

SHELF LIFE AND COLOUR STABILITY OF BEEF LOIN STEAKS PACKAGED IN A MODIFIED ATMOSPHERE WITH CARBON MONOXIDE

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ABSTRACT

Steaks of aged beef loins (*M. longissimus dorsi*) were packaged in 60 % CO₂ / 40 % N₂ / 0.4 % CO (M-CO) or 30 % CO₂ / 70 % O₂ (M-O) or vacuum (V) and stored dark at 4 and 8 °C for up to 14 days. Samples were analysed for odour, total viable counts, *Brochothrix thermosphacta* and visual and instrumental colour. Meat packaged in M-CO and V had longer odour shelf life and lower growth of *B. thermosphacta* than in M-O. Longer odour shelf life and lower total viable counts were obtained for meat of all packaging methods at 4 compared to 8 °C. M-CO steaks maintained a stable bright-red colour throughout storage. M-O steaks were also bright-red initially, but discoloured gradually during storage. V steaks were slightly discoloured throughout storage.

INTRODUCTION

Modified atmosphere packaging (MAP) of meat for retail display has been established as a technology for ensuring a satisfactory shelf life of the products and presenting meat with an attractive colour to the consumer. Usually modified atmospheres (MA) for this purpose contain mixtures of oxygen (O₂), carbon dioxide (CO₂) and/or nitrogen (N₂).

Carbon monoxide (CO) has the ability of binding strongly to myoglobin and forming stable carboxymyoglobin, which has a bright cherry-red colour (El-Badawi et al., 1964; Kropf, 1980). A patent was granted over 100 years ago covering the use of a CO/CO₂ mixture to extend the shelf life of meat (Church, 1994). Despite this knowledge, CO has up to now only been applied to a limited extent in MAP of meat. However, meat plants in Norway have for the past decade been using a MA of approximately 60 to 70 % CO₂ / 30 to 40 % N₂ and 0.3 to 0.4 % CO for retail meat of beef, pork and lamb. Packages with this gas mixture has reached shares of 50-60 % of the domestic retail meat market. A literature review describing the toxicological, technological and hygienic aspects of CO in MAP of meat is being prepared (Sørheim et al., 1997).

The aim of the present experiment was to compare the effects of different packaging methods, like MA with CO, MA with high concentrations of O₂ and vacuum, on shelf life and colour stability of beef loin steaks stored at 4 and 8 °C for up to 14 days.

MATERIALS AND METHODS

Packaging and storage

Loins (*M. longissimus dorsi*) of bulls of Norwegian Red Cattle with ultimate pH below 5.8 were aged in vacuum for 11 days at 3 °C. Thereafter, steaks of 2.5 cm thickness were cut from the loins and assigned randomly, with two steaks per package, to the following packaging methods: 60 % CO₂ / 40 % N₂ / 0.4 % CO (M-CO), 30 % CO₂ / 70 % O₂ (M-O) and vacuum (V).

Steaks for M-CO and M-O were both packaged on an Ilapak Delta 2000 flow-packaging machine (Ilapak Machine Auto S.A., Grancia, Switzerland) using trays and Cryovac BDF 550 shrink film with O₂-transmission rate of 19 cm³ / m² / 24h / bar at 23 °C / 0 % RH (Cryovac, Milan, Italy). The gas mixture for M-CO was blended from 99 % N₂ / 1 % CO and 100 % CO₂ (Hydrogas, Norway) to an initial gas to meat ratio of approximately 1.5 : 1. At the time of packaging, residual O₂ in the M-CO packages was below 0.5 %. V steaks were packaged on a Multivac 5100 thermo-forming machine (Multivac, Germany) using upper and lower films with O₂-transmission rates of 10 and 16 cm³ / m² / 24h / bar at 23 °C / 0 % RH, respectively (Danisco, Denmark).

The steaks were stored in darkness at 4 +/- 0.5 and 8 +/- 0.5 °C for up to 14 days. Five samples per packaging method and temperature were collected at days 3, 7, 10 and 14 of storage until termination of odour shelf life.

Analyses

Odour. Steaks were evaluated by a three member panel within 1 minute after opening of the packages using an off-odour scale of 1=none, 3=small and 5=extreme. Acceptability level was set at a score of 3.

Microbiology. A 25 cm² area of the meat surface was removed by scalpel, diluted in peptone water and spread in duplicate on PCA (plate count agar; Difco) for total viable counts and on STAA (Streptomycin thallous acetate actidione agar base, type CM 881 with selective supplement SR 151; Oxoid) for *Brochothrix thermosphacta*. The plates were incubated aerobically at 20 °C for 4 days.

Visual colour. A six member panel evaluated the colour of the meat in intact packages on a scale of 1=bright red, 2=purple, 3=slightly gray/brown, 4=moderately gray/brown and 5=extremely gray/brown.

Instrumental colour. A Minolta Chroma Meter CR-300 (Minolta Camera Co., Osaka, Japan) with 8 mm viewing port and illuminant D₆₅ was used for measuring CIE (1976) a* (redness) values directly on the meat surface immediately after opening of the packages.

Statistics

Analysis of variance with Tukey's multiple comparisons test was performed using SYSTAT, version 6 (SYSTAT Inc., Evanston, IL, USA).

RESULTS AND DISCUSSION

The evaluation of off-odour revealed that steaks stored at 8 °C of all packaging methods, M-CO, M-O and V, were unacceptable after 7 days (Fig. 1). At 4 °C, steaks in M-O were unacceptable after 10 days and in M-CO and V after 14 days of storage. Total viable counts were not affected by packaging method (p>0.05) (Fig. 2). However, total viable counts were higher for all methods at 8 than 4 °C after 3 and 7 days storage (p<0.05). Although reduced shelf life of steaks in M-O compared to M-CO and V at 4 °C cannot be explained by difference in total viable counts, higher counts of the spoilage bacteria *B. thermosphacta* (Fig. 2) or a shift in the metabolism of lactic acid bacteria under aerobic conditions can cause development of off-odour (Nissen et al., 1996).

The colour of M-CO steaks was stable bright-red throughout storage, as determined by the panel (Fig. 3). M-O steaks were also bright-red initially, but discoloured gradually, faster at 8 than 4 °C (p<0.05). V steaks were slightly discoloured with purge in the packages which resulted in a poor appearance. a* (redness) values confirmed the visual colour scores. M-CO steaks had stable high a* values, higher than the V steaks

($p < 0.05$) (Fig. 4). Initially, a^* values of M-O steaks were at the same level as of M-CO steaks, but the a^* values of the M-O steaks decreased gradually and differed from the M-CO steaks after 7 days at 8 °C and after 10 days at 4 °C ($p < 0.05$). A concentration of 0.4 % CO in the M-CO of this experiment was sufficient for producing a stable bright-red colour of beef, less than the 0.5-1.0 % CO reported from previous studies (Kropf, 1980).

CONCLUSION

Beef loin steaks packaged in M-CO and V obtained a maximum shelf life of 14 days compared to 10 days in M-O, as determined by development of off-odour. M-CO steaks were bright-red and had a better colour stability than M-O and V steaks. MAP with M-CO resulted in a combination of long shelf life and high colour stability of the steaks. Due to the possible risk of masking of spoilage, the producers of retail meat in M-CO must not extend storage life beyond well-defined limits. Provided use of proper quality control, gas mixtures with CO should have a potential for wider applications in retail packaging of meat.

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FIGURES 1, 2, 3 & 4

Storage of beef loin steaks in different packages/modified atmospheres in darkness at 4 and 8 °C for up to 14 days.

1. off-odour, scale 1=none to 5=extreme
2. total viable counts (whole lines) and *B. thermosphacta* (dotted lines)
3. visual colour, scale 1=bright red to 5=extremely gray/brown
4. a^* values (redness)

- 60 % CO₂ / 40 % N₂ / 0.4 % CO at 4 °C
- 60 % CO₂ / 40 % N₂ / 0.4 % CO at 8 °C
- 30 % CO₂ / 70 % O₂ at 4 °C
- 30 % CO₂ / 70 % O₂ at 8 °C
- ▽ vacuum at 4 °C
- ▼ vacuum at 8 °C

