PACKAGING OF GROUND BEEF IN AN ATMOSPHERE WITH HIGH CARBON DIOXIDE AND LOW CARBON MONOXIDE RESTRAINS GROWTH OF *YERSINIA ENTEROCOLITICA, LISTERIA MONOCYTOGENES* AND *ESCHERICHIA COLI* O157:H7

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Background

Ground beef for retail sale is often ready-packed in modified atmospheres (MA) or in chub packs (stuffed in plastic casings). MA-packed (MAP) ground beef has a longer microbiological shelf life and also maintains an attractive red colour. For the past decade the Norwegian meat industry has been using a gas mixture of 60-70 % CO_2, 30-40 % N_2 , 0.3-0.5 % CO. The most commonly used gas mixture for retail-ready meat in other European countries is 70 % O_2/30 % CO_2 (Gill, 1996). The microbiological shelf life of the high O_2 mixture will be longer than in air, but less than in the high CO_2/ low CO gas mixture (Sørheim et al., 1999).

The inclusion of CO is controversial because the stable cherry–red colour can last beyond the microbiological shelf life of the meat and thus mask spoilage (Kropf, 1980). The extended shelf life obtained by MAP may under some conditions imply increased risk of growth of pathogens. Accordingly, this issue has also been discussed by the European Commission (1997).

Objective

The objective of the present work was to evaluate the microbiological safety of ground beef when packed by three commercially used packaging techniques when challenged with pathogens at refrigerated temperatures (4 and 10°C). Growth of the pathogens *Yersinia enterocolitica, Listeria monocytogenes, Escherichia coli* O157:H7 and strains of *Salmonella* was compared in ground beef packed in modified atmospheres of 60 % CO_2/ 40 % N_2 /0.4 % CO (high CO_2/ low CO mixture), 70 % O_2/ 30 % CO_2 (high O_2 mixture) and in chub packs (stuffed in plastic casings).

Methods

The ground beef was inoculated with rifampicin-resistant or nalidixic acid/streptomycin-resistant strains of the pathogens (final concentration 10^2-10^3 bacteria/g) and stored at 4 and 10 °C for up to 14 days.

Results and discussions

In our study, growth of *Y. enterocolitica* was totally inhibited in ground beef packed in the high CO_2/ low CO mixture even at 10 °C while it grew fairly well both in the high O_2 mixture and in the chub packs (Figure 1). Manu-Tawiah et al. (1993) found that pork chops packed in different MAs with 20 or 40 % CO_2 with or without O_2 allowed growth of *Y. enterocolitica*, but the CO_2 concentration applied was lower than in the high CO_2/ low CO mixture (60 %) used in our study.

L. monocytogenes is also a pathogen that grows well at low temperatures, but in our study there was no growth of this bacterium in the ground beef in any of the packages at 4 °C, and only slow growth at 10 °C (Figure 2). This agrees with results of Farber and Daley (1994) and Manu-Tawiah et al. (1993) who found no growth or long lag times of *L. monocytogenes* in different meat products when stored at 4 °C.

At the abusive storage temperature of 10 °C, *E. coli* O157:H7 in the chub packs multiplied quickly. However, growth was nearly totally inhibited in the high CO_2/ low CO mixture and in the high O_2 mixture (Figure 3). This is in accordance with the predictive model of Sutherland et al. (1997). Their study showed that *E. coli* O157:H7 is relatively tolerant for CO_2, but growth could be inhibited at 10 °C at high CO_2 concentrations and pH < 6.0.

In our study, growth of *Salmonella* spp. was not inhibited in ground beef packed in high CO_2/ low CO mixture and stored at 10 °C (Figure 4), contrary to what is found in many other studies (e.g. D'Aoust, 1991). Although *Salmonella* may grow well and out-compete the background flora on fresh meat stored at 10 °C (Alford and Palumbo, 1969; Mackey and Kerridge, 1988), most reports claim that growth will be inhibited in MAP at this temperature (Siliker and Wolfe, 1980; D'Aoust, 1991; Gill and DeLacy, 1991). The competitive flora may, however, also play a role (Garcia de Fernando el al., 1995) and in the *Salmonella* challenging experiment the number of lactic acid bacteria was initially very low.

Conclusions

The present study shows that packaging of ground beef in an atmosphere with high carbon dioxide and low carbon monoxide restrains growth of *Y. enterocolitica, L. monocytogenes* and *E. coli* O157:H7. The observed growth of *Salmonella* in the high CO_2/low CO mixture and chub packs does however emphasise the importance of temperature control during storage.

Pertinent literature

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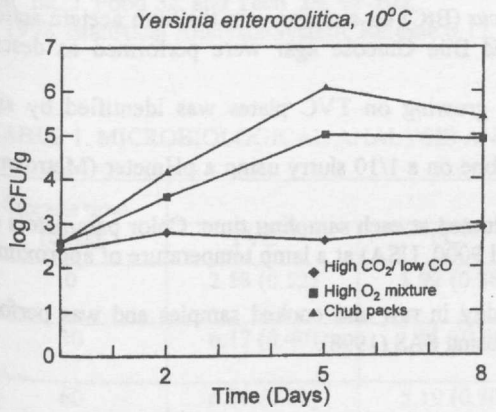

Fig. 1. Growth of *Yersinia enterocolitica* inoculated in ground beef packed in high CO_2/ low CO mixture (0.4 % CO/ 60 % CO_2/ 40 % N_2), high O_2 (70 % O_2 / 30 % CO_2) or in chub packs. The ground beef was stored at 10 °C.

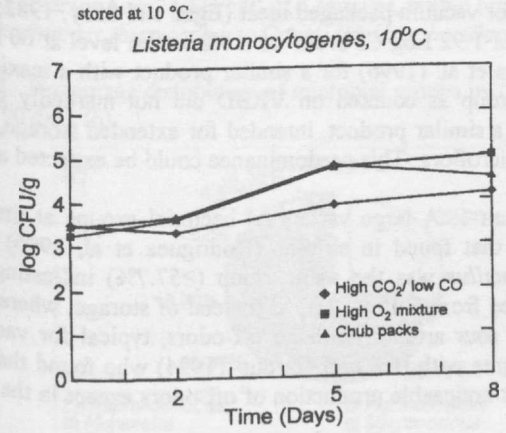

Fig. 2. Growth of *Listeria monocytogenes* inoculated in ground beef packed in high CO_2/ low CO mixture (0.4 % CO/ 60 % CO_2/ 40 % N_2), high O_2 (70 % O_2/ 30 % CO_2) or in chub packs. The ground beef was stored at 10 °C.

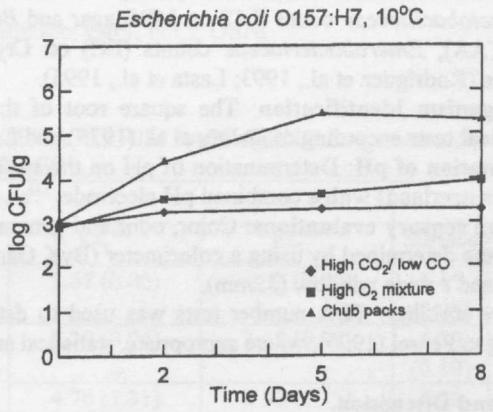

Fig. 3. Growth of *Escherichia coli* O157: H7 inoculated in ground beef packed in high CO_2/ low CO mixture (0.4 % CO/ 60 % CO_2/ 40 % N_2), high O_2 (70 % O_2/ 30 % CO_2) or in chub packs, stored at 10 °C.

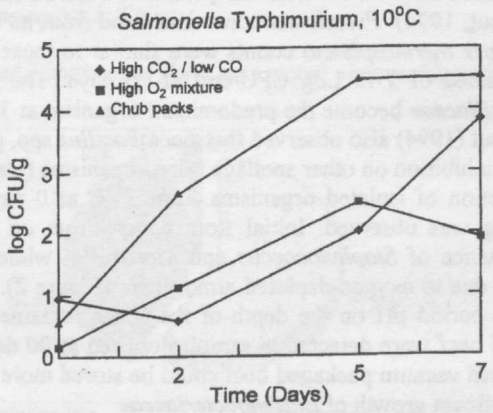

Fig. 4. Growth of *S. typhimurium* inoculated in ground beef packed in high CO_2/ low CO mixture (0.4 % CO/ 60 % CO_2/ 40 % N_2), high O_2 (70 % O_2/ 30 % CO_2) or in chub packs, stored 10 °C.