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MANAGEMENT STRATEGIES FOR IMPROVING THE SHELF LIFE OF FRESH PORK

K.J. COATES, J.C. BEATTIE, and P.R. WIDDERS

Victorian Institute of Animal Science, Department of Agriculture, Attwood, Victoria, Australia

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INTRODUCTION

Spoilage of aerobically-stored fresh pork is caused microbiologically by *Pseudomonas spp* (Ayres, 1960). The organoleptic changes of spoilage, manifested as sliminess and "off-odour" are generally present when the levels of spoilage organisms reach $10^7/cm^2$ (Ayres, 1960). The levels of pseudomonads present on carcases immediately after slaughter is generally very low, less than 1% of the total flora (Morgan *et al.*, 1991). During storage and transport of carcases prior to boning, the psychrophilic pseudomonads proliferate. At boning, the spoilage organisms are disseminated onto the surface of the meat, where they thrive under the low temperatures of retail storage, becoming the dominant flora on spoiled pork (Widders *et al.*, 1993). Since current laboratory methods are unable to measure, in real time, the levels of bacteria on carcases at the time of boning, retailers must use "worst case" scenarios to set use-by dates for fresh meat. The wide variation in the microbiological quality of carcases has forced meat managers in Australia into discarding fresh pork after two days on the supermarket shelf, even if the product is still useful. An improvement in the ability to control the shelf-life of pork would reduce this waste. The objective of this study was to develop strategies to improve the shelf-life of fresh pork by modifying carcase handling practices.

MATERIALS AND METHODS

Sample Collection

Boning rooms were visited four times each. Carcases were sampled on the skin surface before boning and the cut surface of the meat was sampled post boning. Two carcases were sampled at each visit and environmental samples taken from areas in the boning room in contact with carcase surfaces, i.e., saw table, saw blade, chiller walls, chiller door handles and boning table boards. Boning boards were sampled before and after boning. Carcases were selected at random and sampled from the ham region using the method of Morgan *et al.* (1987). The swabs were then placed in 9.9ml of sterile peptone water at 4°C for transport back to the laboratory.
Swabs and peptone water were stomached in a Colworth Stomacher (Seward, England) and the homogenate was plated out at serial dilutions to estimate Total Viable Counts (TVC) and Pseudomonas counts.

On the first visit ten butterfly steaks from a sampled carcase were packaged at each boning room under retail conditions with two per pack. These were returned to the laboratory, sampled in duplicate using the above method from days 0 to 5 after boning, TVC's and Pseudomonas counts were estimated, and duplicates were averaged.

Bacteriology

Pseudomonas counts and TVC's were performed as previously described (Coates *et al.*, 1993). Briefly, decimal dilutions of homogenates were plated onto Plate Count Agar (Oxoid) and Pseudomonas CFC Agar (Oxoid), incubated

at 21 °C for 2 days and counted.

Boning Board Hygiene

In the normal supermarket boning-room routine, clean boards were used at the start of each day and remained in use unchanged for the entire day's boning. The boards were cleaned at the end of each day by the supermarket employees by scrubbing in hot water with quaternary ammonium compounds. To test the effect of improved hygiene, a fresh board, cleaned in the same way, was used for each carcase. The boards (pre- and post-boning), carcase skins and the cut surfaces of the meat were sampled as above. These counts were compared with the counts on meat and boards during a routine day's activity with no change of boards.

Carcase Quality

Carcases were monitored for microbiological quality at an abattoir supplying the supermarkets. *Pseudomonas spp* were undetectable on these carcases which averaged TVC's of less than $10^2/cm^2$. After three to six hours chiller storage post-slaughter, 138 carcases were chosen at random and tagged with time-temperature indicators ("Monitor Mark", type 5I, 3M Australia). Tags were activated at this time. Tagged carcases were delivered to metropolitan supermarkets and then sampled between 18 and 120 hours after tagging, prior to boning. The status of the indicator was recorded (migration of the dye-front in mm from the origin), and carcase swabs were collected from the fore and hind quarters and processed to measure the level of contamination with *Pseudomonas spp* and total microbial counts. Data was collected from a random selection of 61 carcases.

RESULTS AND DISCUSSION

Meat which had been allowed to spoil under retail storage conditions, showed an increase in numbers in both TVC (1.7 to 3.9 log increase) and Pseudomonas counts (2 to 4.4 log increase) over the spoilage period. Organoleptic changes, sliminess and "off-odour" were evident when bacterial counts reached approximately $10^7/cm^2$. Initially Pseudomonas counts comprised as low as 10% of the TVC. However, at the end of storage, when spoilage was evident, *Pseudomonas spp* accounted for almost 100% of the total bacterial flora. In a previous study counts for meat from a wholesale boning room followed the same pattern of dominance by *Pseudomonas* species. At this boning room, the initial counts of *Pseudomonas* species were undetectable and only increased to $1.0 \times 10^2/cm^2$ over the time of storage, at which time they were 2% of the total count. This meat displayed no evidence of spoilage at day 7 (Coates *et al*, 1993).
Environmental sampling in the boning room showed that, although *Pseudomonas spp.* were present on most surfaces, they were most abundant on surfaces which contacted the carcases, i.e., the boning boards. These, and the carcases themselves, were the main sources of *Pseudomonas* species in the boning room (Figure 1).

Comparison of Pseudomonas counts on meat and carcases showed a range of counts (Figure 2). Both carcase and meat counts ranged from less that $10/cm^2$ to greater than $10^7/cm^2$. Overall mean (+/-SEM) log of Pseudomonas counts on carcases was 3.29 (±0.15, n=199) and on meat was 4.03(±0.18, n=86).

In order to evaluate the effect of board hygiene on meat contamination, carcases were grouped as "clean" if the Pseudomonas carcase counts were less than $10^4/cm^2$ or "unclean" if counts were greater than $10^4/cm^2$. Boards that were changed for boning each carcase had Pseudomonas counts less than $20/cm^2$, while boards that remained in use throughout the day had average Pseudomonas counts of $2x10^4/cm^2$ immediately prior to boning. The level of *Pseudomonas spp.* contamination on meat was measured for the carcase groups boned on "clean" and "unclean" boards (Fig 3). When both boards and carcases were of good quality microbiologically, the level of *Pseudomonas spp.* contamination on meat was significantly lower than on meat produced from "unclean" boards and/or contaminated carcases (Figure 3).

Carcases used for the time-temperature indicator trial were from an abattoir which had monitored carcase microbial contamination for some months prior to the trial. Carcases typically had less than $10^2/cm^2$ TVC. Carcases were tagged three to six hours post-slaughter. The chiller air temperature at the time of tagging was 10-13°C. The migration (mm from origin) of the dye front in the time-temperature indicator strips was measured and analyzed with respect to days of carcase storage (Figure 4). There was considerable variation in the position of the dye-front in relation to days of storage, suggesting that there had been variation in the temperature of carcase storage. There was a significant regression ($P<0.001$) of dye migration on days of storage. There was no significant regression of TVC on dye migration. There was significant regression of *Pseudomonas* counts on dye migration ($P<0.01$: Fig 5). Based on this regression analysis, carcases which were boned out before the dye-front reached the end of the indicator (53mm) would have an average Pseudomonas count of less than 10^2 organisms/cm^2.

These results confirm that *Pseudomonas spp* are the main spoilage organisms on aerobically stored fresh pork. From this and previous studies (Morgan *et al.*, 1991; Widders *et al.*, 1993)), it has been shown that carcases have low or undetectable levels of *Pseudomonas spp.* on carcases immediately after slaughter. The results from the wholesale boning room, where the pigs were slaughtered at the site and had no transport and minimal storage (18 to 24 hours) prior to boning, suggest that carcase management post-slaughter and pre-boning is responsible for the increase and variation in Pseudomonas counts on carcases (Coates *et al.*,1993). Carcases in this study had a wide range of contamination (less than 10 to greater than $10^7/cm^2$). Previous studies have shown that carcases leaving the abattoir have very similar microbial quality (Morgan *et al.*, 1991; Widders *et al*, 1993). This suggests that variation in carcase handling is the main factor affecting the final carcase quality immediately prior to boning. In this study, the use of time-temperature indicators has been shown to be useful as an estimation of carcase storage history. Although the model which describes the behaviour of the dye-front migration system does not follow the same models as those which describe bacterial growth (Wells and Singh, 1988) the markers are useful as indicators of the temperature history of the carcases and thus the final microbial contamination of the carcases.

Monitoring the temperature storage history of carcases prior to boning will facilitate an extension in the shelf-life of fresh pork, by reducing the level of meat contamination and improving the accuracy of shelf-life estimation. Attention to hygiene during the boning process will ensure that the final microbial quality of meat is optimal. We have shown that the boning-board is the main focus of dissemination of spoilage organisms in the boning room. This agrees with other studies (Greer *et al.*, 1983; Nortje *et al.*, 1989a; 1989b; Sheridan and Lynch, 1992). The results of the board cleaning experiments showed that the hygiene of the boning board is irrelevant when carcase counts are high. However when clean carcases are boned out, the board has a significant impact on the quality of the meat. Clean carcases boned out on clean boards produced meat which had Pseudomonas counts less than or equal to the level of contamination on the carcase of origin.

CONCLUSION

In boning-rooms *Pseudomonas* spoilage bacteria are transferred to the cut surface of pork from the carcases via meat contact surfaces. Improved board hygiene limits carcase to carcase transfer of bacteria, restricting the level of contamination on the meat to that of the carcase. Improvement of carcase quality by monitoring carcase storage and handling pre-boning, will empower boning-room managers to produce fresh pork of a consistent and high microbial quality by effective carcase management. The combination of these two strategies will produce pork with average final Pseudomonas counts of less than $10^2/cm^2$. The shelf life of this meat would not only be more predictable because the variation in levels of bacteria on meat would be reduced, but it would also be prolonged, allowing retailers to extend the "sell-by date" to more than 5 days.

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REFERENCES

AYRES, J.C. 1960. The relationship of organisms of the genus *Pseudomonas* to the spoilage of meat, poultry and eggs. *J. Appl. Bacteriol.* 23:471-486.

COATES, K.J., BEATTIE, J.C., and WIDDERS, P.R. 1993. Dissemination of *Pseudomonas* spoilage organisms in pork boning rooms. Submitted for publication.

GREER, G.G., JEREMIAH, L.E., and WEISS, G.M. 1983. Effects of wholesale and retail contamination on the case life of beef. *J. Food Prot.* 46(10):824-845.

MORGAN, I.R., KRAUTIL, F.L., and CRAVEN, J.A. 1987. Bacterial populations on dressed pig carcases. *Epidemiol. Inf.* 98:15-24.

MORGAN, I.R.,KRAUTIL, F.L., and CRAVEN, J.A. 1991. Evaluation of the effect of abattoir hygiene and pre-slaughter management on the microbiological quality of meat. *Research Report Series*. Victorian Department of Agriculture, 22.

NORTJE, G.L., NEL, L., JORDAAN, E., and NAUDE, R.T. 1989a. A microbiological survey of fresh meat in the supermarket trade. Part 1:Carcases and contact surfaces. *Meat Sci.* 25:81-97.

NORTJE, G.L., NEL, L., JORDAAN, E.,and NAUDE, R.T. 1989b. A microbiological survey of fresh meat in the supermarket trade. Part 2:Beef retail cuts. *Meat Sci.* 25:99-112.

SHERIDAN, J.J., and LYNCH, B. 1992. The effect of boning and plant cleaning on the contamination of beef cuts in a commercial boning hall. *Meat Sci.* 32:185-194.

WELLS, J.H., and SINGH, R.P. 1988. Application of time-temperature indicators in monitoring changes in quality attributes of perishable and semiperishable foods. *J. Food Sci.* 53(1):148-156.

WIDDERS, P.R., COATES, K.J., BEATTIE, J.C., and WARNER, S. 1993. The use of time-temperature indicator strips to monitor pig carcase quality. Submitted for publication.