THE USE OF CO2 ATMOSPHERE AND AN OXYGEN SCAVENGER TO PROLONG THE SHELF-LIFE OF BEEF

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INTRODUCTION

The colour stability of prepackaged meat is the most important quality attribute contributing to its shelf-life. As the consumer associates the bright-red meat of oxymyoglobin with good eating quality, new packaging systems for self-service retailing have been investigated. Vacuum-packaging may allow storage of fresh raw meat for many weeks but limits are more rapidly reached with pork and lamb meat and with high pH beef meat (Renerre & Labadie, 1993). To obtain a storage life of many months of these delicate meats, "Captech" process under 100% CO_2, with aluminium foil and a T° of -1.5 to 0.5°C, was developped (Gill & Penney, 1986). Nevertheless, researchs has shown that CO_2 storage of meat reduced colour stability during its display life. Very low residual O_2 concentrations have been found to be responsible for this discoloration (Rousset & Renerre, 1990). Consequently, it has been shown, under laboratory conditions, that meat packaged under 100% CO_2, with commercial films and at 3°C, but with an oxygen scavenger, exhibited a bright red colour when displayed aerobically for many days (Rousset & Renerre, 1991).

The present study was undertaken to test, under industrial conditions, the efficacy of a new French oxygen scavenger (ATCO) on the colour changes that occur during CO_2 storage for many weeks, compared to vacuum packaging, of beef steaks and subsequent retail display for many days.

MATERIAL AND METHODS

From one Charolais cow, Longissimus Lumborum (LL) muscle was excised 3 days after slaughter at the abattoir. The steaks (normal pH) were packaged in vacuum ("VA samples") by a Supervac machine in Cryovac bags (skin packaging). The steaks were also packaged in preformed and semi-rigid PS / EVOH / PE trays under CO_2 (using an Espace machine from Multivac). The trays were first evacuated, flushed with CO_2 ("CO_2" samples) to atmospheric pressure (Aligal 2 from Air Liquide) and then sealed with PC / EVOH / PE (O_2 permeability < $1 cm^3\ m^{-2}\ 24h^{-1}$). In some cases, an oxygen scavenger ATCO (STANDA industrie) was added to these trays ("CO_2-A" samples).

The oxygen scavenger ATCO was made of powdered active iron, not sensible to humidity and composed of one impermeable side to put on the meat and the other permeable to oxygen (tyveck from Dupont de Nemours).

Packs were withdrawn after storage for 7, 21, 35, 49, 63 days. After pack-opening, the odour of the meat was assessed and the meat was repackaged with a shrinkable film and assessed for colour at 2h, 48h and 96h with a spectrophotometer Uvikon equipped with an integrating sphere; only the results obtained after a 2h pack-opening will be presented in this paper. Colour coordinates (L*,a*,b*) were measured between 360 and 760 nm in the1976 CIELAB system (D65, 2°). MetMb % was calculated by the Krzywicki method (1979) and meat reoxygenation was assessed by calculating reflectance differences: R630-R580 (Renerre & Mazuel, 1985).

Microbiological measurements (AFNOR Standards) and determination of residual O_2 concentration (GC Delsi Nermag DN 200) was made at the ADRIAC.

RESULTS AND DISCUSSION

Among the colour parameters, redness a* was a good index of the colour fading (figure 1A). It was observed at all storage times, and 2h after pack-opening, that the a* values were always the highest in CO_2-A samples (> 16) compared to the others. When a* was measured 96h. after pack-opening, the CO_2-A samples always had the highest values but there was an inversion with a*VA > a*CO_2 (results not shown). Redness was higher in VA than in CO_2 for multiple reasons to be elucidated and as a function of metmyoglobin reducing activity, oxymyoglobin autoxidation and oxygen consumption (Renerre & Labadie, 1993).

When the luminosity L* was examined, it could be observed very high values for L*(>52) from CO_2-A storage after only 1 week of storage time (figure 1B). For CO_2 and VA storage, 2h after pack-opening (figure 1B), the values were very close and near of 48. 96h. after pack-opening, independent of storage time and the packaging mode , L* was lower and near of 47 for CO_2-A samples. · In summary, the meat stored with CO_2 + an oxygen scavenger was the most luminous and the most attractive.

When the R_{630}-R_{580} differences were compared, the conclusions were identical because the highest values (the reddest colour) were noted with CO_2-A whatever the storage time (from 1 to 9 weeks) and the pack-opening time (from 2h. to 96h.). After short opening times such as 2h (figure 1C),and 48h (not shown), the R_{630}-R_{580} values were very high, between 25 and 20 for CO_2-A samples. These values are higher than those previously reported with a Japanese oxygen scavenger used in CO_2 packaging (Rousset & Renerre, 1991) indicating a better blooming at the meat surface and, consequently, a longer display-life. When the pack-opening time increased to 96h (results not showed), the R_{630}-R_{580} difference of CO_2-A samples remained higher than the two others which, at this time, had a R_{630}-R_{580} close to 12, and reached the point of unacceptability (Renerre & Mazuel, 1985). Nevertheless, after a 5 weeks storage time, the R_{630}-R_{580} difference of CO2-A and VA samples are close together (not shown).

Finally, when the evolution of MetMb % was examined after a 2h pack-opening, CO_2-A samples had the lowest value of MetMb and the CO_2 samples the highest (figure 1D) but the differences between CO_2-A and VA samples were low.

In parallel (results not shown) Lactic acid bacteria and Pseudomonas were counted on the same samples the day of the pack-opening. It was observed that the counts of lactic acid bacteria were higher in VA samples than in CO2-A and CO2 samples. Nevertheless, their growing was less (10^4 after 6 weeks) than those reported in previously work on beef (Rousset & Renerre, 1991; Nesom-Fleet et al., 1993) and pork (Jeremiah et al., 1995) where 10^6 were often found. In the same time, Pseudomonas grew rapidly and higher (10^4) in VA samples than in CO2 samples.(10^2). The counting for Pseudomonas, in these industrial conditions, was higher than a previous one obtained in laboratory conditions (Rousset & Renerre, 1991). No difference was noted in Lactic acid bacteria as in Pseudomonas counts between CO_2-A and CO_2 samples; these values of bacterial growth were similar to those noted by Nesom-Fleet et al. (1993). No off-odour was noted at the pack-opening.

Moreover, (results not shown) when an oxygen scavenger ATCO was used, the residual oxygen in the package, measured by GC, was less than 0.1%. These results show that, with this new French oxygen-scavenger, one can satisfactorily store beef for 9 weeks and to have an acceptable display life of 4 days.
Previously (Rousset & Renerre, 1990), it was noted that for packaging of meat in CO_2 alone, residual oxygen concentration remained almost constant and close to 0.2-0.3% during an experiment of 7 weeks. Conversely, when an oxygen scavenger was added in the package, oxygen concentration became lower than 0.1% after 2 weeks of storage and gave also satisfactory results with normal and also with high-pH beef. Penney & Bell (1993) confirmed these results and indicated that oxygen concentrations in excess of 0.15% will seriously compromise the colour stability of both beef and lamb packed at -1.5°C. In contrast, with the same pack atmospheres and packaging, Gill & Jones (1994a) found that ground beef stored at 2°C muscle remains discoloured for periods of up to 4 days when the concentration of O_2 in the pack was < 400ppm.

In conclusion, this experiment has shown that 100% CO_2 storage with an oxygen scavenger is able, in usual packaging conditions, without using metallized film, and at 3°C, to lower rapidly the oxygen residual concentration to less than 1000 ppm for up to a minimum of 9 weeks and to obtain a display of retail beef for a minimum of 4 days without surface discolouration and microbial growth. Moreover, the packaging with 100% CO_2 is promising because, when compared to vacuum, a positive effect is noted in inhibiting the growth of many pathogens (Renerre & Labadie, 1993).

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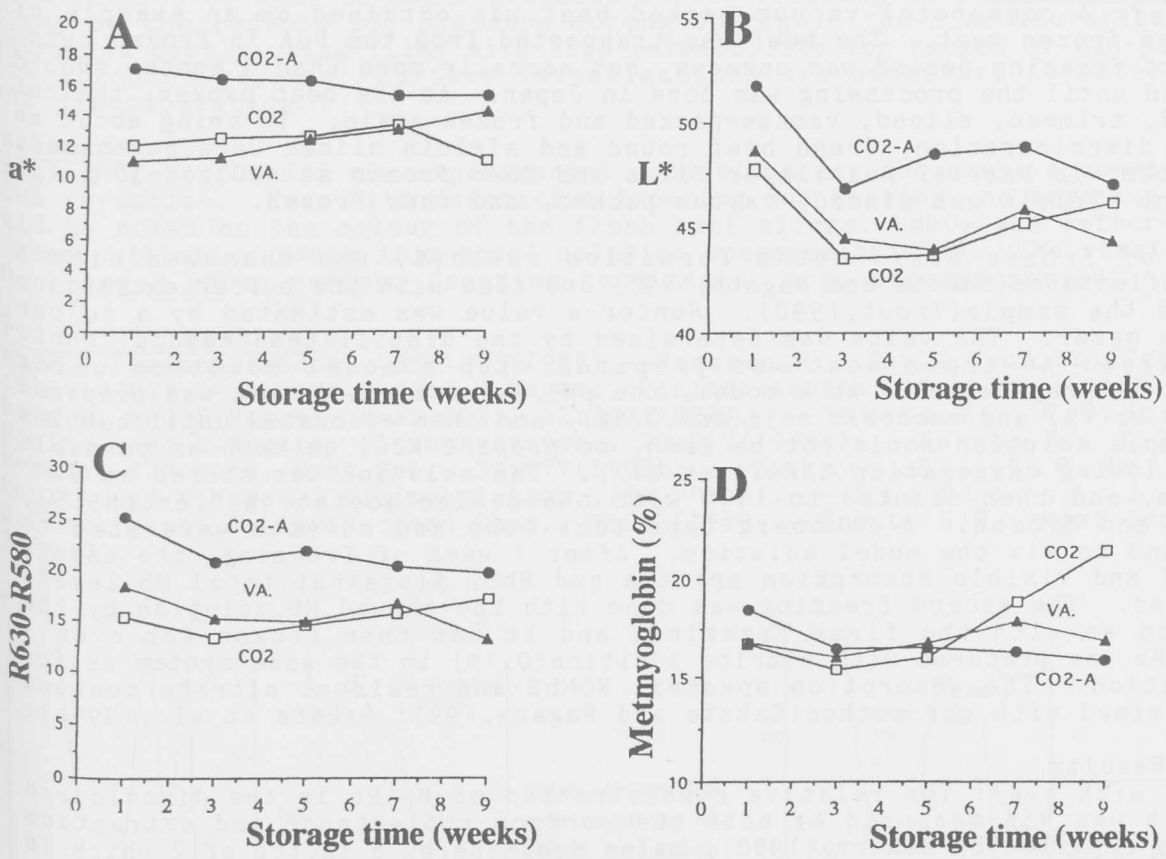

Figure 1: Evolution of colour parameters during storage and after 2 hours pack-opening (**A**: redness a* ; **B**: luminosity L* ; **C**: R630-R580 ; **D**: metmyoglobin %)