LACTIC ACID INHIBITS BACTERIAL GROWTH ON PORK LEAN AND FAT

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SUMMARY

Aseptically excised tissue discs were inoculated (105/cm2) with the cold tolerant pathogens Listeria monocytogenes, Yersinia enterocolitica or Aeromonas hydrophila, or with the spoilage bacteria Pseudomonas fragi or Brochothrix thermosphacta. After inoculation, each meat disc was immersed in water (55°C) or lactic acid (3%, 55°C) for 15 s and aerobic bacterial growth was followed during 15 days of storage at 4°C. Bacteria associated with pork fat were more sensitive to the effects of lactic acid than those on lean. The immediate, lethal effects of lactic acid were followed by a residual antibacterial effect that persisted for up to 15 days of pork storage. None of the bacterial strains could be recovered from acid-treated fat within 4 days of treatment. Of the pathogens inoculated on lean pork, L. monocytogenes was the most resistant while A. hydrophila was the most sensitive to lactic acid. P. fragi on lean tissue was the most resistant of the spoilage bacteria. Lactic acid produced an unacceptable grey/brown discolouration of pork lean.

Introduction

The antibacterial effects of organic acids and their value in controlling meatborne bacteria have been reviewed (Smulders, 1987). Beef carcass rinses containing acetic acid are permitted in abattoirs in the United States (Cutter and Siragusa, 1994) and approval for use in Canada is imminent. There are, however, drawbacks to those proposed carcass decontamination systems. Initially, the limited 1 log cycle reduction in carcass surface contamination after acid treatment (Greer and Jones, 1991; Dickson and Anderson, 1992) is of questionable relevance to the safety and storage life of the final product, particularly when recontamination during further processing is inevitable. Also, the common North American practice of spray-chilling would dilute any of the potential, residual effects of the organic acid.

A more serious concern is the insensitivity of mesophilic pathogens (Greer and Dilts, 1992). Recently it was shown that enterohaemorrhagic E. coli 0157:H7 was resistant to hot solutions of acetic, citric and lactic acids (Brackett and Doyle, 1994).

There are few reports of the effects of organic acids on the growth of the more prevalent cold tolerant pathogens and spoilage bacteria on raw meat. Published data suggest that some of these bacteria may be more sensitive to organic acids than the mesophilic pathogens (Greer and Dilts, 1992; Cutter and Siragusa, 1994). Thus, it may be more feasible to improve the safety and storage life of meat by controlling the growth of the prevailing psychrotrophs during the storage of primal or retail cuts. In this regard, delayed bacteriostatic effects of lactic acid have been documented (Smulders and Woolthuis, 1985).

The present study was undertaken to provide needed data on the effects of lactic acid on the aerobic growth of meatborne psychrotrophic pathogens (Listeria monocytogenes, Yersinia enterocolitica, Aeromonas hydrophila) and spoilage bacteria (Pseudomonas fragi, Brochothrix thermosphacta) inoculated on pork fat or lean tissues.

Materials and Methods

Bacterial strains included the clinical isolates Listeria monocytogenes 4 B Scott A#3 and Yersinia enterocolitica 0:4,32, Aeromonas hydrophila ATCC 7966 and the wild type spoilage bacteria Pseudomonas fragi Ju 14 and Brochothrix thermosphacta B2.

Pork loins were surface sterilized with ethanol and sterile meat discs (10 cm^2) were removed from the lean and fat surfaces. The tissue discs were inoculated by immersion in the bacterial suspension to give initial

levels of bacterial contamination of about 10^5 colony forming units/cm2 (CFU/cm^2). Inoculated fat or lean tissue discs were treated by immersion for 15 s in 55°C water or 55°C , 3% (v/v) lactic acid.

Bacterial numbers were determined by plate counts immediately after treatment (time 0) and after 4 and 15 days of aerobic storage at 4°C. Diluted homogenates of the tissue discs were plated by the pour plate technique using Tryptic Soy Agar (Difco Laboratories, Detroit, Michigan) supplemented with 0.6% yeast extract and colonies were enumerated after 48 hours of incubation at 25°C. Least squares means of 5 samples for each tissue type at each sampling time were determined.

An identical design was used in a related experiment to evaluate changes in meat colour and pH, post-treatment. Surface pH was measured using an Oakton portable pH meter (Anachemia Scientific, Calgary, Alberta) equipped with a flat surface electrode.

The L* (dark to light), a* (green to red) and b* (blue to yellow) colour coordinates were determined using a tristimulus colour reflectance analyzer (Minolta Chroma Meter II Reflectance Meter, Minolta Camera Company, Ramsey, New Jersey). The acceptability of meat colour was also subjectively evaluated by 2 observers at the end of each storage interval.

Results and Discussion

In accordance with the "delayed" antibacterial effects first described by Smulders and Woolthuis (1985) current results show that the immediate bactericidal effects of lactic acid on bacteria-inoculated pork were often followed by a period of prolonged bacteriostasis with limited growth for up to 15 days at 4°C.

Both spoilage bacteria (Table 1) and pathogens (Table 2) were more sensitive to the lethal effects of lactic acid on pork fat than lean and were eliminated from fat tissue within 4 days of acid treatment. A. hydrophila was unique in its susceptibility to lactic acid in that is was immediately reduced to below detectable levels on both fat and lean (Table 2).

Following an initial reduction of about 1 log cycle after acid treatment, P. fragi growth on lean was inhibited over the 15 day storage period. Contrarily, B. thermosphacta was more sensitive to lactic acid and its numbers gradually declined to below detectable levels by 15 days of storage. The sensitivity of meatborne spoilage bacteria to organic acids has been noted previously (Greer and Dilts, 1992; Cutter and Siragusa, 1994) and future research is warranted to determine the impact upon keeping quality.

Pathogens grew poorly or did not survive when inoculated on pork lean but proliferated on fat (Table 2).

Published results of studies with lean beef have shown an immediate reduction of about 1 log cycle in L. monocytogenes and Y. enterocolitica following treatment with 3% acetic or lactic acid at 55°C (Greer and Dilts, 1992). More recently, van Netten et al. (1994) found that a 2% solution of lactic acid at 21°C had negligible immediate, lethal effects to L. monocytogenes on pork bellies.

Present data confirm the immediate reduction in L. monocytogenes and Y. enterocolitica on pork lean and also show residual antibacterial effects of the lactic acid for up to 15 days at 4°C (Table 2). After the initial 1 log cycle reduction on pork lean, lactic acid prevented further growth of L. monocytogenes while the population of Y. enterocolitica gradually declined during storage.

The magnitude of the immediate reduction in meat surface pH after organic acid treatment has been reported to be greater on beef fat than lean tissue (Dickson, 1992). The current results confirm these data by showing that in comparison to water control treatments, 3% lactic acid immediately reduced the surface pH of pork lean and fat by 0.92 and 3.01 pH units, respectively (Table 3). The results also showed that after 15 days of storage, the pH of acid treated lean and fat was 5.24 and 3.49, respectively.

Cutter and Siragusa (1994) established a linear relationship between low pH and the extent of the reduction in E. coli on beef. Thus, higher concentrations of undissociated acid in fat may explain the greater antibacterial effects of lactic acid in this tissue.

Lactic acid affected fat appearance by increasing the intensity of the white colour. Lean colour reflectance data showed that in comparison to water-treated control samples, 3% lactic acid usually increased L* values, decreased a* values (except time 0) and increased b* values (Table 4). The extent of these treatment differences tended to increase with storage time. Subjective assessment of lean colour revealed a grey/brown surface discolouration by day 4. Organic acids have been previously found to produce an undesirable discolouration of pork and this may be an impediment to their practical application (Cacciarelli et al., 1983).

Conclusion

In contrast to carcass decontamination, lactic acid may be of more practical value in improving the keeping quality and assuring the safety following the treatment of primal or retail cuts of pork. The residual antibacterial effects can persist for 15 days of aerobic storage. It will be necessary to overcome problems with the unacceptable discolouration of acid-treated lean tissue

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