulated, were graded lean or extra lean and had ultimate pH < 5.8. Each loin was deboned and the *M. longissimus lumborum* was divided into 5 sections of approximately 0.4 kg.

**Packaging and storage.** Randomized samples from each carcass were stored in the dark for 33 days at 2 and -1 °C after using 5 packaging treatments: 100 %  $\text{CO}_2$ , 50/50 %  $\text{CO}_2/\text{N}_2$ , 20/80 %  $\text{CO}_2/\text{N}_2$ , 100 %  $\text{N}_2$  and vacuum. The sections were packaged on an Intevac chamber machine (Intevac Verpackungsmaschinen, Wallenhorst, Germany) in ethylenvinylalcohol bags with an  $\text{O}_2$  transmission rate of 8  $\text{cm}^3/\text{m}^2/24\text{h}/\text{atm}$  at 23 °C at 60 % RH. The vacuum of the packages was 7 mbar. The gas packages were filled to an initial gas to meat ratio of approximately 2:1. In all packages with gas, one  $\text{O}_2$  scavenger was inserted, of type SPU-100 for 2 °C and SS-100 for -1 °C (both Ageless®, Mitsubishi Gas Chem. Inc., Tokyo).

**Gas analyses.** Oxygen was analysed with a Toray LC-700F and  $\text{CO}_2$  with a Toray PG-100 (both Toray Eng., Japan) immediately after packaging and at days 1, 3 and 33 of storage.

**Colour analyses.** A Minolta Chroma Meter CR-300 (Minolta Camera Co., Osaka, Japan) with 8 mm viewing port and illuminant  $D_{65}$  was used for measuring CIE(1976)  $L^*$  (lightness),  $a^*$  (redness) and  $b^*$  (yellowness) values on the *M. longissimus lumborum* of the sections. The measurements were made through the packaging film at days 1, 3, 7, 14, 21, 28 and 33 of storage. The values were corrected for those of the film by subtraction. A six member trained panel evaluated the *M. longissimus lumborum* of the sections after 33 days storage on a colour scale: 1 = bright red, 2 = dark red, 3 = slightly gray/brown, 4 = moderately gray/brown and 5 = extremely gray/brown.

**Statistics.** Analysis of variance with Tukey's multiple comparisons test was performed by using the SAS statistical programme (SAS Institute, 1987). Since the main interest of this report was on the influence of gases, the results of the two different storage temperatures were combined and treated as replicates.

## RESULTS AND DISCUSSION

**Gas composition.** Immediately after packaging, all the packages with  $\text{CO}_2$  and/or  $\text{N}_2$  atmospheres had residual  $\text{O}_2$  concentrations below 0.8 %. After 3 days storage, the  $\text{O}_2$  scavengers had consumed all residual  $\text{O}_2$  in these bags, and no  $\text{O}_2$  was detected at the end of storage. The initial  $\text{CO}_2$  concentrations in the packages were close to specifications of the gas supply. At the end of storage, the  $\text{CO}_2$  levels were slightly reduced in the atmospheres containing  $\text{CO}_2$ . The atmosphere with initially 100 %  $\text{N}_2$  then contained 5 %  $\text{CO}_2$ .

**Colour stability.** The colour of the beef loin sections was affected by the gas and vacuum packaging, as shown for  $L^*a^*b^*$  values in Figs. 1, 2 and 3 and for visual colour evaluation in Fig. 4. The meat stored in the four gas atmospheres was more light, less red, more ultimately yellow and had higher scores for discoloration than the meat in vacuum ( $p < 0.05$ ). Further, no difference in colour stability was found on meat in the  $\text{CO}_2$  and/or  $\text{N}_2$  atmospheres, except for a slightly more rapid increase in yellowness in the 100 %  $\text{CO}_2$  and 50/50 %  $\text{CO}_2/\text{N}_2$  atmospheres ( $p < 0.05$ ). These results confirmed previous findings of more discoloration on beef stored in  $\text{CO}_2$  than vacuum (Sørheim et al., 1995). Bacteriological growth is not a probable explanation for discoloration, as beef in atmospheres containing 20 to 100 %  $\text{CO}_2$  was less or equal to vacuum in total counts (Nissen et al., 1996). Based on our results,  $\text{CO}_2$  *per se* seemed to have no direct effect on discoloration. In agreement with this conclusion, O'Keeffe & Hood (1980) and Gill & McGinnis (1995) found no difference in the colour stability of beef stored in pure  $\text{CO}_2$  and  $\text{N}_2$  atmospheres. However, it is possible that other researchers claiming discoloration of  $\text{CO}_2$  has actually been looking more at detrimental colour effects of traces of residual  $\text{O}_2$ , especially on beef with its low tolerance level for  $\text{O}_2$ , as described by Renerre & Labadie (1993) and Church (1994).

**Conclusion.** Beef loin sections stored in atmospheres of  $\text{CO}_2$ ,  $\text{N}_2$  or  $\text{CO}_2/\text{N}_2$  were slightly more discoloured than those in vacuum, as concluded from instrumental and visual colour analyses. No difference in colour stability was found between the gas treatments. These results most likely rule out the possibility of  $\text{CO}_2$  *per se* as a direct cause for discoloration of beef, but a negative effect on colour arising from initial residual  $\text{O}_2$  in the gas atmospheres can not be excluded.

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Figs. 1, 2 and 3

CIE (1976) L\* (lightness), a\* (redness) and b\* (yellowness) values of beef loin sections of different packaging methods during storage for 33 days.

- - vacuum
- - 100 % CO<sub>2</sub>
- - 50/50 % CO<sub>2</sub>/N<sub>2</sub>
- - 20/80 % CO<sub>2</sub>/N<sub>2</sub>
- △ - 100 % N<sub>2</sub>

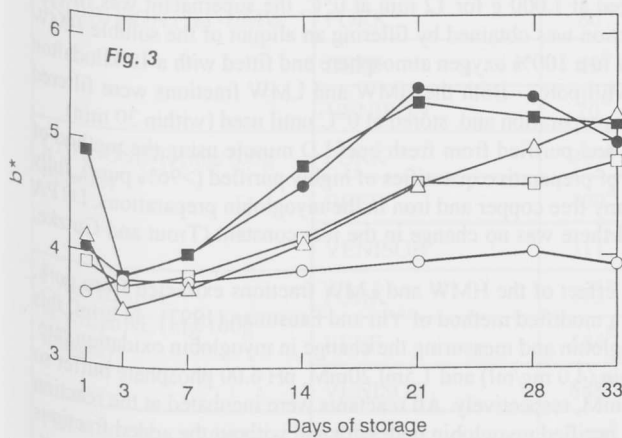
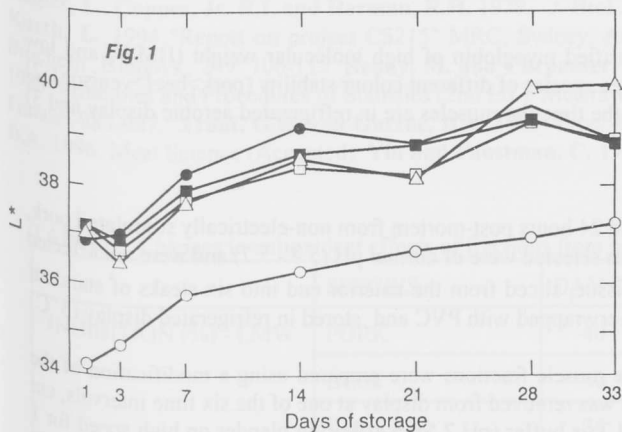


Fig. 4

Visual colour evaluation of beef loin sections of different packaging methods after 33 days storage. Scale: 1 = bright red to 5 = extremely gray/green.

