EXTENSION OF SHELF-LIFE OF FRESH PORK FOR THE EXPORT MARKET

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INTRODUCTION

The Australian pork industry is predominantly aimed at the domestic market. The export market makes up only 2% of total pigmeat consumption. The Australian export market is currently limited by the ability of potential exporters to economically produce pork for the overseas consumer. A fresh modified atmosphere packed product is perceived by consumers as higher quality than the same product which has been frozen (Gill, 1989). The positive effect of the presence of CO_2 on the respiration and growth of meat spoilage organisms has been recognised for some time (Christopher et al, 1980). The Captech packaging (Gill, 1989), developed in New Zealand, uses 100% CO_2 and packaging materials of very low oxygen permeability. The bacteriostatic effect of CO_2 is most effective at oxygen concentrations of less than 0.1% and at storage temperatures of less than 1°C (Gill and Harrison, 1989). *Pseudomonas* spp. are the most common spoilage organisms on fresh aerobically stored pork which has a shelf-life, in Australian retail stores, of less than 10 days. These organisms are inhibited by CO_2 packaging (Greer et al, 1993) and when pork is stored in such an atmosphere but at lower temperature, -1.5°C, it has an increased shelf-life of 18-26 weeks, with spoilage caused by growth of *Lactobacillus* spp. reaching maximum bacterial density at 9 weeks storage (Greer et al, 1993). In the Captech system, the microbiological status of pork prior to packaging is critical. One of the effects of CO_2 on microbial growth is an increase of lag time on the microbial flora on opening the packs into retail display conditions (Gill and Tan, 1980). Using meat with low density of spoilage organisms in the initial packaging stage will therefore increase the retail display life as well as the CO_2 storage life. Any increase in shelf-life may increase the opportunity for growth of cold tolerant pathogens and some such as *Yersinia enterocolitica* are inhibited by CO_2 but if present on meat are able to grow on opening the packs (Gill and Reichel, 1989).

This study examines the potential for export of fresh Australian pork to the Asian sector by the production of safe pork of acceptable eating quality and shelf-life using CO_2 packaging.

MATERIALS AND METHODS

On each of five days, meat cuts (leg muscles, loins, tenderloins, picnic shoulders, denuded bellies and shoulder) from each of six carcasses were packaged into one of two packaging materials in 100% CO_2. Carcasses were selected to cover the range of colour (as a measure of PSE status) and lesions that are normally present on the slaughter line. In the boning room, prior to packaging, colour, pH and base-line levels of pathogens and spoilage organisms were measured. Packaged samples were stored at -1°C (± -0.5°C). At 6, 8 and 10 weeks post-packaging, equal numbers of samples from each packaging type were opened and evaluated microbiologically for pathogens and spoilage organisms and organoleptically for odour and colour. Taste panel testing was performed on the samples. Validation of the Predictor™ model (for *Pseudomonas* spoilage of pork in aerobic storage) were made on meat removed from the packaging, and predictions of retail shelf-life after removal from the packaging were made.

RESULTS AND DISCUSSION

The microbiological results for fresh meat can be summarised as follows. No *S.aureus, Listeria* spp. or *Yersinia enterocolitica* were isolated from any sample. *E coli*/coliforms were isolated in low levels from two samples (10 coliforms/cm^2 from one baseline sample pre-packaging and 10 *E.coli*/cm^2 and 60 coliforms/cm^2 from one shoulder butt in CO_2 after 6 weeks). The results indicate that there is some variation in microbial quality of meat packaged in this way. This may be as a result of packaging defects, as the quality of the meat pre-packaging had little variation, and the temperature of storage was consistent for all treatments. However, pig meat, whether fresh or processed, had few pathogens.

The TVC and spoilage organism counts would indicate that fresh meat has a shelf-life of at least 6 weeks in this packaging format.

Consumer acceptance of fresh pork packed in CO_2 for up to 10 weeks was appraised by a taste panel in Australia comprised of Japanese nationals. No significant effects of time or packaging were detected by the panel over the period of the trial.

Lag time was 42 hours and generation time was 6.2 hours on meat seeded with *Pseudomonas* spoilage organism, stored under CO_2 at 1°C and opened to air. This compares well with those parameters estimated for spoilage organisms on pork not pre-stored in CO_2. Using this information, predictions were made for the estimated time to reach levels of 10^5 *Pseudomonas* /cm^2 . Validation of the model was made on unseeded commercially prepared pork by sampling meat stored for 6 weeks in CO_2 at 1°C, then the time estimated to reach 10^5/cm^2 (84 hours). Based on previous studies the generation time of *Pseudomonas* at 4°C is 6.2 hours and a lag of 6.68 times the generation time (or 41.4 hours) (Widders, 1995). In the pork trials expected lag by density and measured lag and density are in the table below:

Trial	Expected lag (hrs)	Lag (hrs)	Expected gen. Time (hrs)	generation time (hrs)
A	41.4	42	6.68	5.71
B	41.4	42	6.68	5

Based on these results Predictor™ was used to predict shelf-life on store bought meat packaged in CO_2 at 1°C for 6 weeks and then exposed to air and stored at 4°C.

The first validation trial involved retail meat with *Pseudomonas* counts of $5.3 \times 10^2/cm^2$ (mean count). The estimated lag time for this trial was based on 41.4 hours (the expected lag time at 4°C from previous studies) and an estimated time to spoilage of 88.27 hours, based on the initial counts. This could not be confirmed as counts on the meat immediately upon opening motherbag were excessive due to equipment malfunction. Validation trial 2 on retail meat with pre-packaging counts of $8.4 \times 10^3/cm^2$, and post CO_2 counts of $5.2 \times 10^3/cm^2$ with a lag time of 41.4 hours and time to reach $10^5 cfu/cm^2$ of 68.2 hours. The counts at the predicted time for counts of $10^5/cm^2$ were $1.1 \times 10^5/cm^2$. The final validation trial with meat pre-packaging counts of $7.5 \times 10^2/cm^2$ and meat counts post CO_2 of $5.1 \times 10^3/cm^2$, using a lag time of 41.4 hours predicted the time to reach $10^5/cm^2$ as 85.2 hours, and at this time the counts were $1.1 \times 10^5/cm^2$.
The levels of lactobacilli were also measured for this trial and were at levels of $10^7 cfu/cm^2$ on opening. The product did not have odour or colour change on opening, however the high levels of lactobacilli may have caused off flavour. If levels of lactobacilli were controlled (lower at packaging) and pseudomonads were the dominant spoilage organisms on opening, then the Predictor™ model could be used.

CONCLUSION

Fresh pork packaged under 100% CO2 for up to 10 weeks was evaluated microbiologically for shelf-life and safety. Levels of spoilage organisms indicated a shelf-life of at least 6 weeks in this atmosphere. Consumer acceptance of MAP pork was appraised by a taste panel in Australia comprised of Japanese nationals. No significant effects of time or packaging were detected by the panel over the period of the trial. A model (developed on aerobically stored meat) can be used to predict remaining shelf-life of meat on subsequent exposure to air in retail display. This study demonstrates the potential for export of fresh Australian pork to the Asian sector by the production of safe pork of acceptable eating quality and shelf-life.

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