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The use of predictive microbiology by the Australian meat industry

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Abstract

In Australia, the key regulatory body, the Meat Standards Committee (MSC) of the Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) and the Export Meat Industry Advisory Council (EMIAC) have accepted in principle the usefulness of predictive microbiology for science-based regulation. The predictive microbiology approach is being used in a range of areas including hot-boning, distribution of meat, retailing of meat, fermentation, plant breakdowns and extended chilling regimes.

Keywords: Hot-boning; Predictive microbiology; Meat

1. Introduction

In the mid-1990s, the Australian meat industry invested in a research program on predictive microbiology. The results of the program have led to the use of predictive microbiology as the basis for changing regulations for processing, distribution and retailing of meat in Australia. The predictive microbiology approach has been accepted in principle as a tool in the development and monitoring of science-based regulation by the key regulatory and industry bodies, the Meat Standards Committee (MSC) of the Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) and the Export Meat Industry Advisory Council (EMIAC). Current research and development is being undertaken to implement the changes in a manner that will be acceptable to all stakeholders.

The aim of the present paper is to indicate the wide-ranging impact predictive microbiology has had, and is having, on regulation of the meat industry.

2. Hot and warm-boning of beef carcases

For almost a century, carcases have been slaughtered, dressed and chilled before being processed into primals, subprimals and trimmings. During the past decade, it has become possible to debone the carcase either immediately after slaughter and dressing (hot-boning) or after a short (ca. 4 h) chilling period (warm-boning). The process has obvious advantages in reducing handling and chilling costs. At the end of each processing day, cartons of meat are

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stacked under controlled chilling, as opposed to conventional boning where carcases are chilled overnight and boned the next day. From the food safety viewpoint, however, the process allows growth of Gram-negative pathogens such as *Salmonella* and pathogenic *Escherichia coli* because of slow cooling rates at the carton centre.

The initial regulatory approach to controlling growth was to prescribe the time to reach 7 °C at the carton centre, from an initial temperature that typically ranged between 25 and 35 °C. The time/temperature requirements were based on experiments conducted in meat tissue using inoculated cultures of *Salmonella* and *E. coli* (Smith, 1985).

In practice, the time-to-7 °C prescription has proven difficult to attain both for vacuum-packed subprimals/primals, and for trimmings used for hamburger meat. The difficulty was most acute for chilling of cartons in blast freezers with considerable variability occurring. Product frozen in plate freezers has achieved the prescribed chilling time.

Recently, a predictive microbiology approach has been pursued, similar to that employed by the New Zealand industry (Gill et al., 1991) using a model for *E. coli* developed by University of Tasmania (Ross, 1999). Key elements of the model as applied to the cooling process of hot (30–35 °C) beef trim are: lag 5 generations; pH 6.2; lactate 80 mM; Aw 0.992. A protocol for chilling for meat trimmings to 7 °C in cartons of meat has been proposed based on a mean 1.5 predicted log increase of *E. coli*, maximum 2.5 log increase with an 80th percentile not exceeding 2.0 log.

The model is currently being evaluated by companies that undertake hot-boning. Under the protocol, plants will be required to meet the proposed standard and to monitor the microbiological status of the product. Preliminary indications (MLA, 1999) are that frozen trim produced from hot-boned carcases has a satisfactory microbiological profile. In a survey of 131 samples, mean total viable count (25 °C incubation) was 1.79 cfu/g with *E. coli* detected on 1/131 (0.8%) samples.

3. Distribution of carcases and meat products

The Australian Standard for distribution of meat and meat products for human consumption stipulates that carcases be delivered no warmer than 7 °C at the surface. However, ambient temperatures in Australia often range between 30 and 40 °C, making the 7 °C regulation for carcase surfaces impossible to achieve consistently, particularly for the final deliveries when only a few bodies remain in the truck. At this time, when the truck doors are opened so that bodies can be carried into butcher shops or railed into supermarkets, the vehicle interior fills with hot air and the carcase surface temperature rises above 7 °C. When the doors are closed the vehicle refrigeration cools both the air space within the truck and the carcase surface.

Using a model for *E. coli*, a case has been prepared to allow temperatures to rise above 7 °C during delivery, providing that the temperature/time parameters allow no more than one generation of *E. coli* growth. The regulatory model is based on a model for *E. coli* growth on meat (Ross, 1999). To satisfy the needs for conservatism in public health regulations (the ‘‘precautionary principle’’), the model was adjusted to predict the 9Oth percentile of fastest growth rates. In practice, at any temperature, the model predicts growth as fast or faster than all growth rates reported in the literature for *E. coli* on meat at that temperature.

The proposal has been accepted in principle by the MSC and further work is in progress to install a system by which the truck driver can quickly prove, when required to do so by regulators and customers, that product temperature and time have not allowed one generation growth of *E. coli.*

4. Retail meat storage temperatures

Current Australian regulations stipulate that raw meat pieces be stored no warmer than 5 °C in retail premises. However, a number of surveys have shown that temperatures in retail display cabinets often exceed 5 °C. Meat and Livestock Australia (MLA) commissioned a study of temperatures of meat during the entire retailing period, both on display (when the temperature often rose above 5 °C) and during overnight storage in chill rooms (when the temperature fell as low as 1 °C). Using the model for *E. coli*, predicted growth was logged over the entire period. The model is based on that of Ross

(1999). To generate conservative predictions, pH 6.5, no lactic acid and Aw 0.992 were assumed for predictions of growth. Lag times were assumed to be zero.

A proposal was made to MSC to allow a predictive microbiology approach to regulation of meat in the retail sector. Current research and development is underway to monitor displays in a large number of butcher shops to provide information for use in a campaign to assure all stakeholders of the benefit of the approach.

5. Fermented meat processing

Current regulations require that fermentation of comminuted meat effects at least a 3-log reduction in generic *E. coli*. Implicit in the regulation is the requirement to validate each process type using challenge studies. For the hundreds of smaller, traditional smallgoods manufacturers, this requirement is onerous in terms of cost, together with the risk which stem from bringing *E. coli* (albeit non-pathogenic strains) into the process environment. Work is currently underway to establish whether a predictive microbiology approach for the validation of fermentation processes is feasible.

6. Plant breakdowns

Occasionally, plants suffer breakdown causing the chilling/freezing process to be interrupted. To date, extensive microbiology sampling programs have been used to try to adduce whether the product is wholesome, sometimes with results which are equivocal. Predictive microbiology is being evaluated as an alternate method to calculate predicted growth resulting from the interruption of the cycle.

7. Meat undergoing extended chilling

About 20% of Australian beef undergoes extended chilling over the weekend, prior to being boned on the Monday. Unfortunately, the product is difficult to bone because the fat hardens, particularly on cattle which have been grain-fed. Alternate chilling regimes have been proposed to overcome the problem. Rewarming the meat surface by passing hot gas through the refrigeration system, and holding meat around 10 °C are suggested alternatives. Predictive microbiology is used to estimate potential growth of pathogens and spoilage organisms under these regimes. Models for the growth of pathogens and spoilage organisms can be used to specify time and temperature combinations that increase worker comfort, safety and productivity without endangering public health. For example, at 10 °C the generation times of *E. coli*, *S. aureus* or *L. monocytogenes* are all greater than 5 h, suggesting that warming to 10 °C for a few hours would not lead to detectable increases in pathogen numbers, particularly if a lag phase occurred.

8. Discussion

The investment in research into predictive microbiology, which the meat industry made during the mid-1990s, has yielded information which is proving essential to amending a number of regulations so that they are based on robust science. Clearly, each of these initiatives will require both industry and regulators having access to, and being able to use, the predictive model for *E. coli*. Commercialisation of the *E. coli* model is, therefore, being pursued. It is anticipated that the model will be integrated into a software package that will interface seamlessly with electronic data loggers to provide an estimate of the potential growth of *E. coli* during the period of interest.

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