THE MICROBIOLOGICAL STATUS OF MEAT FROM SOME TYPICAL NEW ZEALAND MEAT SLAUGHTERING AND PROCESSING LINES

G.M. Keeley, The Canterbury Frozen Meat Co. Ltd, Christchurch, NEW ZEALAND.

The bacterial status of meat throughout the slaughtering and processing lines of four meat plants that have been monitored over the last fourteen years has shown a general improvement consistent with large scale changes and improvements in processing methods. The use of microbiological data for on-line process control of fresh red meat is of doubtful value, but viewed in historical terms as a means of preventative quality assurance and for evaluating such concepts as Hazard Analysis Critical Control Point programmes it is a vital and necessary tool.

Microbiological monitoring cannot replace the process control principles embodied in Good Manufacturing Practice but it is an important adjunct for evaluating the general level of product hygiene and is complementary to the systems auditing procedures embodied in standard quality assurance programmes.

This paper seeks to redress the paucity of microbiological data on modern meat slaughtering and processing lines.

INTRODUCTION

New Zealand has 71.6 million sheep and 8.4 million cattle (30 June 1986) of which 41 million and 3.2 million respectively were slaughtered in year ended 30 September 1987. Total sheepmeats exported during the same period were 437,900 tonnes and beef 275,200 tonnes, or 61% of the total production. NZMPB (1987). This was processed through 44 plants operated by 20 companies of which CFM operates 4 slaughtering plants and produces approximately 10% of the total.

Thus New Zealand is one of the world's largest single producers of sheepmeats, ranking third in importance after Australia and the USSR. While this only amounts to some 7% of the total world's sheepmeat New Zealand is by far the world's leading exporter of sheepmeat, particularly lamb, and accounts for over 50% of world trade in this product (Keeley 1984).

Because of the national importance of the meat processing industry to the economy of the country and because there is a policy of catering for every export opportunity worldwide, considerable importance is placed on achieving the highest standards of meat hygiene to meet the specific requirements of each meat importing country. Monitoring the microbiological status of product throughout the processing line forms part of the evaluation procedure of the overall quality assurance programme. The total viable counts (TVC) produced over the last 14 years of this monitoring programme are presented as part of a substantial data base for some typical New Zealand meat slaughtering and processing lines. In this context it provides a pool of microbiological data related to Good Manufacturing Practice (GMP) which can be viewed against the otherwise limited data found in the scientific literature (Nottingham et al. 1974; Roberts et al. 1980; Johanson et al. 1983; Roberts et al. 1984; Whelehan et al. 1986).

MEAT HYGIENE REGULATIONS

The New Zealand Meat Regulations have undergone revision and change over the years and reflect the international understanding of meat hygiene principles (Codex Alimentarius 1976). Overseas legislation that has had a major bearing on the NZ Meat Industry include the US Wholesome Meat Act and the EEC Third Country Veterinary Directive (EEC 1972). Formal quality control procedures were adopted by the Industry in 1972 and embodied in these are detailed requirements for

Table I. Microbial status of beef throughout a processing line.

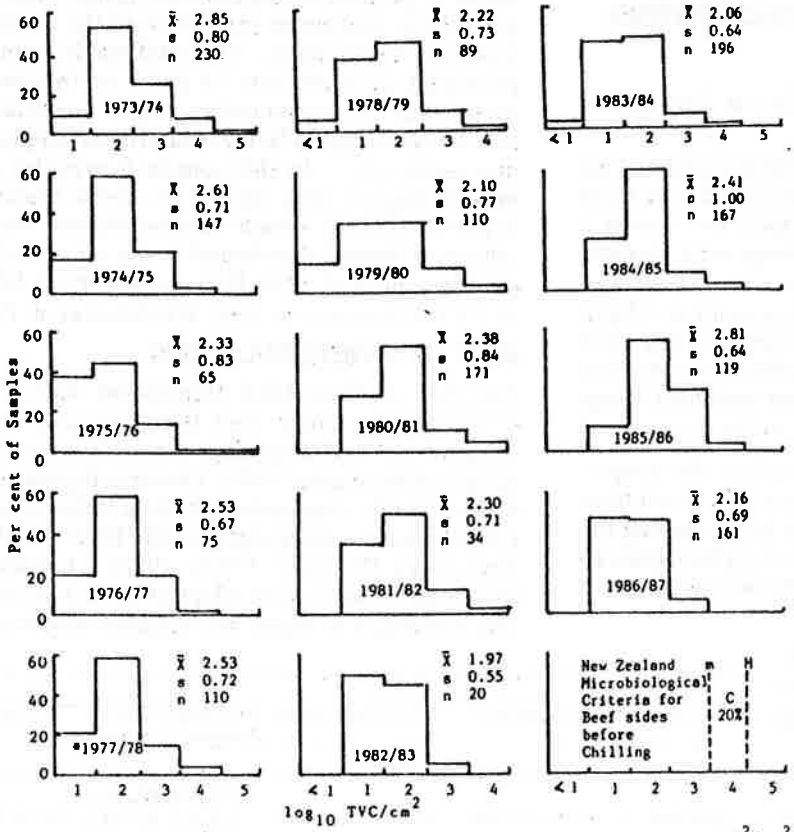
Period	*Fresh sides	*Chilled sides	**Primal cuts **Boneless beef	**MSM
1981/82	2.30(0.71,34)	2.76(1.06,240)	3.48(0.56,20) 3.74(0.86,46)	5.10(1.20,57)
1982/83	1.97(0.55,20)	2.86(1.22,263)	3.35(0.81,32) 3.86(0.98,46)	4.90(0.56,45)
1983/84	2.06(0.64,196)	2.59(0.96,265)	3.31(0.67,67) 3.54(0.60,49)	4.90(0.36,42)
1984/85	2.41(1.00,167)	2.66(0.96,220)	3.29(1.3,64) 3.34(1.3,48)	4.76(0.51,10)
1985/86	2.80(0.64,119)	2.66(0.84,119)	2.67(0.73,22) 2.80(0.54,25)	4.09(0.61,22)
1986/87	2.16(0.68,161)	2.28(0.72,165)	3.02(0.88,58) 3.14(0.64,41)	N/A
1981-87	2.30(0.75,697)	2.66(1.00,1272)	3.21(0.92,262) 3.46(0.89,255)	4.86(0.80,176

* $\log_{10}$ Mean TVC/sq.cm (SD,N), ** $\log_{10}$ Mean TVC/g (SD,N),
MSM = Mechanically Separated Meat

Table II. Microbial status of sheep and lamb carcases from three different slaughtering plants.

Period	$\log_{10}$ Mean TVC/sq.cm (SD,N)		
	Plant A	Plant B	Plant C
1973/74	3.55(0.73,187)	3.37(0.66,114)	3.37(0.82,170)
1974/75	3.75(0.69,297)	3.63(0.53,48)	3.42(1.18,144)
1975/76	3.51(0.66,156)	3.41(0.43,63)	3.62(0.69,157)
1976/77	4.02(0.78,71)	N/A	2.70(1.08,125)
1977/78	3.52(0.72,128)	3.56(0.64,44)	2.93(0.72,87)
1978/79	3.65(0.83,206)	3.56(0.72,490)	2.73(1.17,80)
1979/80	3.51(0.61,84)	3.75(0.74,507)	3.31(0.83,538)
1980/81	3.53(0.70,191)	3.62(0.73,130)	N/A
1981/82	3.60(0.77,198)	3.75(0.90,155)	2.88(0.59,328)
1982/83	3.64(0.62,104)	3.54(0.78,318)	2.78(0.80,131)
1983/84	3.57(0.64,180)	2.94(0.79,135)	3.06(0.56,57)
1984/85	3.32(0.70,174)	3.12(0.79,138)	3.28(0.62,180)
1985/86	2.76(0.73,99)	3.38(0.73,257)	3.31(0.76,119)
1986/87	2.83(0.72,150)	3.88(0.69,255)	3.06(0.49,95)
1973-87	3.50(0.71,2225)	3.56(0.74,2654)	3.16(0.81,2211)

Figure 1 - Distribution of $\log_{10}$ TVC/cm^2 from beef sides after slaughter



* Up until 1977/78 the lowest detection level was expressed as $<10^2$/cm^2 Counts $<10^1$/cm^2 have been included in the 10^1/cm^2 category.

microbiological monitoring of meat and meat products. Additional to the testing for organisms of public health significance the total viable count (TVC) is used as a general indicator for evaluation of meat hygiene. It has been suggested that such a measure in itself, is not entirely satisfactory in this regard (Ingram and Roberts 1976), but in the absence of a more precise tool a large pool of data does provide an historical view of the level of hygiene achieved in meat production. It is particularly useful for comparative evaluation when sampling and methodology has been standardised.

PROCEDURE

Random weekly samples have been taken from product at various points in the processing line. Field samples taken from either 3 or 5 sampling locations on carcasses or 5 units of product in the case of boned and cut meat form a composite sample unit for testing. Thus each value obtained is a composite arithmetic mean count per carcass or product category, viz. primal cuts, boneless meat, etc. Swab sampling has been used for carcass meat and weight samples taken from meat processed past the carcass stage, except for beef sides, which since 1981 have been sampled by removing a 5 sq.cm disc of meat 2-5 mm thick from each sampling location.

For boned and comminuted meat 25 g samples have been taken randomly from the pack volume. Comparative testing of samples taken under these standard procedures indicates the following relationship generally holds:

Count/sq.cm = Count/g x 0.3

Microbial counts have been obtained by using either a Stomacher or manually preparing a suspension in 0.1% peptone water by shaking with glass beads. Decimal dilutions have been pour plated with Standard Methods Agar or nutrient agar plus 0.5% yeast extract and plates incubated at 30°C for 2-3 days prior to counting (Lowry 1980). All counts have been normalised by transforming to logarithms to the base 10 (Ingram and Roberts 1976; Kilsby and Pugh 1981). While there has been much discussion in the literature on the equivalence of a wide range of differing sampling and testing methodologies (Ingram and Roberts 1976; Roberts et al. 1980; Johanson et al. 1983; Roberts et al. 1984), the data presented here is, in general, consistent within itself and if comparisons are to be made, due recognition should be taken of such limitations.

BEEF SLAUGHTER AND PROCESSING

The mean annual TVC from beef sides after slaughter (Figure 1) show a decreasing trend from 1973 through to 1983. Since that time stock supply problems have led to interrupted slaughtering patterns with physical and labour disruptions being reflected in a poorer microbiological quality being achieved. During 1975 beef slaughtering was changed from a manual bed dressing system to an automated chain system in a completely new facility. From 1978 visual carcass contamination rates were progressively reduced from a high of 13.3% to a low of 3.6% in 1981. In 1979 management changes occurred in the slaughter house and in 1987 new quality control procedures were adopted. Changes in the frequency distributions in Fig. 1 coincide with a number of these operational changes and from a global point of view they reflect the effects of control at source, which is generally accepted as the only effective way of maintaining a satisfactory hygienic standard (ICMSF 1986).

As distinct from examining microbiological data in the form of frequency distributions it is useful to graphically display data in the form of a time-plot or control chart. While this is still historical, due to the time delay between sampling and obtaining a microbiological count, it may give an indication, albeit delayed, of significant changes in the process and thus form the basis of preventative quality assurance and a means for monitoring or auditing GMP. Figure 2 shows such a plot for chilled beef sides.

Counts up to sample 17 were running below the mean with low variability week to week, followed by a period where they were more variable and with a higher process average. The changeover corresponded to a change in stock type with predominantly prime steer being replaced by boner cow. In this case either the boner cow was not processed as hygienically as prime steer or a change in chiller operation may have been implicated. A similar evaluation of counts from the freshly slaughtered carcasses is therefore indicated.

Figure 2 - Control chart for $\log_{10}$ TVC/cm^2 from chilled beef sides

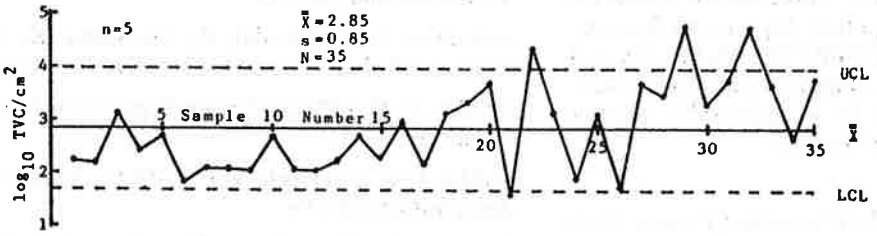
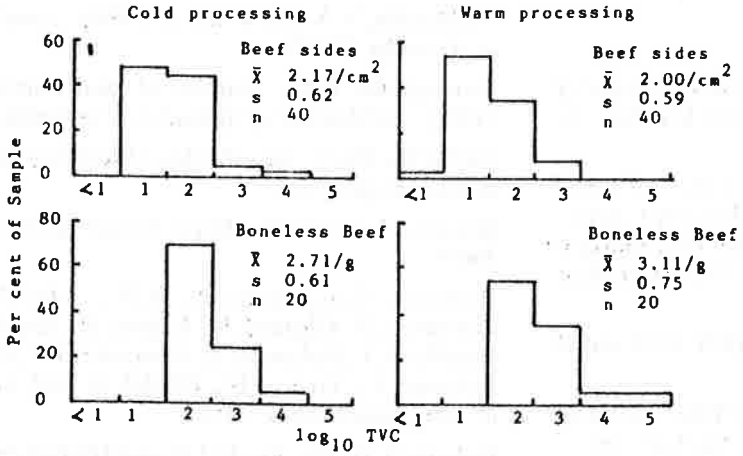


Figure 3 - Distribution of $\log_{10}$ TVC from cold & warm processed beef



A derogation recently made to the EEC Third Country Veterinary Directive for Fresh Meat (EEC 1987) has opened the way for export to the EEC of warm cut meat as long as certain specified conditions are adhered to. Prior to this meat had to be chilled to +7°C or below before cutting could commence.

A microbiological evaluation of beef sides and the boneless beef arising from them, cut both cold (< 10°C in this case) and warm is shown in Figure 3.

The mean deep leg temperature (SD,N) for the cold sides was 8.1°C (1.4, 40) and for the warm sides 13.7°C (2.4, 40). For the boneless beef it was 7.6°C (1.4, 20) and 10.2°C (2.1, 20) respectively but a proportion of these arose from sides chilled over the weekend. Estimation of Total Viable Counts not only provides a useful data base for evaluating the hygienic performance of specific processing operations but they also provide a basis for preventative quality assurance and become an essential part in setting up a Hazard Analysis Critical Control Point (HACCP) system for a meat slaughtering and processing line.

Judicious sampling and testing throughout a meat processing line itself is important not only to optimise available laboratory resources but also to provide the best information on the control of the process and the standard of hygiene being achieved. In this context, evaluation of such data is a necessary part of any systems and product audit of the processing plant. Table I summarises the results of monitoring such a processing line over a period of seven years.

SHEEP SLAUGHTER AND PROCESSING

It is important that product exported to a specified customer is consistent within the lot and meets the customer's specification and performance expectations. It is therefore necessary to ensure that if the same product originates from different processing facilities then it is of similar microbiological standard. Microbiological monitoring of product from three sheep and lamb slaughtering and processing plants, carried out over the last 14 years, has provided this assurance.

The plants are licensed establishments and meet USDA and EEC regulatory requirements. In addition they are capable of slaughtering animals according to the Islamic Halal requirements. Careful attention is paid to all aspects of slaughtering and processing hygiene as required under the NZ Meat Regulations and the principles of Good Manufacturing Practice are maintained through a process control system as part of the overall Quality Assurance programme. The general principles enumerated by the ICMSF (1986) are used to evaluate microbiological quality of product together with criteria elaborated by the Meat Industry Research Institute of NZ.

Table II summarises the results of monitoring sheep and lamb carcasses from the slaughterline of 3 different plants over the last 14 years.

CONCLUSIONS

The microbiological monitoring of meat from slaughtering and processing lines serves to provide an historical record of the general standard of hygiene achieved. The data needs to be viewed in a global sense under standard conditions so that variations in methodology and differences due to sampling are minimised.

The Total Viable Count (TVC) appears to be the method of choice due to its ease of enumeration and its ability to reflect the overall effect of processing hygiene. It thus becomes an essential part in any HACCP analysis of the process and forms part of the preventative quality assurance programme for meat slaughtering and processing.

While current methodologies prevent its use for on-line process control the microbiological status of fresh meat does reflect major changes in process improvements once a satisfactory data base has been established. The data presented here should add to the paucity of information on the microbiological status of meat from modern meat slaughtering and processing operations.

The approach to monitoring product performance through the use of predictive microbiological models has been available for some time (Baird-Parker and Kilsby 1987). Such techniques as temperature function

integration applied to fresh meats opens the way for on-line data describing the interaction between processing method and product hygiene to become available for process control (Gill 1986; McMeekin and Olley 1986). Before such techniques gain acceptance, however, they will need to be demonstrably proven against Good Manufacturing Practice.

ACKNOWLEDGEMENT

The author wishes to thank The Canterbury Frozen Meat Co Ltd for permission to publish the data in this paper and all the microbiology staff who have participated in its gathering.

REFERENCES

Baird-Parker, A.C. and Kilsby, D.C. (1987). *Journal of Applied Bacteriology*, Symposium Series No 16 Supplement **63**:43S.

Codex Alimentarius Commission (1976). Recommended International Codes of Hygienic Practice for Fresh Meat, for Ante-mortem and Post-mortem inspection of Slaughter Animals and for Processed Meat Products. CAC/RCP 11/13-1976.

EEC (1987) Commission Decision C(87) 1782 dated 16.10.87.

EEC Third Country Directive 1972/462/EEC. Official Journal of the European Communities. No. L302/28.

Gill, C.O. (1986). *Food Technology in Australia*, **38**:203.

ICMSF (1986). Microorganisms in Foods. 2 Sampling for microbiological analysis: Principles and specific applications.

Ingram, M. and Roberts, T.A. (1976). *Royal Society of Health Journal*, **96**:270.

Johanson, L., Underdal, B., Grosland, K., Whelehan, O.P. and Roberts, T.A. (1983). *Acta Vet. Scand.*, **24**:1.

Keeley, G.M. (1984). Proceedings of the World Quality Congress, p345.

Kilsby, D.C. and Pugh, M.E. (1981). *Journal of Applied Bacteriology*, **51**:345.

Lowry, P.D. (Ed). (1980). Microbiological Methods for the Meat Industry. MIRINZ Publication 757.

McMeekin, T.A. and Olley, J. (1986). *Food Technology in Australia*, **38**:331.

Nottingham, P.M., Penney, N. and Harrison, J.C.L. (1974). *NZ Journal of Agricultural Research*, **17**:79.

NZMPB (1987). New Zealand Meat Producers Board. Annual Report 1987.

Roberts, T.A. (1980). *Royal Society of Health Journal*, **100**:3.

Roberts, T.A., Hudson, W.R., Whelehan, O.P., Simonsen, B., Olgaard, K., Labots, H., Snijders, J.M.A., Van Hoof, J., Debevere, J., Dempster, J.F., Devereux, J., Leistner, L., Gehra, H., Gledel, J. and Fournaud, J. (1984). *Meat Science*, **11**:191.

Roberts, T.A., MacFie, H.J.H. and Hudson, W.R. (1980). *Journal of Hygiene*, **85**:371.

Whelehan, O.P., Hudson, W.R. and Roberts, T.A. (1986). *Journal of Hygiene*, **96**:205.