A COMPUTER PROGRAM FOR EVALUATING THE HYGIENIC EFFICIENCY OF MEAT PROCESSING PROCEDURES FROM PRODUCT TEMPERATURE HISTORY DATA

C.O. Gill, D.M. Phillips, M.P.F Loeffen and C. Bishop* Meat Industry Research Institute of New Zealand (Inc.), Hamilton, NEW ZEALAND, *Management Information Resources Ltd, Wellington, NEW ZEALAND

INTRODUCTION

Enteropathogens can be transferred to the surfaces of previously sterile edible tissues during dressing and breaking down of carcasses. There is no practicable method of establishing the absence of such organisms on meat, so for public health purposes, their presence on all fresh meat must be assumed. Meat processing regulation therefore aims to ensure that transfer of pathogenic bacteria to edible tissues is minimal and that opportunities for these organisms to grow on meat are severely restricted.

Control of pathogen transfer to meats is achieved by inspection, to maintain Good Manufacturing Practice (GMP), and by limited microbiological sampling for some objective assurance of GMP maintenance. Provided that such regulatory inspection adequately controls the addition of contaminants to fresh meats, then the major processing hazard is temperature abuse that permits pathogen proliferation. Currently, regulatory authorities attempt to control temperature abuse by stipulating a maximum ambient temperature for meat processing areas. Unfortunately, this requirement is of limited value because the temperatures relevant to bacterial growth are those of the product, not those of the environment. Moreover, this simplistic requirement may unnecessarily increase processing costs and restrict process flexibility without achieving the avowed objective. This inadequacy of current regulatory practice could be relieved by routine monitoring of product temperature histories and analysis of the data by an appropriate temperature function integration technique (Gill, 1985). If this approach to hygiene assurance is to be used in commercial practice, a user-friendly program that allows meat plant staff to analyse temperature history data will be required. This paper describes such a program.

THE PROGRAM CONCEPT

The purpose of the program is to evaluate the hygienic efficiency of processing procedures for raw meat, not to assure the quality of a given batch of product. The hygienic adequacy of product at the end of processing is assured only when it can be assumed that the product is of adequate hygienic status when it enters a process. Product hygiene will then remain adequate if it can be shown that excessive proliferation of pathogens on the product cannot have occur during the process.

Regulatory inspection during carcass dressing must be assumed to give assurance of the initial hygienic adequacy of product. The program then evaluates subsequent processing conditions by calculating the potential growth of a bacterium that is considered a suitable indicator for growth of pathogenic species. Proliferation of the bacterium is calculated for sites on the product where bacterial growth will be most extensive. If the potential growth at these worst possible sites is within an acceptable limit, then growth at other sites cannot be excessive. Hence, the hygienic status of the product is adequately maintained during processing.

THE MODEL FOR PATHOGEN PROLIFERATION

It is generally accepted that *Escherichia coli* is a suitable marker organism for indication of unsatisfactory product hygiene (Schmidt-Lorenz and Spillmann, 1988). Substantial data relating the growth rate and the duration of the lag phase to temperature are available for this species. Temperature function integration calculations based on such data give values for increases in *E.coli* numbers that are in good agreement with directly determined increases of both inoculated and naturally occurring populations on meat (Gill and Harrison, 1985; Smith, 1987; Mackey and Kerridge, 1988; P.D. Lowry, personal communication). Thus, calculations based on appropriate data should adequately indicate the real increase in numbers of any *E.coli* present at a site on meat from which a temperature history has been recorded.

The program contains data sets for resolution of the lag phase at temperatures permitting growth after chilled or frozen storage, under aerobic or anaerobic conditions, and for variation of the growth rate with temperature under aerobic or anaerobic conditions. All data sets are for high pH (6.0) meat, because in assumption of a worst case the inhibitory effects of lactic acid in normal pH meat cannot be considered.

The minimum temperature for growth of *E.coli* is 7°C. A process is therefore not considered complete until product falls below this temperature, followed either by freezing or storage for at least 7 days at chiller temperatures. If there is a transient temperature fall below 7°C during a process, a lag phase is not induced unless the product freezes.

The suggested levels for acceptable calculated proliferation during a process, three generations for chilled product and six generation for product that is to be frozen, are based on a preliminary evaluation of current processing operations that comply with accepted Good Manufacturing Practice. These preliminary criteria are highly conservative, and increased tolerances will probably be suggested when more extensive temperature history data for a range of accepted meat processing operations are available.

OPERATION OF THE PROGRAM

Any carcass reduction process can be divided into an alternating sequence of processing regimes, when product temperature monitoring is inconvenient or impossible, and temperature-monitored regimes, when product is passing between processing regimes or is held after the final processing regime. The process to be monitored must be established in the computer and identified in the temperature logger when the logger is set up for temperature monitoring. The computer will print a form detailing the process, and stating where the

logger and temperature probe should be placed to monitor the process correctly.

When temperature monitoring is completed, the logger is returned to the computer and the temperature history data are entered. The data are then displayed in graphical form. After inspection of the data, the operator enters the start and stop times for the process and for temperature monitored regimes within the process. This is necessary to exclude periods when the probe was not placed with product as the ambient air temperature would be recorded at these times. The computer then compares the edited temperature history with the process description. If the data are in adequate agreement with the time and temperature criteria established for the process, the data are accepted for analysis. Otherwise, an error is indicated and the operator must resolve the discrepancy.

Data accepted as the temperature history for a process are used for calculation of the potential proliferation of *E.coli*. The process description tells the computer which data sets from the growth model should be used for calculating proliferation at each stage of the process. As no temperature data are available for processing regimes, the program assumes that the higher of the product temperatures recorded at the beginning or end of such a period applies during that period.

The process description, temperature history and the analysis are printed. This report is identified as being formal if all checks on the procedure have been met, or as being informal if full compliance with the defined procedure has not been demonstrated. This latter form of reporting is also used when data are intentionally modified as an aid to determining means by which process hygiene could be optimised.

DISCUSSION

Calculations of *E.coli* proliferation can be used to quantify the potential proliferation of pathogens during meat processing, so allowing this aspect of meat hygiene to be assessed for various processes on a consistent, objective basis. However, in practical applications, difficulties arise with defining a process, ensuring collection and analysis of only those temperature data that are appropriate, ensuring that appropriate bacterial growth data are applied in each particular case, and defining realistic criteria for permissible potential proliferation of *E.coli*. The first three problems are addressed in the program by construction of template processes against which the adequacy of data from real processes can be determined. Tests have so far indicated that this approach is largely successful. The program can therefore currently be used for comparing processes, and for identifying areas within processes where better management of product could significantly improve product hygiene.

The remaining question, of criteria for permissible proliferation, can be properly addressed only when sufficient data for meat plant practices are available to clearly define the control of proliferation that is actually achieved under conditions of acknowledged Good Manufacturing Practice.

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