EFFECTS OF PACKAGING GASES ON THE COLOUR OF BEEF

Oddvin Sørheim, Per Lea, Monica Gilde* and Hilde Nissen

MATFORSK, Norwegian Food Research Institute, Osloveien 1, N-1430 Ås, Norway * BioMar AS, N-8430 Myre, Norway

Keywords: carbon dioxide, nitrogen, residual oxygen, beef loin, colour stability

INTRODUCTION

Commercial modified gas atmospheres for long time storage of beef and other meats usually consist of carbon dioxide (CO_2) or carbon dioxide/nitrogen (N_2). Extending the microbiological shelf life of meat with atmospheres containing CO_2 is beneficial, provided that the meat does not discolour. Traces of residual oxygen (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 O_2 in the atmospheres can be removed by inserting O_2 scavengers in the packages (O`Keeffe & Hood, 1980). While N_2 is regarded as an inert gas not affecting meat colour, conflicting data exist on CO_2 (Renerre & Labadie, 1993). CO_2, particulary 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 CO_2/N_2 atmospheres and vacuum during chilled storage.

MATERIALS AND METHODS

Meat samples. Both loins from 5 beef carcasses were obtained at a commercial abbatoir 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 % CO_2, 50/50 % CO_2/N_2, 20/80 % CO_2/N_2, 100 % N_2 and vacuum. The sections were packaged on an Intevac chamber machine (Intevac Verpackungsmachinen, Wallenhorst, Germany) in ethylenvinylalcohol bags with an O_2 transmission rate of 8 $cm^3/m^2/24h/atm$ at 23 °C at 60 % RH. The vacuum of the packages was 7 mbar. The gas packages were filled to an inital gas to meat ratio of approximately 2:1. In all packages with gas, one 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 anlysed with a Toray LC-700F and 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 CO_2 and/or N_2 atmospheres had residual O_2 concentrations below 0.8 %. After 3 days storage, the O_2 scavengers had consumed all residual O_2 in these bags, and no O_2 was detected at the end of storage. The initial CO_2 concentrations in the packages were close to spesifications of the gas supply. At the end of storage, the CO_2 levels were slightly reduced in the atmospheres containing CO_2. The atmosphere with initially 100 % N_2 then contained 5 % 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 CO_2 and/or N_2 atmospheres, except for a slighly more rapid increase in yellowness in the 100 % CO_2 and 50/50 % CO_2/N_2 atmospheres ($p<0.05$). These results confirmed previous findings of more discoloration on beef stored in 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 % CO_2 was less or equal to vacuum in total counts (Nissen et al., 1996). Based on our results, 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 CO_2 and N_2 atmospheres. However, it is possible that other researchers claiming discoloration of CO_2 has actually been looking more at detrimental colour effects of traces of residual O_2, especially on beef with its low tolerance level for O_2, as described by Renerre & Labadie (1993) and Church (1994).

Conclusion. Beef loin sections stored in atmospheres of CO_2, N_2 or CO_2/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 CO_2 *per se* as a direct cause for discoloration of beef, but a negative effect on colour arising from initial residual O_2 in the gas atmospheres can not be excluded.

ACKNOWLEDGEMENTS

The authors highly appreciate the technical assistance from Anne Kari Arnesen and Frank Lundby. We are grateful for the gift of Ageless ® O_2 scavengers from W.R. Grace, Denmark.

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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_2
● - 50/50 % CO_2/N_2
□ - 20/80 % CO_2/N_2
△ - 100 % N_2

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.