Results for today; Ideas for tomorrow

Meat Technology Update

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How useful are microbiological criteria for fresh meat?

All fresh meats become contaminated with microorganisms during the slaughter and dressing process. Some of these bacteria may include pathogens (these are the food poisoning microorganisms) or spoilage bacteria that cause off-odours and slime on meat surfaces.

If the bacteria on meat include pathogens (such as *Salmonella*) there could be a risk to human health. However, it is impractical to set microbiological criteria that would indicate when the food safety risk is unacceptable. This is because pathogens, if present, are usually there in very low numbers and are rarely distributed evenly. In practice, only a small proportion of the surface area of a small number of carcases can be sampled. In this circumstance, there is a high probability that pathogens would not be detected, even if they are present. Thus the absence of pathogens in a sample does not assure food safety.

Another problem is that there are no clear food safety objectives (FSO) for pathogens on fresh meat. An FSO is the maximum level of a food safety hazard in a food that can be considered acceptable for consumer protection. Even if microbiological testing reliably indicates the level of contamination by pathogens (and this may be possible if enough samples are tested) it is difficult to assess the level at which the pathogen is an unacceptable food safety risk. Food safety is better assured through the application of hazard analysis critical control point (HACCP) principles and good manufacturing practice (GMP).

In the context of HACCP and GMPs, microbiological testing is a guide to the consistency of the application of processing procedures. Microbiological testing is typically slow and expensive; and because contamination is not uniform, it is difficult to obtain representative samples. Notwithstanding these difficulties, microbiological testing (over time) can be used to help verify the consistent operation of processing systems. The tests should be aimed at the enumeration of indicator organisms rather than the detection of pathogens (See Box 1).

This newsletter explains some of the background to the use of microbiological testing to verify HACCP and highlights the relevance of indicator tests. The newsletter also discusses the special case of vacuum-packed meat and the tests that are useful in identifying problems with vacuum-packed meat.

Microbiological criteria

Microbiological criteria may be used to define the acceptability of a process, product or food lot. The criteria could be the absence, presence, or number of microorganisms and/or the quantity of their toxins/metabolites in samples.

Microbiological criteria may be used either:

- by an individual establishment, to verify that their process control systems are working as intended to prevent contamination; or
- to set national baselines to allow benchmarking against the overall performance of all meat processors, and to satisfy market access issues.

The Codex Alimentarius Commission (Codex) of the United Nations World Health Organization has established internationally accepted guidelines for the development of microbiological criteria. The guidelines state that microbiological criteria should only be established if it is practical and necessary to do so. Codex states that the following factors are relevant to assessing need and practicality:

- evidence of actual or potential hazards to health;
- effect of further processing on the likely microbiological status of the food and intended use of the product;
- likelihood and consequences of microbial contamination and/or growth during subsequent handling, storage and use;

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- the underlying health of the consumers concerned.

Consider these points for a case study of *Salmonella* on red meat. For example, there is epidemiological evidence that red meat plays a role in foodborne salmonellosis; but the majority of cases are a result of poor preparation and cross-contamination after cooking. In addition, an effective cold chain prevents growth of *Salmonella* and cooking prior to consumption destroys *Salmonella*. Using the Codex guidelines, it is not appropriate to test raw meat for *Salmonella* for the purpose of lot acceptance.

The American Meat Science Association (AMSA) convened a panel of leading microbiologists, statisticians and other food safety experts from USA, Canada, Australia, New Zealand and United Kingdom to examine the role of microbiological testing in a beef food safety program. The panel was asked to document the science behind the sampling process and to present clear recommendations for the evaluation of sampling programs. The panel found that:

- at no stage during a process will pathogen testing assure food safety;
- pathogens or other microorganisms at a low incidence cannot be used to assess process control;
- foodborne pathogens will not be detected consistently when they are not randomly distributed and/or occur at low incidence;
- testing for appropriate non-pathogenic organisms will allow validation and verification of process control systems designed to improve food safety;
- effective microbiological testing programs are based on sound food-safety objectives with definable microbiological performance criteria;
- the main purpose of microbiological testing of foods is to validate and verify process control measures in the context of a properly implemented HACCP system.

The Australian meat industry accepts the recommendations of groups such as AMSA and the International Commission on Microbiological Specifications for Foods (ICMSF) and has implemented them as part of its microbiological testing regimes. Where trading partners require specific testing regimes these have also been implemented; but, in general, the Australian meat industry has successfully implemented HACCP programs as the preferred food safety management strategy.

Indicator tests for meat

Meat can be contaminated with a variety of pathogens and spoilage bacteria and it would be difficult to monitor each of these organisms in a meaningful way. Indicator organisms are groups of bacteria that indicate the possible presence of organisms of concern, and may point to the origins of microbial contamination. Generally, it can be assumed that the numbers of a pathogen are less than the numbers of the corresponding indicator organism. Also, a reduction in the number of indicator organism will produce a similar reduction in the number of any pathogen associated with it.

Total Viable Counts

Most of the bacteria on freshly dressed carcasses will be from the hides or skins of the animals. Some of the contamination will be of faecal origin but it will include the normal flora of the skin (staphylococci, micrococci, pseudomonads, yeasts and moulds) as well as a variety of organisms from soil and water. Only a small proportion of bacteria present are able to grow once the meat has been chilled and factors such as temperature, surface dryness and gaseous atmosphere, will influence how quickly these bacteria can multiply.

In the presence of oxygen and under moist conditions (as for meat prepackaged on trays) the bacterial population will increase quickly and will probably be dominated by pseudomonads. Off odours and slime on the meat surface are evident when pseudomonads reach 100-500 million per cm^2. Imminent spoilage of the meat could be anticipated if a total bacterial count approaches these numbers. However, in vacuum-packed meat, the packaging brings about changes in the bacterial flora, and the storage life depends more on the nature of the flora that develops during storage than on the total numbers of bacteria present after processing.

Generic *E. coli*

Most *E. coli* are derived, directly or indirectly, from the rumen or the lower intestinal tract contents. For this reason, *E. coli* is considered to be a specific indicator of potential faecal contamination during the slaughter and dressing process.

The growth and survival characteristics of *E. coli* are broadly comparable to many pathogenic Enterobacteriaceae species such as *Salmonella* and pathogenic *E. coli*. Therefore, increases in *E. coli* during chilling, storage and distribution suggest that the meat has been subjected to conditions, which would also allow growth of these pathogens.

Coliforms

Coliforms are part of the Enterobacteriaceae family of bacteria and include *E. coli*, *Enterobacter*, *Klebsiella* and *Citrobacter*. A major drawback to the use of coliforms as indicators of pathogen contamination in chilled meat is that many of them are capable of growth below 5°C. *E. coli* cannot grow below 7°C, so a high coliform count does not necessarily indicate growth of faecal pathogens.

Elevated numbers of coliforms are evidence that processing or unsatisfactory post-process contamination might have occurred, but the history of the product must be examined closely before the precise nature of the problem can be determined.

Hazard analysis and control systems

Within the HACCP framework the Australian standards for hygienic meat production require bacterial testing for validation of processes and verification of process control. The primary application of testing is to support process control. Total viable counts and *E. coli* (Biotype 1) are used to verify slaughter floor processes, for evaluating the effectiveness of cleaning procedures and to monitor chilling practices. Adverse trends in bacterial numbers or detection rates can be identified and actions taken to correct elements of the production system.

The Australian industry collects and analyses carcase samples for verification of process control systems, and to satisfy market access issues. In the export sector, ESAM (carcase microbiological monitoring program for *E. coli* and *Salmonella*) microbiological data are collated by AQIS and used to set national baselines.

Baselines set a range in which microbiological test results are expected to fall. If results fall outside the range, there is a high probability that the result is from a different population distribution than the baseline data set. This is interpreted to mean that the sample is from meat that has not been processed according to the usual hygiene procedures and an investigation of procedures is triggered.

Data obtained in national surveys include test results from meat produced in a wide range of processes. National baseline data allow benchmarking against the overall performance. For a particular establishment, it is even more useful to look at the range of results from a specific process, and use this range to set a baseline from which performance of the process can be judged.

Baselines can also be used to set sampling plans intended to be used for accepting of rejecting lots. For example, a food safety objective could be a determination that the presence of *Salmonella* in a lot is an unacceptable food safety risk. The distribution of the incidence of *Salmonella* in baseline data can be used to design a sampling plan that has a known probability of identifying lots that do not comply with the food safety objective.

The prevalence of *Salmonella* on carcases has been reported as 0.31% for beef and 0.63% for sheep. To have a 90% probability of detecting *Salmonella* on beef carcases if the average incidence is 0.31% it is necessary to test 1171 samples. In practice it is not possible to design a commercially acceptable sampling plan to detect contaminated lots when the incidence of contamination is at such a low level.

Conclusions

Despite the opinions of independent, scientific expert groups such as ICMSF and AMSA, results of sampling plans are still used to judge the quality of the particular product (lot) under evaluation. This is done despite the overwhelming probability that the wrong decision will be made i.e. rejection of a conforming lot and acceptance of a nonconforming lot, depending on the test procedure and specification.

The most effective way of controlling quality is through monitoring and appropriate intervention during the production process to assure that food safety standards are continuously met. On its own, testing does not provide enough information to assure food safety. A far better approach is the adoption of HACCP and the validation of continuing performance through targeted sampling programs. Routine testing of raw meat for the presence of pathogenic bacteria such as *Salmonella* for the purpose of lot acceptance cannot be scientifically justified.

Further Reading

Vanderlinde, P., Shay, B., Murray, J. (1998) Microbiological quality of Australian beef carcass meat and frozen bulk packed beef. Journal of Food Protection. 61: 437-443.

Vanderlinde, P., Shay, B., Murray, J. (1999) Microbiological status of Australian of sheep meat. Journal of Food Protection. 62: 380-385.

Phillips, D. *et al*. (2001) Microbiological quality of Australian beef. Journal of Food Protection. 64: 692-696.

Phillips, D. *et al*. (2001) Microbiological quality of Australian sheep meat. Journal of Food Protection. 64: 697-700.

Key points for Industry

When using bacterial test results to assess fresh meat, processors should:

- concentrate on problem prevention and process improvement by testing to detect trends and monitor process control;
- use them to validate activities that are the key to the successful application of HACCP;
- recognise that quantitative indicators provide a much more effective tool for verifying that HACCP is properly implemented;
- recognise that the choice of target organisms should be process and product specific;
- realise that the methods chosen should be based on science and the resources available in an industrial setting

Relevance of microbial criteria applied to vacuum-packed meat

The Meat Standards Committee of ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand) introduced the guidelines 'Microbiological testing for process monitoring in the meat industry'. These guidelines expand on the requirements of the Australian standards to do microbiological testing at meat processing plants. The guidelines give examples of how to interpret microbiological counts and are appropriate for red meat in carcases and pieces, but they are not appropriate for vacuum-packed primals.

Vacuum packaging does not prevent the growth of all bacteria, but those that do grow are quite different species from those that grow on meat exposed to air. When meat is stored in air, under refrigeration, spoilage is mainly due to the growth and metabolism of *Pseudomonas* bacteria. As the numbers of pseudomonads reach around 100 million per cm^2 they produce a putrid odour and slime forms on the meat surface.

Vacuum-packed meat is stored in the absence of oxygen and the strict aerobes mentioned above cannot grow and metabolise. Instead, the bacterial population will consist mainly of lactic acid bacteria. These will be the only organisms present in significant numbers if the low oxygen atmosphere is maintained, the pH of the meat remains below 5.8 and the temperature is controlled below 4^oC.

Lactic acid bacteria grow slowly at chill temperatures and even when the count is high (100 million per g) they do not produce unpleasant odours and the product is still in good condition. In contrast, pseudomonads at a similar concentration would start to show signs of off-odour, but because of the absence of oxygen, the growth of this group of bacteria is suspended.

In this situation, a total viable count is not a useful indication of the microbiological quality of the product. If the total count is made up of lactic acid bacteria, counts of more than 10 million per g do not indicate incipient spoilage or any processing or storage problem. However, an *E. coli* count is a useful indicator of the quality of vacuum-packed meat and is similar to the assessment of a carcase, that is, the *E. coli* count should be low. *E. coli* counts on stored meat could indicate temperature abuse because *E. coli* do not grow below 7^oC.

If vacuum-packed meat has a pH greater than 6.0, spoilage bacteria such as *Brochothrix thermosphacta*, *Shewanella putrefaciens*, and psychrotrophic enterobacteria may play a role in spoilage. In high pH meat, the glucose content is lower, and off odours may be detected when the bacterial count is just over 1 million per cm^2. These bacteria will cause souring, and in the case of *Shewanella putrefaciens*, spoilage is indicated by a greening of the meat surface and a strong hydrogen sulphide odour (like rotten eggs).

For more information, contact one of the Meat Industry Services staff listed below.

Food Science Australia Meat Industry Services Section

The Meat Industry Services (MIS) Section of Food Science Australia is an initiative supported by Meat and Livestock Australia (MLA) and the Australian Meat Processor Corporation (AMPC) to facilitate market access for, and support world-class practices in, Australia 's meat industry.

Need additional information help, information or advice?

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