

CHAPTER 4

RESULTS

4.1 EFFECT OF HACCP IMPLEMENTATION ON MICROBIAL LOADS OF CARCASSES

Baseline data were taken to build up a profile on the microbial status of the plant to assess the effectiveness of the HACCP implementation on the pathogen loads. The statistical evaluations of the data showed that all variables were significantly reduced ($p < 0.05$) after HACCP implementation except for the aerobic plate count data and *Escherichia coli* at splitting of carcass as illustrated in Tables 4.1 and 4.2. The summaries of the mean \log_{10} counts reductions for each pathogen at the carcass splitting step and after 24 hours of chilling after HACCP implementation are also indicated in Tables 4.1 and 4.2 respectively.

A consistent positive hygiene trend was achieved for most of the variables tested over the 5-week duration as illustrated in Figures 4.1 to 4.5. Minimal detections in as low as 40% of the carcasses at splitting and 2% after 24 hours chilling for *Escherichia coli* and 14% at splitting and 0% after 24 hours chilling for *Clostridium perfringens*, was recorded after HACCP implementation. *Staphylococcus aureus* was reduced significantly as illustrated in Figure 4.2. HACCP implementation resulted in a significant overall reduction of total coliforms both at the splitting step and after chilling as illustrated in Figure 4.3. In general total coliform reductions of approximately 0.52 and 1 log cycle were observed for the splitting step and 24 hours chilling, respectively.

The presence/absence test was used for *Salmonella* detection and results are therefore reported as % detection. *Salmonella* was isolated from only 2% of the carcasses during the baseline data collection at the splitting step. After HACCP implementation all the samples were negative both at the splitting of carcass and after 24 hours chilling.

Table 4.1: Mean¹ microbiological counts (\log_{10} cm⁻²) on bovine carcasses at baseline and after HACCP implementation taken after splitting of the carcass.

Microorganism	Baseline N = 50	HACCP N = 50	Reduction ²	P - value
Aerobic plate counts	3.77 ^a	3.74 ^a	0.03	0.85
<i>Staphylococcus aureus</i>	2.12 ^a	1.53 ^b	0.59	0.0001
Total coliform	1.08 ^a	0.56 ^b	0.52	0.0004
<i>Escherichia coli</i>	-0.06 ^a (64% of carcasses)	-0.20 ^a (40% of carcasses)	0.14	0.214
<i>Clostridium perfringens</i> ,	-0.37 ^a (28% of carcasses)	-0.48 ^b (4% of carcasses)	0.11	0.006
<i>Salmonella</i>	2% of carcasses	0% of carcasses		

²Reduction = $\log_{10}\text{cfu/cm}^2$ Baseline - $\log_{10}\text{cfu/cm}^2$ HACCP.

¹Means within rows with different superscripts are significantly different ($p < 0.05$)

Table 4.2: Mean¹ microbiological counts ($\log_{10} \text{cm}^{-2}$) on bovine carcasses at baseline and after HACCP implementation taken after 24 hours chilling of the carcass.

Microorganism	Baseline N = 50	HACCP N = 50	Reduction ²	P - value
Aerobic plate counts	3.33 ^a	3.52 ^b	-0.19	0.04
<i>Staphylococcus aureus</i>	1.98 ^a	0.64 ^b	1.34	0.0001
Total coliform	0.77 ^a	-0.30 ^b	1.07	0.0001
<i>Escherichia coli</i>	0.01 ^a (62% of carcasses)	-0.50 ^b (2% of carcasses)	0.51	0.0001
<i>Clostridium perfringens</i> ,	-0.44 ^a (14% of carcasses)	-0.50 ^b (0% of carcasses)	0.06	0.02
<i>Salmonella</i>	0% of carcasses	0% of carcasses		

²Reduction = $\log_{10}\text{cfu/cm}^2$ Baseline - $\log_{10}\text{cfu/cm}^2$ HACCP.

¹Means within rows with different superscripts are significantly different ($p < 0.05$)

Figure 4.2: Mean¹ microbiological counts ($\log_{10} \text{cfu/cm}^2$) on bovine carcasses at the carcass splitting step ($p = 0.85$) and after 24 hours chilling ($p = 0.04$).

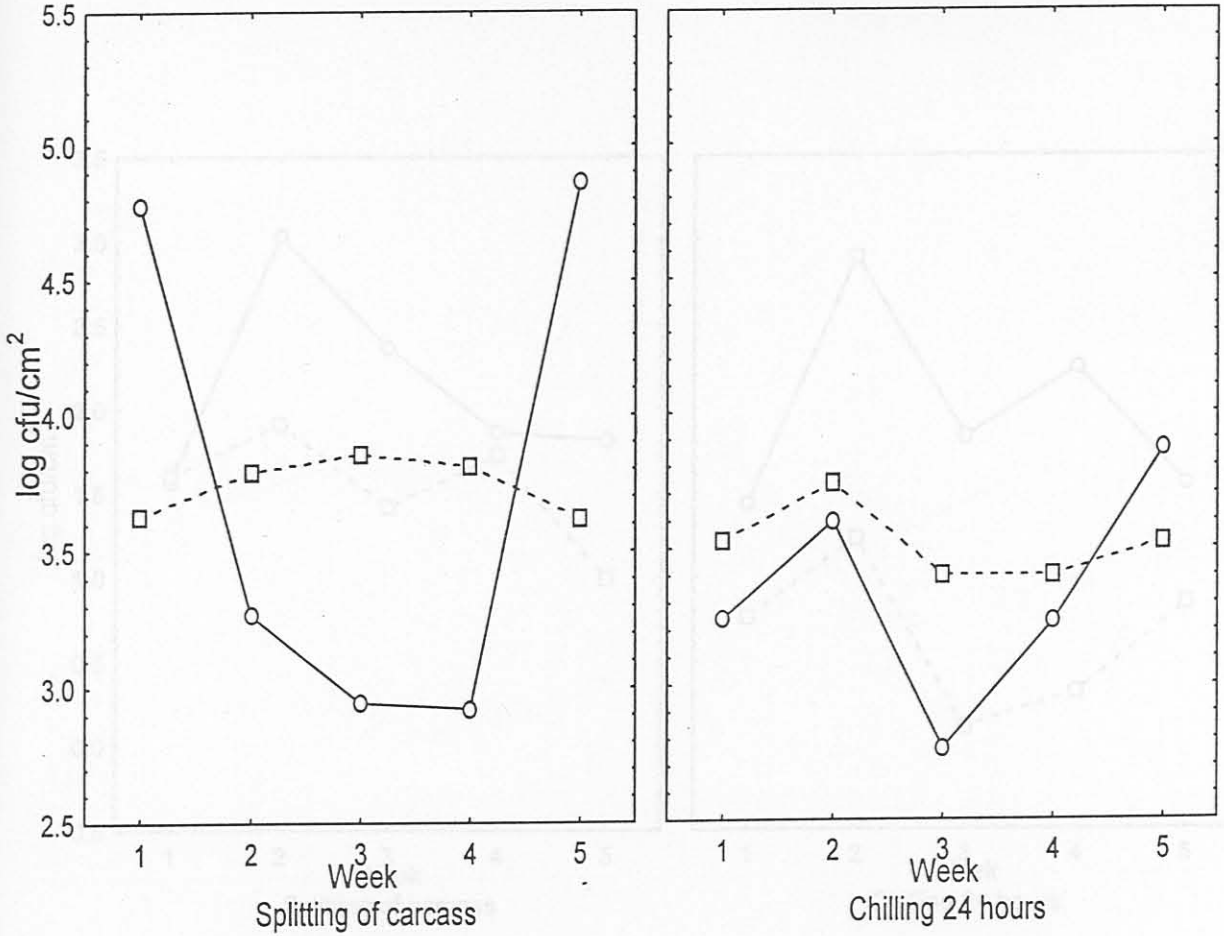


Figure 4.2: Effect of HACCP implementation (O = before training □ = after training) on *Staphylococcus aureus* counts (log₁₀cfu/cm²) at the carcass splitting step (p = 0.0001)

Figure 4.1: Effect of HACCP implementation (O = before training □ = after training) on aerobic plate counts (log₁₀cfu/cm²) at the carcass splitting step (p = 0.85) and after 24 hours chilling (p = 0.04).

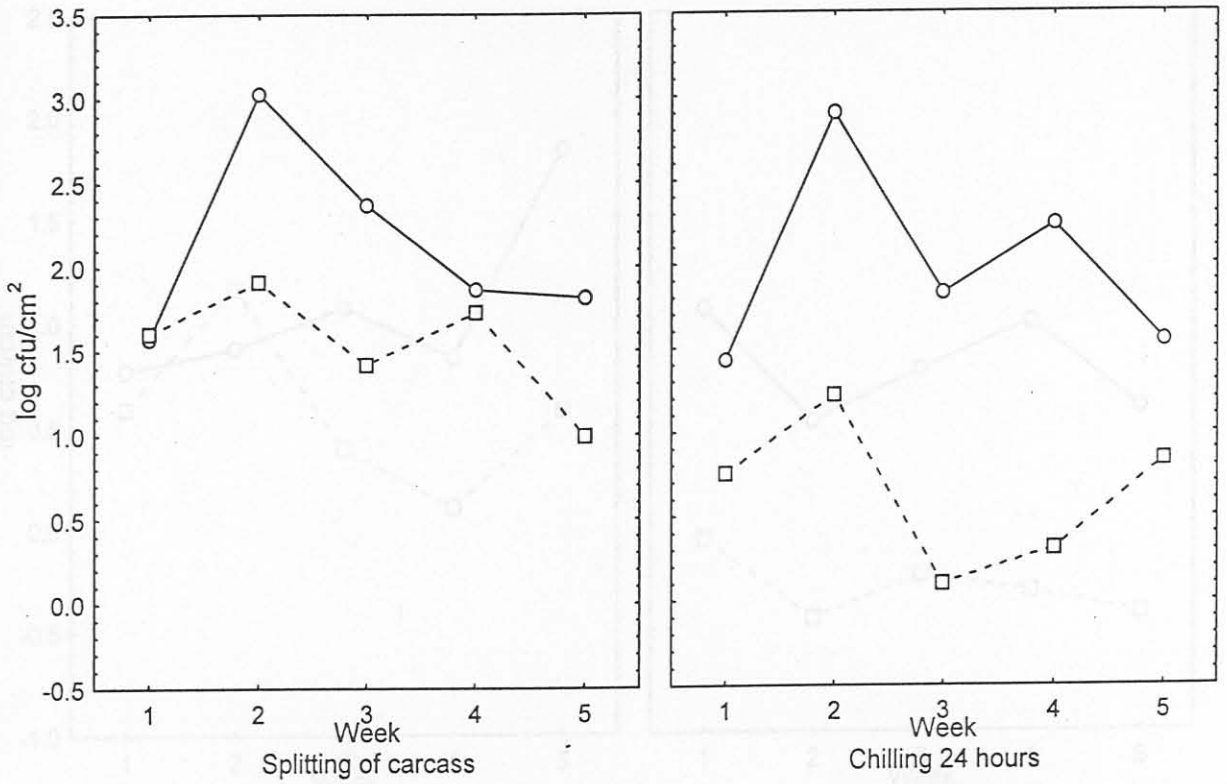


Figure 4.2: Effect of HACCP implementation (O = before training □ = after training) on *Staphylococcus aureus* counts ($\log_{10} \text{cfu/cm}^2$) at the carcass splitting step ($p = 0.0001$) and after 24 hours chilling ($p = 0.0001$).

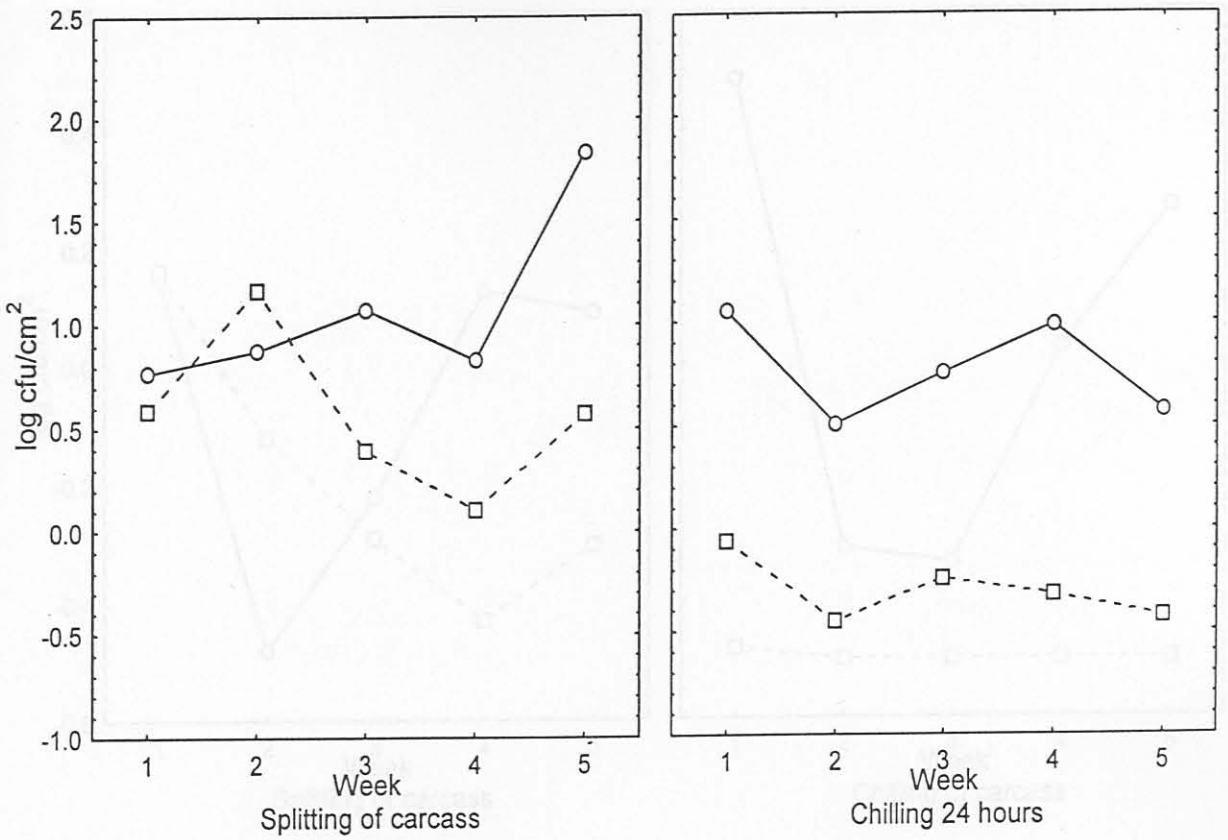


Figure 4.3: Effect of HACCP implementation (O = before training □ = after training) on total coliform counts ($\log_{10}\text{cfu}/\text{cm}^2$) at the carcass splitting step ($p = 0.0004$) and after 24 hours chilling ($p = 0.0001$).

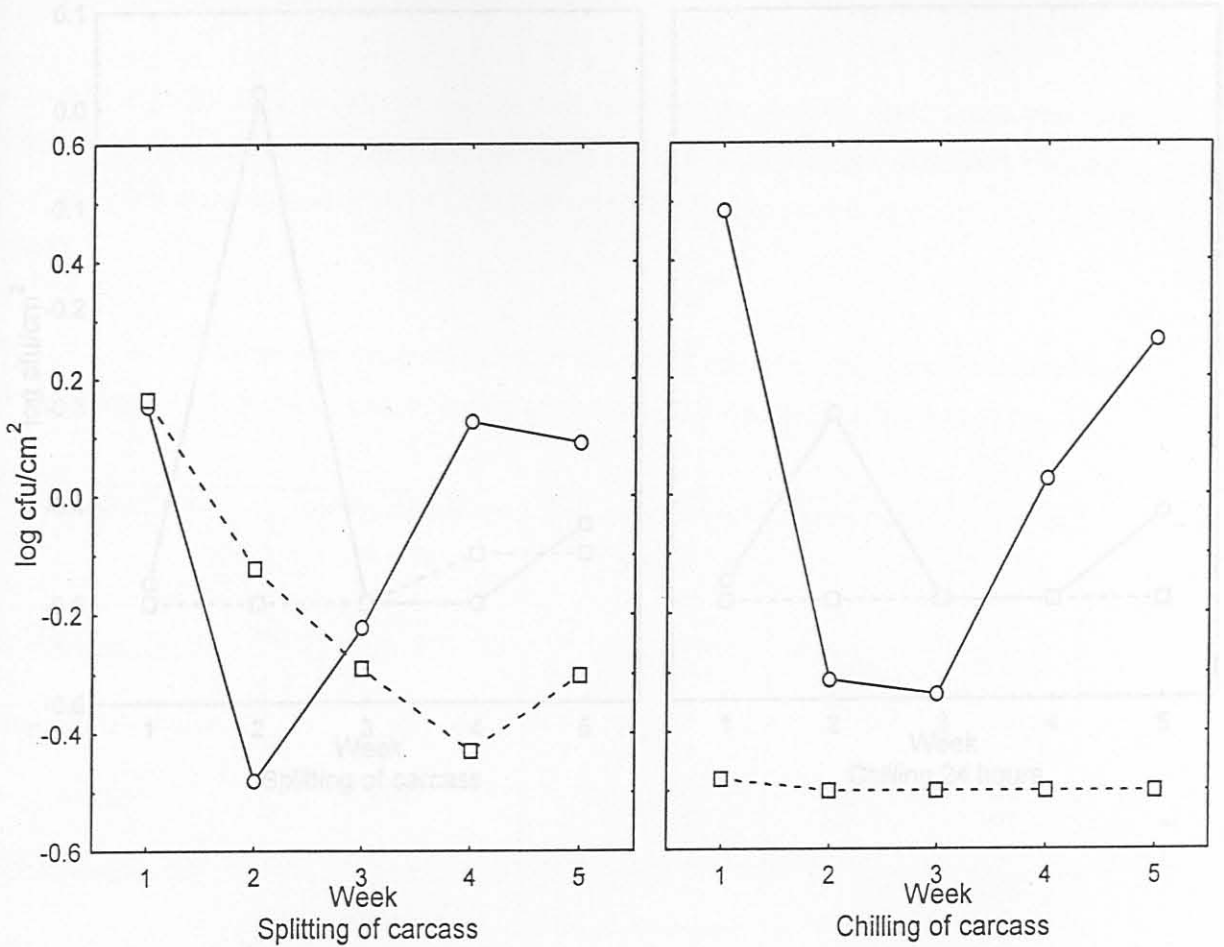


Figure 4.5: Effect of HACCP implementation (O = before training □ = after training) on *Clostridium perfringens* counts (\log_{10} cfu/cm²) at the carcass splitting step (p = 0.006) and Figure 4.4: Effect of HACCP implementation (O = before training □ = after training) on *Escherichia coli* counts (\log_{10} cfu/cm²) at the carcass splitting step (p = 0.214) and after 24 hours chilling (p = 0.0001).

4.2 EFFECT OF CHILLING ON MICROBIAL LOADS OF CARCASSES

An assessment was also done to determine if chilling had any significant effect on the carcass microbial loads for the baseline and after HACCP implementation. Temperatures of the carcasses, which had been stored in the chill rooms over a period of 24 hours for the baseline were in the range of 8-14 °C whereas those after HACCP implementation dropped to a range of 2-5 °C.

A significant reduction ($p < 0.05$) was achieved for aerobic plate count and total coliforms at the baseline as illustrated in Table 4.1. However, no significant reduction occurred for *Salmonella* spp., *Escherichia coli* and *Clostridium perfringens*, after 24 hours chilling.

Table 4.1: Mean baseline microbiological counts ($\log_{10} \text{cm}^{-2}$) on bovine carcasses before splitting of the carcasses and after 24 hours chilling at the baseline.

Microorganism	Splitting carcasses	Chilling 24 hours	P-value
Aerobic microorganisms	3.77*	3.51	0.01
Steph. aureus	3.10*	2.51	0.01
Total coliform	4.06*	3.07	0.07
<i>Escherichia coli</i>	0.43	0.44	0.97
<i>Clostridium perfringens</i>	0.43	0.44	0.01
<i>Salmonella</i>	2% of carcasses	0% of carcasses	0.11

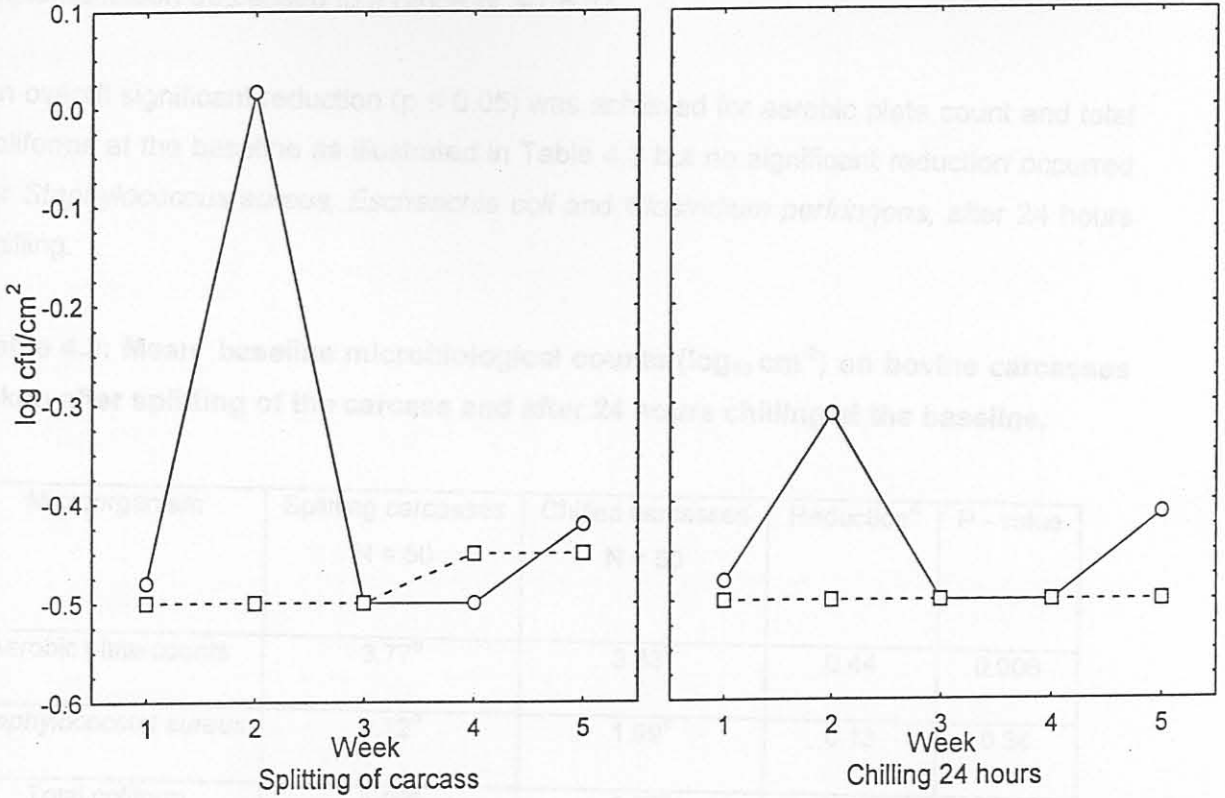


Figure 4.5: Effect of HACCP implementation (O = before training □ = after training) on *Clostridium perfringens* counts ($\log_{10} \text{cfu/cm}^2$) at the carcass splitting step ($p = 0.006$) and after 24 hours chilling ($p = 0.02$).

However, after HACCP implementation an overall significant reduction ($p < 0.05$) was achieved for all the pathogens except for the *Clostridium perfringens*. It should be

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An overall significant reduction ($p < 0.05$) was achieved for aerobic plate count and total coliforms at the baseline as illustrated in Table 4.3 but no significant reduction occurred for *Staphylococcus aureus*, *Escherichia coli* and *Clostridium perfringens*, after 24 hours chilling.

Table 4.3: Mean¹ baseline microbiological counts ($\log_{10} \text{cm}^{-2}$) on bovine carcasses taken after splitting of the carcass and after 24 hours chilling at the baseline.

Microorganism	Splitting carcasses N = 50	Chilled carcasses N = 50	Reduction ²	P - value
Aerobic plate counts	3.77 ^a	3.33 ^b	0.44	0.006
<i>Staphylococcus aureus</i>	2.12 ^b	1.99 ^b	0.13	0.34
Total coliform	1.08 ^a	0.77 ^b	0.31	0.01
<i>Escherichia coli</i>	-0.06 ^a (64% of carcasses)	0.01 ^a (62% of carcasses)	-0.07	0.47
<i>Clostridium perfringens</i> ,	-0.43 ^a (28% of carcasses)	-0.44 ^a (14% of carcasses)	0.01	0.11
<i>Salmonella</i>	2% of carcasses	0% of carcasses		

¹Means within rows with different superscripts are significantly different ($p < 0.05$)

²Reduction = $\log_{10} \text{cfu/cm}^2$ splitting step - $\log_{10} \text{cfu/cm}^2$ 24 hours chilling.

However, after HACCP implementation an overall significant reduction ($p < 0.05$) was achieved for all the pathogens except for the *Clostridium perfringens*. It should be

noted, however, that no *Clostridium perfringens*, was found in any of the samples after HACCP implementation. The mean log results for each specific pathogen at the baseline and after HACCP implementation are indicated in Table 4.4.

Table 4.4: Mean¹ microbiological counts (log₁₀ cm⁻²) on bovine carcasses taken after splitting of the carcass and after 24 hours chilling after HACCP implementation.

Microorganism	Splitting carcasses N = 50	Chilled carcasses N = 50	Reduction ²	P - value
Aerobic plate counts	3.77 ^a	3.52 ^b	0.25	0.003
<i>Staphylococcus aureus</i>	1.53 ^a	0.64 ^b	0.89	0.0001
Total coliform	0.56 ^a	-0.30 ^b	0.86	0.0001
<i>Escherichia coli</i>	-0.20 ^a (40% of carcasses)	-0.50 ^b (2% of carcasses)	0.7	0.0001
<i>Clostridium perfringens</i> ,	-0.48 ^b (4% of carcasses)	-0.50 ^b (0% of carcasses)	0.02	0.16
<i>Salmonella</i>	0%	0%		

¹Means within rows with different superscripts are significantly different (p<0.05)

²Reduction = log₁₀cfu/cm² splitting step - log₁₀cfu/cm² 24 hours chilling.

From the results obtained it is noted that chilling reduced the aerobic plate counts significantly both at the baseline and after HACCP as illustrated in Figure 4.6. *Staphylococcus aureus* was however, not reduced by chilling at baseline but a significant reduction was noted after HACCP implementation as illustrated in Figure 4.7. For total coliforms a significant reduction was achieved at both the baseline and after HACCP implementation. The levels at the baseline were reduced from 1.08 to 0.77 log₁₀cfu/cm² after 24 hours chilling at the splitting step, while those after HACCP implementation were reduced from 0.56 at the splitting step to a mean log₁₀cfu/cm² of -

0.30 after chilling as illustrated in Figure 4.8. A significant reduction of approximately 1 log cycle for *Escherichia coli* counts was achieved after HACCP implementation at the chilling phase whereas data at the baseline recorded an increase of 0.07 log₁₀cm² as illustrated in Figure 4.9. Generally, *Clostridium perfringens*, was detected in very few carcasses with 0% detections after HACCP implementation and 14% detection at the baseline in the chilling step (Figure 4.10). *Salmonella* was not isolated from any of the carcasses after chilling both at the baseline and after HACCP implementation.



Figure 4.8: Effects of chilling (O = after splitting, □ = 24 hours chilling) on aerobic plate counts (log₁₀ cfu/cm²) before (p = 0.006) and after training (p = 0.003).

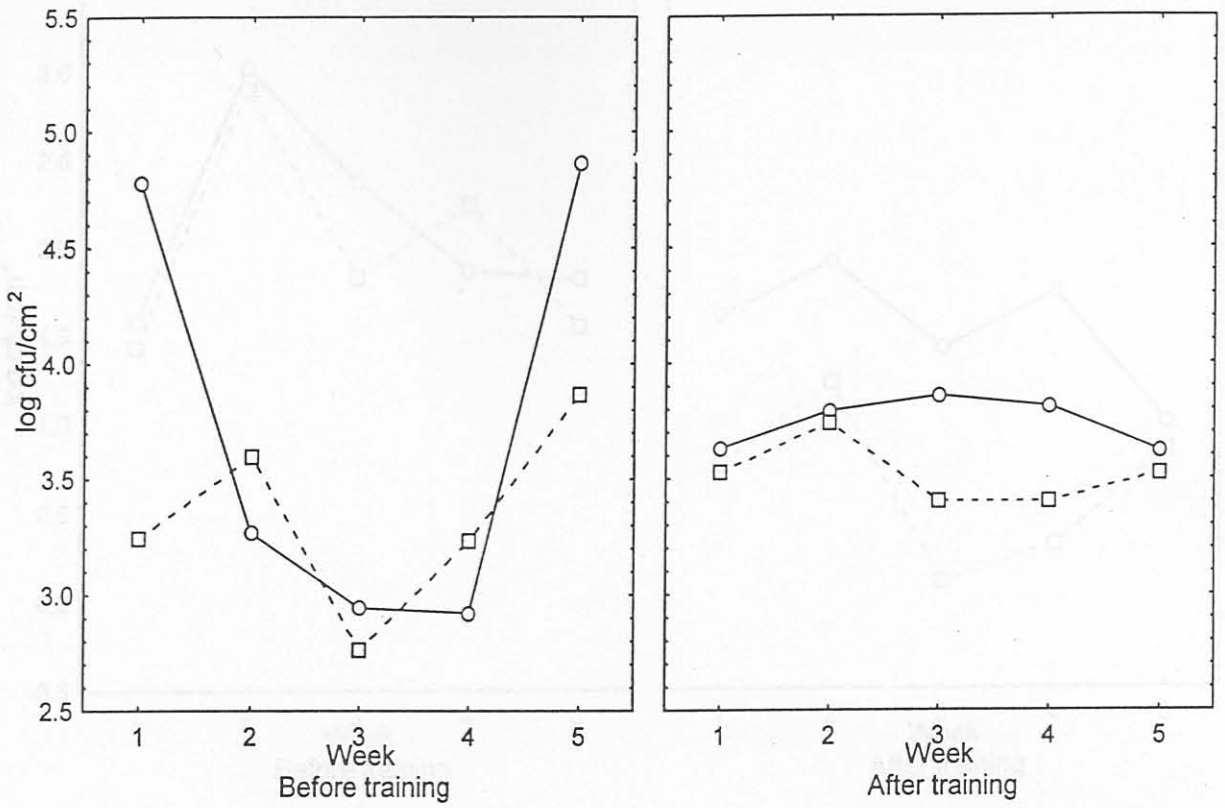


Figure 4.6: Effect of chilling (O = after splitting, □ = 24 hours chilling) on aerobic plate counts ($\log_{10}\text{cfu/cm}^2$) before ($p = 0.006$) and after training ($p = 0.003$).

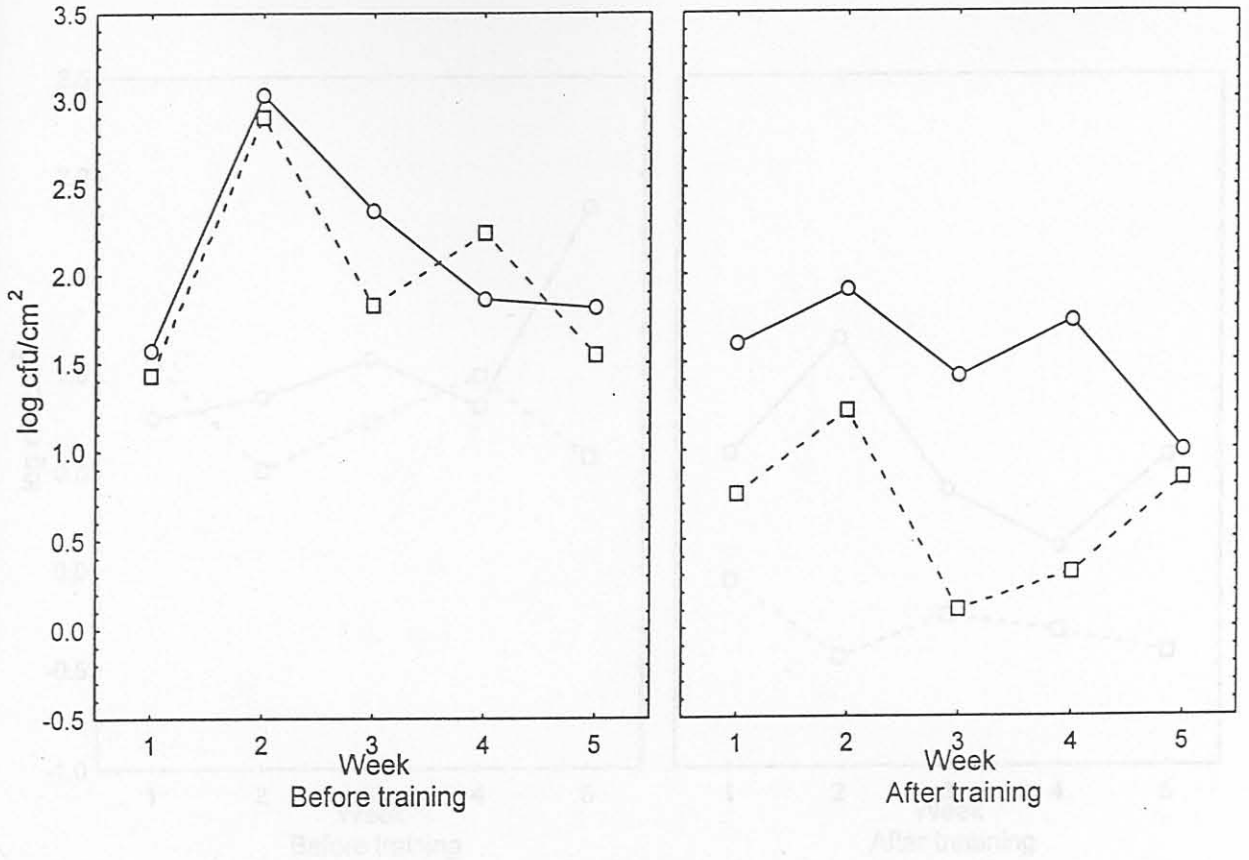


Figure 4.7: Effect of chilling (O = after splitting, □ = 24 hours chilling) on *Staphylococcus* counts (\log_{10} cfu/cm²) before ($p = 0.34$) and after training ($p = 0.0001$).

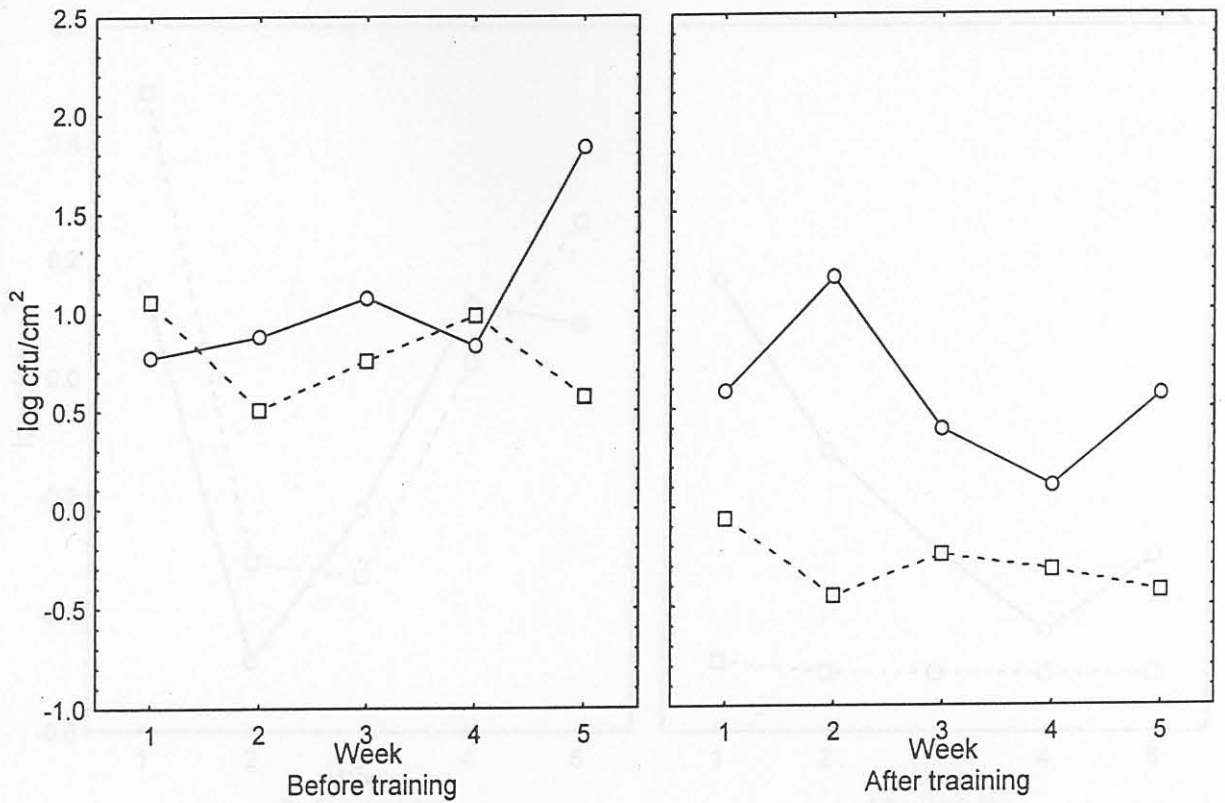


Figure 4.8: Effect of chilling (O = after splitting, □ = 24 hours chilling) on total coliform counts ($\log_{10}\text{cfu}/\text{cm}^2$) before ($p = 0.01$) and after training ($p = 0.0001$).

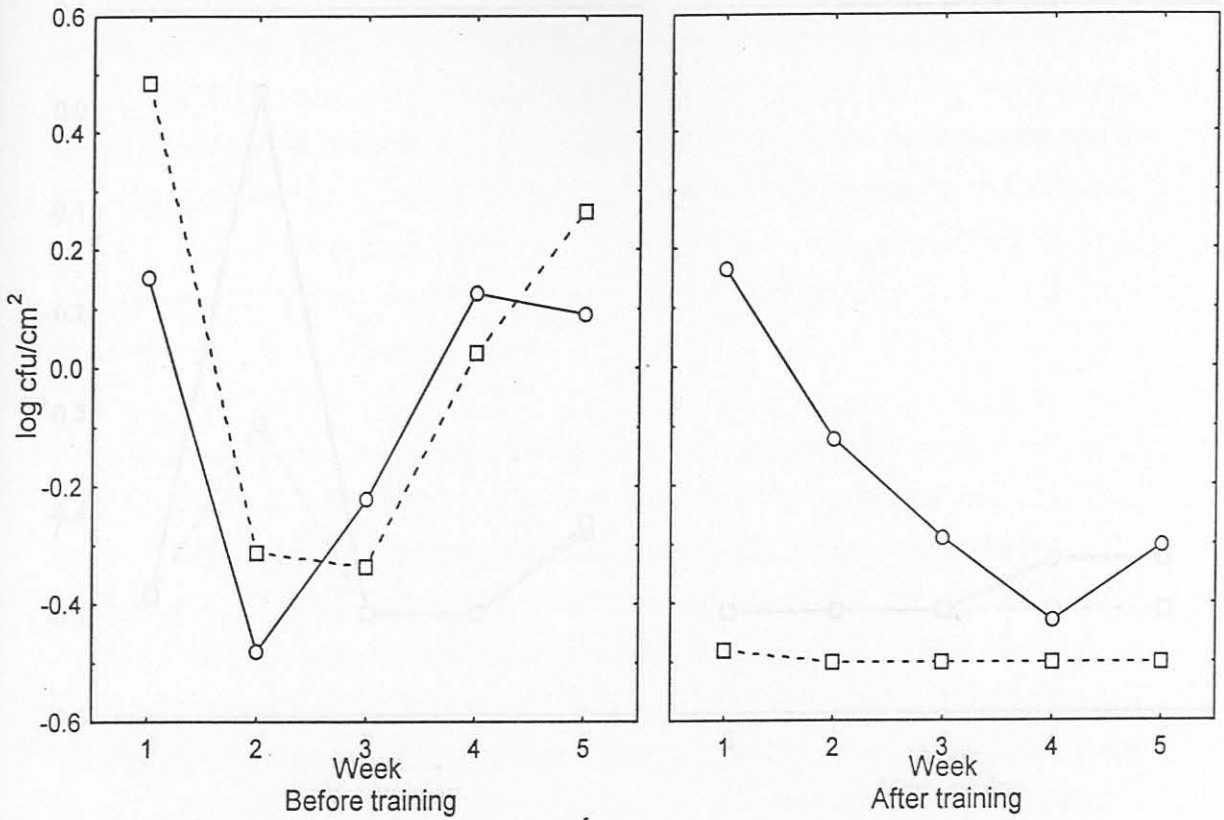


Figure 4.9: Effect of chilling (O = after splitting, □ = 24 hours chilling) on *Escherichia coli* counts ($\log_{10}\text{cfu}/\text{cm}^2$) before ($p = 0.47$) and after training ($p = 0.0001$).

CHAPTER 3

DISCUSSION

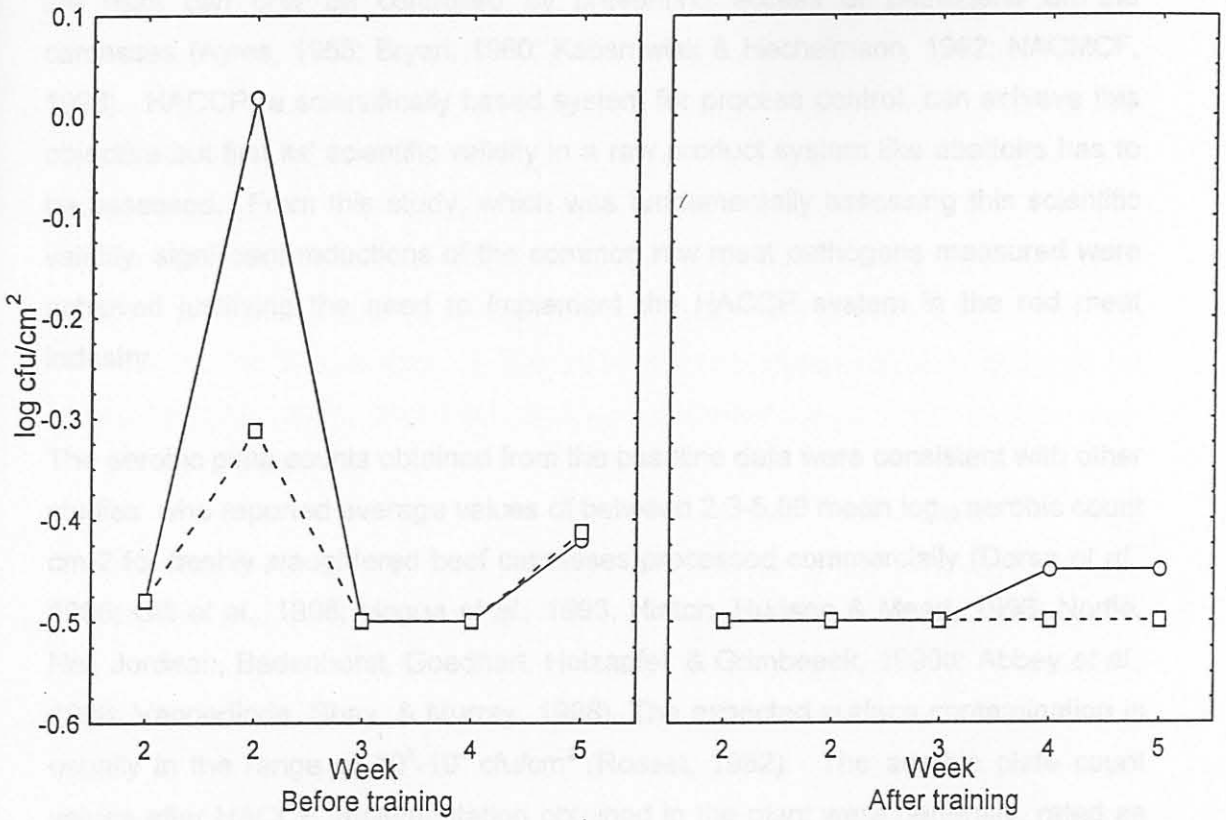


Figure 4.10: Effect of chilling (O = after splitting, □ = 24 hours chilling) on *Clostridium perfringens* counts ($\log_{10}\text{cfu}/\text{cm}^2$) before ($p = 0.11$) and after training ($p = 0.16$).