CHAPTER 5

DISCUSSION

There is a general consensus that microbiological contamination during slaughter and dressing is the most important source of meat-borne public health hazards and the risks can only be controlled by preventing access of pathogens on the carcasses (Ayres, 1955; Bryan, 1980; Kapsrowiak & Hechelmann, 1992; NACMCF, 1993). HACCP, a scientifically based system for process control, can achieve this objective but first its' scientific validity in a raw product system like abattoirs has to be assessed. From this study, which was fundamentally assessing this scientific validity, significant reductions of the common raw meat pathogens measured were achieved justifying the need to implement the HACCP system in the red meat industry.

The aerobic plate counts obtained from the baseline data were consistent with other studies who reported average values of between 2.3-5.89 mean $\log_{10}$ aerobic count cm-2 for freshly slaughtered beef carcasses processed commercially (Dorsa *et al.,* 1996; Gill *et al.,* 1998; Hogue *et al.,* 1993; Hinton, Hudson & Mead, 1998; Nortjé, Nel, Jordaan, Badenhorst, Goedhart, Holzapfel, & Grimbeeek, 1990a; Abbey *et al.,* 1998; Vanderlinde, Shay, & Murray, 1998). The expected surface contamination is usually in the range of 10^3-10^4 cfu/cm^2 (Rosset, 1982). The aerobic plate count values after HACCP implementation obtained in the plant were generally, rated as fair according to the rating scale from the ICMCF (1986) in which the maximum acceptable microbiological limit for carcass meat before chilling is 10^6 cfu/cm^2 and chilled carcass meat is 10^7 cfu/cm^2. The non-significant reduction of the values after splitting of the carcasses could be attributed to higher handling of the carcasses as this abattoir was manually operated without basic equipments like hooks for pulling carcasses. There was also a constant movement of personnel from one station to the next to clear backlogs and this can easily compromise hygienic principles. There is therefore, also a need to train the personnel for a longer duration on basic hygiene. Hogue *et al.* (1993) reported that controlling aerobic plate counts in small volume slaughter houses tend to be a lot more difficult

due to non specialization of labour and less uniformity of cattle slaughtered. This seems to be in agreement with the bovine source for slaughter in this particular abattoir as it catered for a heterogeneous group of farmers. The reductions in the aerobic plate count values after HACCP implementation at the chilling stage was a pointer at proper time/temperature maintenance. Usually within the first 24hours a reduction of total counts is expected in the chill room if running temperatures are less than 10 °C but with subsequent days the log counts will increase. Any analysis done within this period will record lower counts as reported in this study. However, if the chill temperatures exceed 10 °C a consistent growth of pathogens will be reported (Nottingham, 1982). The reduction in counts in the chill room could be due to a loss in viability and injury of the surface bacteria. Rosset (1982) indicated that if warm carcasses (38-40 °C) are placed in a chill room at -1 to +5 °C, its surface cools rapidly down to 0 to +5 after 2.5-3 hours. The loss in energy due to the rapid chilling has a great influence in reducing the growth rate of the spoilage flora. In addition, the carcass surface is also dried with resultant reduction of its water activity (a_w) leading to increased stress of the microbes and sometimes death (Sofos *et al.,* 1999b).

Staphylococcus aureus was the most prevalent pathogen in the meat abattoir under investigation before and after HACCP implementation. This is in agreement with other researchers who also found a high prevalence of *Staphylococcus aureus* in raw meats (Brown, 1982). This is especially a significant observation as it points mainly to the hygiene of the personnel who are the main source of cross contamination of *Staphylococcus aureus* and temperature abuse within the abattoir (Troller, 1976; Patterson & Jackson, 1979) and monitoring their performance is essential (De Wit & Kampelmacher, 1982). The significantly reduced values (Tables 4.1 and 4.2) therefore imply that appropriate monitoring of the critical control points, skinning, evisceration and chilling and GMPs were effective. However, the significant reduction in the counts after the HACCP implementation at the chilling step (Table 4.4) could have been due to a combination of GMP's on the slaughter line and effective monitoring of time/temperature of the chill room. Temperature is described as one of the most effective means of killing *Staphylococcus aureus* (Troller, 1976) and the effect of the low temperatures is shown by studies carried out by Patterson & Jackson (1979). They found that at

chill temperatures of less than 7 °C *Staphylococcus aureus* undergoes an unbalanced metabolism resulting in injury and loss of viability.

The effect of HACCP on the faecal coliforms was also investigated since faecal organisms in beef carcass dressing processes are considered a major source of carcass contamination. Their reduction is important as it is viewed not only from a safety aspect but also from a hygiene point of view. Because of this the assessment of the effectiveness of a quality system against hygienic risks in an abattoir therefore always involves enumeration of the coliforms or *Escherichia coli* (Gill *et al.,* 1996). Faecal contamination of dressed carcasses occurs mainly as a result of direct contact with the faeces and contact with surfaces which have been in contact with the faeces, e.g. hides or from punctured gut (Bell, 1997). In this study significant reductions of total coliforms was achieved at both the control points but *Escherichia coli* was reduced significantly only after 24 hours chilling. Inspite of this *Escherichia coli* levels were generally, low in the abattoir (Tables 4.1 and 4.2). It should be noted that in cases where the detections are few, high values from even one carcass would result in great differences in means (Gill *et al.,* 1999). This could therefore explain the non-significant values for *Escherichia coli* at the splitting step in which a slight increase was recorded in the 5th week yet overall detections were low (40%) and were reducing consistently compared to the baseline values which were 60%. This reduction could be attributed to good slaughtering techniques and monitoring at the skinning and evisceration steps during carcass dressing. The baseline values for the total coliforms were comparative to previous studies in which values in the range of 0.9 - 2 $\log_{10}$cfu/cm^2 was recorded (Gill *et al.,* 1996; Gill *et al.,* 1998; Sofos *et al.,* 1999a). HACCP implementation Significantly reduced the total coliform populations to below the detection limit for some carcasses at the chilled stage. Once the carcass temperature falls below 10 °C growth of most mesophiles like coliforms are suppressed and further temperature reductions lead to loss in viability and injury (Brown, 1982). The baseline values for *Escherichia coli* were also comparative to those of other studies who reported general mean values of 0.71-2 $\log_{10}$cfu/cm^2 (Abbey *et al.,* 1998; Gill *et al.,* 1998; Sofos *et al.,* 1999a). The slight decrease in the *Escherichia coli* values after 24 hours chilling could also be attributed to improved slaughtering techniques and general improvement in the GMPs (proper washing of workers hands). Workers hands are the main source of

cross contamination of *Escherichia coli* as they rarely wash their hands effectively unless monitored (De Wit & Kampelmacher, 1982). The slightly higher *Escherichia coli* levels before HACCP implementation at chilling could have been due to high line speeds resulting in poor slaughtering, continual puncturing of the viscera combined with high chances of cross contamination as personnel rarely stopped to wash their hands. All these factors in combination with poor monitoring of temperature/time at the chilling stage could have provided an appropriate niche for the *Escherichia coli* growth. In general growth of coliforms depends on many other factors such as plant operation, geographical location and season (Sofos *et al.,* 1999a). He indicated that lower values were recorded during the dry season. This observation correlates well with those from this study, which was also carried out in the winter which is the dry season in the Hammanskraal region.

Very few samples were positive for *Clostridium perfringens,*. Low incidences of the *Clostridium perfringens,* are usually expected in fresh meats with higher levels recorded only from offals and cooked meat products, which are kept at warm temperatures (Smart *et al.,* 1979; Craven, 1980). The pathogen is easily controlled by adherence to proper time/temperature as illustrated in Figure 4.10 in which 0% detections are recorded after HACCP implementation. Rosset (1982) showed that the lowest growth temperature for this pathogen is 20°C, which could therefore explain the reductions, which were achieved during the baseline evaluation despite the temperature abuse at which other pathogens grew. *Clostridium perfringens,* is also sensitive to low water activity, which inhibits its growth. Reduction in water activity is usually attained at the chilling stage as a result of evaporation (Rosset, 1982).

Salmonella was detected in very few of the carcasses. The few *Salmonella* incidences on the carcasses might be a reflection on the source of the livestock, which was extensive (open pastures and the short transportation distances), more than on existing conditions within the plant. Sofos *et al.* (1999a) showed that pasture animals tend to have a cleaner hide with less dung locks resulting in lower levels of pathogens. Such animals would also have more bacteria of soil origin unlike their counterparts finished in feedlots that might have more microorganisms of intestinal origin. The low levels could also be an indication of the advantages of

short travelling distances as the animals for slaughter all came from the farms in the same region in which the abattoir was located. The advantage of travelling distances on *Salmonella* levels has been explained by Kapsrowiak & Hechelmann (1992) who indicated that cross contamination of this pathogen depended on the stress levels of the animal which might increase during transportation. The animals might also become dirty during transportation and the degree of cleanliness during slaughter depends a lot on the dirtiness of the animals. Comparative work done by other researchers also recorded similar results in which little or nil detection of *Salmonella* in carcasses was recorded. For instance Sofos *et al.* (1999a) reported that of 30 carcasses sampled and analysed for *Salmonella* an average of 2.6% detection was recorded while Korsak *et al.* (1998) did not recover any *Salmonella* from 310 carcasses. Detection of *Salmonella* is usually prevalent after the break down of the carcasses, for instance in a bowl chopper during sausage production, as the meat is usually more evenly mixed hence a much higher chance of detecting *Salmonella* (Kilsby & Pugh, 1981). Therefore the best examination point for this pathogen might be at the subsequent processing stages but the control point is usually at the abattoir. The lack of *Salmonella* on the chilled carcasses could be explained by redistribution of the pathogens hence not necessarily sampled again (Gill *et al.,* 1996).

Overall for most of the pathogens, reductions were achieved after HACCP implementation due to proper time/temperature management and monitoring of the skinning and evisceration controlling points.