STORAGE OF CARCASSES, CUTS AND CONSUMER PORTIONS OF LAMB IN ATMOSPHERES OF CARBON DIOXIDE

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SUMMARY

Lamb carcasses and primal cuts stored in an atmosphere consisting almost exclusively of carbon dioxide (≮99.7%) had a storage life of twelve weeks at 0°C. The microbial flora of both fat and lean surfaces consisted almost entirely of lactic acid bacteria with the maximum population not exceeding $10^7/cm^2$. Under such conditions there was no sign of spoilage. The subsequent aerobic storage life of consumer portions of lamb (prepared from primal cuts or carcasses) stored in either carbon dioxide or conventional vacuum packs was evaluated against three criteria: microbial status, sensory evaluation and colour maintenance. The results indicated that the aerobic storage life of consumer portions prepared from primal cuts or carcasses which had been stored in carbon dioxide was longer than that of portions prepared from vacuum-packaged meat. This was because the colour stability of consumer portions prepared from carbon dioxide stored meat, and stored under aerobic conditions (retail display), did not decline as rapidly as the storage time in the master pack increased.

The use of master packs made from plastic films with an oxygen permeability of ≯10 ml/m^2/24 h/atm (measured at 25°C and 75% R.H.) did not reduce either anaerobic or subsequent aerobic storage life when compared to that obtained with metal laminate films that are completely impermeable to oxygen.

INTRODUCTION

Australia has the opportunity for the development of a significant export trade in chilled lamb as both whole carcasses and primal cuts. Potential export destinations for this commodity are the Middle East, Japan and parts of Europe. The commercial viability of this process is reliant upon the development of technology that will support a chilled storage life that is long enough to enable the use of cost effective surface (i.e. sea) transportation. To achieve this the use of a modified atmosphere consisting almost exclusively of carbon dioxide has been investigated. The antimicrobial effects of carbon dioxide are well documented and storage of a variety of foodstuffs including meat in such modified atmospheres is becoming increasingly popular. To fully capitalise on the bacteriostatic properties of carbon dioxide in fresh meat storage, high concentrations must be used (i.e. >70%). This is necessary to effectively inhibit the growth of spoilage organisms such as *Brochothrix thermosphacta* (Roth and Clark 1975). However storage of meat under such gas atmospheres can lead to accelerated metmyoglobin formation if there is even a very low concentration of oxygen present (Rousset and Renerre 1990). Recent developments in the design of packaging equipment have made it commercially possible to store meat in flexible packaging film containing an atmosphere of at least 99.7% carbon dioxide with the residual being oxygen. Under such conditions discolouration of the meat is avoided and a prolonged shelf life is obtainable.

Modified atmosphere packed lamb carcasses are currently exported by sea to the Middle East. The packaging system includes the use of metal laminate films which under normal storage conditions are completely impermeable to oxygen. The cost of such films is significantly higher than that of non-metal laminate films that have oxygen transmission rates of approx. 5-10 ml/m^2/24 h/atm. We have now compared the effectiveness of such films for the storage of lamb, both in the master pack under anaerobic conditions and after conversion to consumer cuts, under aerobic conditions of retail display.

MATERIALS AND METHODS

Lamb carcasses were obtained from a local export abattoir. All meat was one day post slaughter and was packaged as either carcasses or primals. The pH value of the loins (*M.longissimus dorsi*) were recorded. Where primals were required, carcasses were broken into legs, loins and shoulders which were wrapped in Bonegard (W.R. Grace, Australia) and placed in UHB bags (linear low density polyethylene modified polyethylene, polyamide blend, modified polyethylene polyamide blend) which had an oxygen transmission rate (OTR) of 8 ml/m^2/24 h/atm measured at 25°C and 75% R.H. (Transpak Industries, Auckland, N.Z.). Bags containing either primals or carcasses were then placed in cartons which were fed into the Chill-Tec gas flushing machine (Transpak Industries Ltd, N.Z.), evacuated and flushed with high purity CO_2 certified to contain less than 200 ppm O_2. The volume of carbon dioxide in each pack was 16 litres for cuts and 60 litres for carcasses. The oxygen concentration was measured at the time of packing by withdrawing a sample of gas via a needle and tube into a Novatech Oxygen Analyser (Novatech Controls, Australia Pty Ltd, Port Melbourne) which is capable of measuring O_2 levels down to 100 ppm. All packs were stored in a chiller operating at 0°C ± 0.5°C. Packs were opened periodically during the storage period, subjected to microbiological analyses and rated for colour and odour by a trained analytical panel.

Retail packs were prepared from primals and carcasses by placing meat on polystyrene trays and overwrapping with polythene. Packs were placed in a bunker style retail display cabinet operating at 5°C.

Lamb primals (i.e. loins) were wrapped in Bonegard and placed in W.R. Grace BB-4L Barrier Bags (OTR 25-30 ml/m$_2$/24 h/atm measured at 25°C and 75% R.H.) and vacuum packaged using a Supervac chamber machine (Supervac, GK170 KN/B/G Vetrielegesellschaft im BH, Austria). Vacuum packs were then heat shrunk by immersion in a hot water bath (1 second) held at 92°C (± 1°C).

Microbiology

All methods for microbiological analyses have been previously described (Shay et al. 1988; Egan and Shay 1984).

Effect of OTR of packaging film on storage life

Thirty-six lamb loins were boned from the opposite sides of 18 carcasses and tagged accordingly. Six loins from three carcasses were CO_2-packaged in either metal laminate bags or UHB bags such that one loin per carcass was assigned to each bag type. Following gas packaging, meat was stored in cartons in the dark at 0°C ± 0.5°C.

After 4, 8, 10, 12, 14 and 16 weeks storage, one pack (containing 3 loins) from each packaging treatment was opened subsequent to determining the residual oxygen concentration. Loins were cut into chops which were packaged on polystyrene trays overwrapped with PVC film. A panel of 12-15 people trained in meat colour assessment were asked to rate the lamb from both packaging treatments for meat colour and the cooked lamb for overall acceptability using a nine point hedonic scale; a rating of zero representing very discoloured meat ranging to a score of eight for meat with excellent colour and appearance.

SULTS & DISCUSSION

mb storage trials

e results of the microbiological examination of lamb carcasses are contained in Fig. 1. Similar patterns of bacterial growth were ained for lamb cuts stored under these conditions. As can be seen from Fig. 1, after a considerable lag period, the total viable nt reached a maximum level of $\log_{10}$ 5.67 after 14 weeks storage. Plating on selective media demonstrated that this total viable nt consisted almost entirely of lactic acid bacteria. The numbers of *Brochothrix thermosphacta* and Gram-negative bacteria did not eed $\log_{10}3$. Sensory analyses at all microbiological sampling times showed that product exhibited no "off" flavours or aromas and h meat and fat colour were acceptable when compared against control samples which had been vacuum packaged for 11 days.

e results of storage life trials of retail consumer portions prepared from carcasses and primals stored under CO_2 are shown in Fig. 2. ese results are expressed as a function of storage time in the master pack. In all cases storage life was limited by colour erioration (i.e. metmyoglobin formation) rather than bacteriological spoilage or flavour defects.

evious investigations (Shay and Egan 1989) aimed at extending the retail storage life of lamb that had been vacuum packaged, had own that, as storage time in the vacuum pack increased, the retail storage life of consumer portions derived from these vacuum ckaged primals decreased from four days to less than one day after 10 weeks storage. This storage life was always limited by lour deterioration. Results presented here indicate that lamb stored under carbon dioxide exhibits an extended colour life under retail play conditions and, unlike lamb stored in vacuum packs, the subsequent retail storage life does not decline significantly as the gth of time in the CO_2 master pack increases.

rbon dioxide storage systems for the long term storage of lamb carcasses and primals recommend and usually include the use of tal laminate films. There are completely impermeable to oxygen under these storage conditions. The use of such films to fabricate gs large enough to accommodate two lamb carcasses adds a significant cost over the use of films with oxygen transmission rates of proximately 10 ml/m^2/24 h/atm measured at 25°C and 75% R.H. The results of experiments designed to compare and contrast the e of films covering this oxygen transmission rate range are contained in Fig. 3. Loins from opposite sides of the same animal ckaged in the two bag types, showed no significant differences with regard to colour regeneration upon exposure to air, or colour aintenance during simulated aerobic retail storage at 5°C. After 4, 8, 10 and 12 weeks storage in carbon dioxide master packs, lamb n chops prepared from these primals had a 3 day retail storage life for both types of films used for the carbon dioxide master pack m. These results demonstrate that no benefit is obtained by using metal laminate films for carbon dioxide storage of lamb loin imals for up to twelve weeks.

ONCLUSIONS

orage of lamb carcasses and cuts in an atmosphere of carbon dioxide (>99.7%) resulted in a storage life of at least twelve weeks at C. Meat stored under such conditions was microbiologically sound and had a retail storage life of at least 3 days after removal from e carbon dioxide master pack. This retail storage life did not decline as the length of storage time in the master pack increased and lditionally, storage life both inside the master pack and after removal (i.e. retail display) was independent of the oxygen transmission tes of the films used for the master pack.

Figure 1 Bacteriological Analysis of Lamb Carcasses Packed Under CO_2

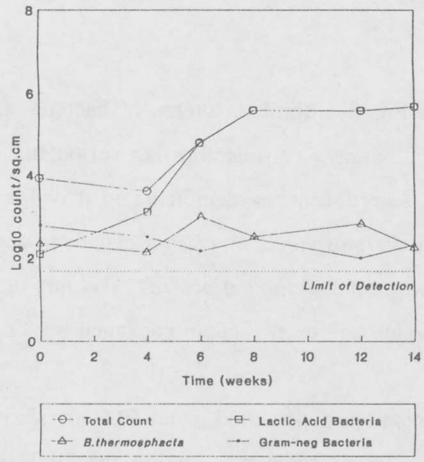


Figure 2 Shelf Life Of Retail Cuts Prepared From Lamb Carcasses and Primals Stored in a CO_2 Atmosphere

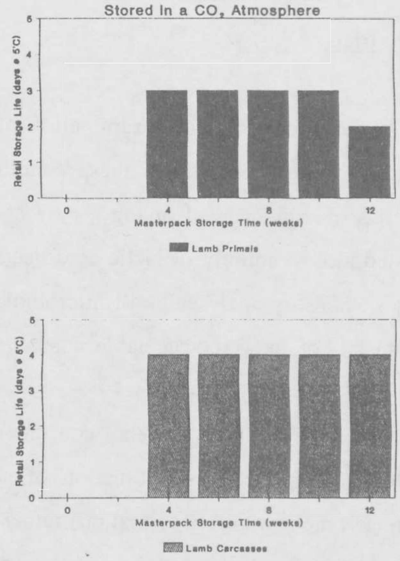
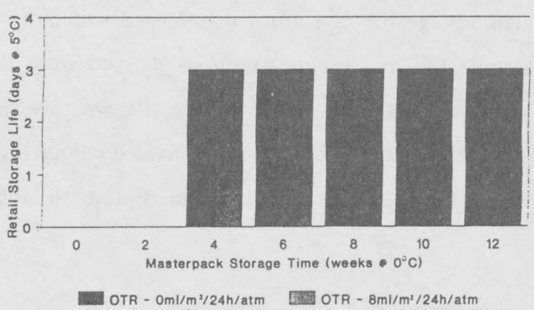


Figure 3 Effect of Oxygen Transmission Rate (OTR) of Carbon Dioxide Masterpack Film on Retail Storage Life of Lamb Loin Cuts



REFERENCES

1. Egan, A.F. and Shay, B.J. (1984). The microbiology of vacuum packaged pork. Proceedings, 30th European Meeting of meat Research Workers, p.215.
2. Roth, L.A. and Clark, D.S. (1975). Effect of lactobacilli and carbon dioxide on the growth of *Microbacterium thermosphactum* on fresh beef. Canadian Journal of Microbiology 21, 629-632.
3. Rousset, S. and Renerre, M. (1990). Comparison of different packaging systems for the storage of fresh beef meat in carbon dioxide atmospheres with or without residual oxygen. Sciences des Alimente 10, p.737-747.
4. Shay, B.J., Egan, A.F., Miller, D. an Tian Ai Jia (1988). Treatment of pork with organic acids prior to vacuum-packaging - A comparison of the effectiveness of lactic and acetic acid. Proceedings, 34th ICMST, p.489-491.
5. Shay, B.J. and Egan, A.F. (1989). Extending the retail storage life of beef and lamb by the use of modified atmosphere packaging. Proceedings, AIFST Convention, Perth, Western Australia, p.171-175.