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Microbiological risk factors associated with the domestic handling of meat: contamination of typical kitchen surfaces

2003

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Microbiological risk factors associated with the domestic handling of meat: contamination of typical kitchen surfaces

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2003

SUMMARY

There has been a steady increase in reported food poisoning cases from 70,130 in 1993 (CDR, 1996) to 86,316 in 1999 (CDR, 2000). It is also suggested that up to 15% of these cases originated in the home (Dijuretic, 1996).

Raw meat and poultry may act as a source of *Salmonella* and *Campylobacter* which are common causes of food poisoning. Other pathogenic bacteria, such as some *Escherichia coli* strains, may also be present in raw meat.

This study was carried out in two parts. The aim of the first part was to assess the extent and persistence of contamination transferred from pieces of raw meat placed on various typical kitchen surfaces.

Chopping boards made of plastic, hardwood (rubber tree), glass, a laminate surface and stainless steel (foodgrade) were used in the trial. The following meat types were used in this trial:

Chicken breast fillets (skin off)
Beef joint (topside/top rump)
Lamb joint (leg, bone present)
Pork joint (leg, bone present)

Separate pieces (x 5) of each meat type were placed on squares of each surface type, left for one minute, and the Total Viable Count (TVC) and Enterobacteriaceae levels enumerated using the swabbing technique for up to 48h.

The results indicate that the differences in the TVC level on the different chopping board surfaces were not statistically significant. However, it was found that there was a difference between the TVC and Enterobacteriaceae levels between the various meat types. Lamb and chicken appeared to transfer higher levels of bacteria, but this may be due to higher initial contamination levels. It was also demonstrated that the TVC and Enterobacteriaceae levels decreased over time; however, TVC levels of 10^2 - 10^3 cfu/25 cm^2 still persisted after 48h.

The aim of the second part of the trial was to assess the persistence of pathogens in a meat juice inoculated onto various typical kitchen surfaces. Surfaces made of plastic, hardwood (rubber tree), glass, a laminate bench surface and stainless steel (foodgrade) were used in the trial.

Studies to evaluate the persistence of bacterial pathogens involved inoculating either *Salmonella*, *E. coli* O157 or *Campylobacter* in the meat juice onto the surfaces, which were then swabbed at time 0, 4, 24 and 48 h in order to enumerate the levels of the respective pathogens.

The results indicated that there was little difference between persistence of *Salmonella* or *E. coli* O157 on each surface type and that the surface type was not statistically significant. There was, however, a 2-3 log decline over 48 h of both *Salmonella* and *E. coli* O157, but a high level of both organisms (10^3 cfu/4 cm^2) still survived on the surfaces for at least 48 h. *Campylobacter* was not able to survive the first four hours on any surface tested.

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1. INTRODUCTION

1.1 Background

There has been a steady increase in reported food poisoning cases from 70,130 in 1993 (CDR, 1996) to 86,316 in 1999 (CDR, 2000). It is also suggested that up to 15% of these cases originate in the home (Dijuretic, 1996).

Raw meat and poultry may act as a source of *Salmonella* and *Campylobacter* which are common causes of food poisoning. Other pathogenic bacteria, such as some *Escherichia coli* strains, may also be present in raw meat.

A study by Worsfold and Griffith (1997) indicated that many people do not consider the domestic environment to be a place with a high risk of food poisoning and feel that the responsibility of lowering the risks of food poisoning is an issue for food manufacturers and/or restaurants to address. Therefore, the implications of incorrect handling of raw meat may not be apparent to the consumers and risks may be increased. This was also demonstrated by Newsholme (2002) who found that in a consumer survey, 67% of consumers rated their own kitchen practices to be hygienic, with 47% of consumers rating themselves better than commercial kitchens.

There have been relatively few studies into the domestic handling of raw meat, although it has been shown that hazardous food handling behaviours are prevalent in the home. A study by Worsfold and Griffith (1997) identified that the major causes of cross contamination in domestic food preparation included insufficient segregation of raw and cooked food, poor personal hygiene and poor food handling techniques. This was also demonstrated in qualitative research by Newsholme (2001). In order to quantify consumer attitudes, a survey was undertaken (Newsholme 2002) which found that 11% of consumers stored raw and cooked meat together.

Further work is required to identify, quantify and verify these food safety risks within the domestic environment in order to reduce domestic incidences of food poisoning.

1.2 Aim

To assess the nature, extent and persistence of naturally present bacterial contamination when various cuts of raw meat are placed on numerous typical kitchen surfaces.

1.3 Scope

This report constitutes the fifth phase of the FSA funded project: Microbiological risk factors associated with the domestic handling of meats. The first qualitative phase identified consumer practices (Newsholme, 2001); in the second phase they were quantitatively addressed (Newsholme, 2002). The third phase assessed the nature, extent and persistence of cross contamination when various consumers prepared meat-containing dishes (Newsholme

et al, 2002). The fourth phase assessed the sequential transfer of bacteria when various meat cuts were repeatedly placed on clean surfaces. This phase is concerned with assessing the contamination of typical kitchen surfaces via raw meat and the persistence of natural meat microflora and pathogens on these surfaces.

PART I

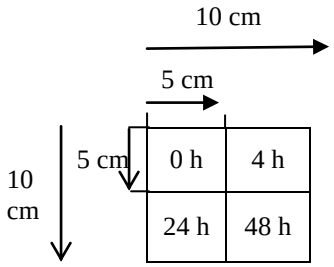
CONTAMINATION OF TYPICAL KITCHEN SURFACES VIA RAW MEAT

2. METHODS

2.1 Surfaces

Chopping boards made of plastic (no antimicrobials present), hard wood (rubber tree) glass and a laminate surface and stainless steel (foodgrade) were used in the trial. All surfaces used were new and not damaged.

Each surface had six 10 by 10 cm squares marked out, with sufficient space between each square to prevent an overlap of the meat onto neighbouring squares. Each square was further divided into four 5 by 5 cm squares in order to allow swabs to be taken at four different time points: 0, 4, 24 and 48 h.



Prior to the start of each trial, each surface was cleaned using a hypochlorite based disinfectant (2,500 ppm). The residual hypochlorite was quenched using Universal Quenching Agent (UQA: Maximum Recovery Diluent containing 3 g sodium thiosulphate, 3 Tween 80 and 3 g of lecithin per litre).

The surfaces were then sprayed with alcohol (70% v/v) which was allowed to evaporate to dryness.

2.2 Meat types

The following meat types were used in this trial:

Chicken breast fillets (skin off)
Beef joint (topside/top rump)
Lamb joint (leg, bone present)
Pork joint (leg, bone present)

The meat was purchased from a local supermarket.

2.3 **Surface contamination**

Separate pieces (x 5) of each meat type were placed on squares of each surface type and left for one minute. Each meat piece was numbered 1 to 5, as was each square of the surface types. Each meat piece was placed on the corresponding numbered square on each surface type. In order to ensure that meat pieces were sequentially placed on the surfaces in a random order, the following sequence (Latin squares technique) was used:

Meat	**Order of Placement**				
1	Glass	Wood	Plastic	Laminate	Steel
2	Wood	Glass	Steel	Plastic	Laminate
3	Plastic	Laminate	Glass	Steel	Wood
4	Laminate	Steel	Wood	Glass	Plastic
5	Steel	Plastic	Laminate	Wood	Glass

2.4 **Sampling**

After each meat piece had been placed on the relevant square, left for one minute and removed, the Total Viable Count (TVC) and Enterobacteriaceae levels were enumerated using the swabbing technique.

A Sterilin cotton tipped swab was dampened in 10 ml UQA. The corresponding area (25 cm^2) was swabbed and the swab placed in the UQA. The UQA was then vortexed for 15 seconds prior to sampling.

A blank square for each surface type was also swabbed at each time point and also prior to the start of the trial.

The TVC was enumerated by using the 1 ml pour plate technique with Plate Count Agar (PCA LabM Lab 149). The plates were incubated at 30°C for 2 days, after which time all resultant colonies were counted.

The Enterobacteriaceae level was enumerated using the 1 ml pour plate technique with Violet Red Bile Glucose Agar (VRBGA Oxoid CM 485). Once set, the plates were overlayed. The plates were incubated at 37°C for one day, after which time all typical colonies were counted.

Excision samples were also taken of each meat piece used. Small samples (2 x 2.5 cm) of meat were removed using a sterile scalpel and placed in 10 ml (Maximal Recovery Diluent, LabM Lab02705 [MRD]) and vortexed. The TVC and Enterobacteriaceae levels were then enumerated using the techniques noted above.

2.5 **Statistical analysis**

The data was analysed using Analysis of Variance (ANOVA), the general linear model function in Minitab. A value of less than 0.001 indicated a 99.9% (***) statistically significant difference, 0.01 a 99% (**) statistically significant difference and 0.05 a 95% (*) statistically significant difference. The TVC data only was analysed as only low levels of Enterobacteriaceae were present.

3. RESULTS

3.1 **Beef joint**

The results are given in Table 2. For each meat piece, the Enterobacteriaceae level was generally <10 cfu/25 cm^2. With respect to the TVC level, there were differences between meat pieces with the initial levels ranging from 10^2 to 10^4 cfu/25 cm^2.

The TVC level for each meat piece/surface combination also decreased over time. This decrease was between 1 and 2 log units.

There appeared to be little difference in TVC levels between surfaces for a particular meat piece. The main effects plot (Figure 1) illustrate these differences.

3.1.1 Statistical analysis

The ANOVA results were as follows:

Table 1: Statistical analysis results

	P value	**Significance**
Surface	0.959	N/S
Meat piece	0.000	***
Order	0.005	**
Time	0.000	***
Surface x time	0.621	N/S
Meat piece x time	0.025	*
Order x time	0.448	N/S

As can be seen (in Table 1), the differences between meat pieces, time and order of surface placement were statistically significant.

Table 2: Beef joint results

Time (h)	Surface	Meat Piece	Enterobacteriaceae cfu/25 cm^2	TVC cfu/25 cm^2
0	Laminate	1	<10	3.0E+03
4	Laminate	1	<10	30
24	Laminate	1	<10	<10
48	Laminate	1	<10	10
0	Glass	1	<10	2.8E+03
4	Glass	1	<10	190
24	Glass	1	<10	260
48	Glass	1	<10	220
0	Plastic	1	<10	6.1E+03
4	Plastic	1	<10	<10
24	Plastic	1	<10	10
48	Plastic	1	<10	170
0	Steel	1	<10	1.0E+03
4	Steel	1	<10	70
24	Steel	1	<10	<10
48	Steel	1	<10	20
0	Wood	1	<10	2.8E+03
4	Wood	1	<10	<10
24	Wood	1	<10	10
48	Wood	1	<10	60
0	Laminate	2	<10	410
4	Laminate	2	<10	120
24	Laminate	2	<10	20
48	Laminate	2	<10	60
0	Glass	2	<10	360
4	Glass	2	<10	50
24	Glass	2	<10	30
48	Glass	2	<10	20
0	Plastic	2	<10	600
4	Plastic	2	<10	80
24	Plastic	2	<10	50
48	Plastic	2	<10	20

Table 2: Beef joint results (continued)

Time (h)	Surface	Meat Piece	Enterobacteriaceae cfu/25 cm^2	TVC cfu/25 cm^2
0	Steel	2	<10	1.1E+03
4	Steel	2	<10	130
24	Steel	2	<10	10
48	Steel	2	<10	20
0	Wood	2	<10	360
4	Wood	2	<10	130
24	Wood	2	<10	920
48	Wood	2	<10	40
0	Laminate	3	<10	1.0E+03
4	Laminate	3	<10	110
24	Laminate	3	<10	10
48	Laminate	3	<10	<10
0	Glass	3	<10	80
4	Glass	3	<10	<10
24	Glass	3	<10	10
48	Glass	3	<10	30
0	Plastic	3	<10	60
4	Plastic	3	<10	90
24	Plastic	3	<10	20
48	Plastic	3	<10	50
0	Steel	3	<10	40
4	Steel	3	<10	30
24	Steel	3	<10	20
48	Steel	3	<10	30
0	Wood	3	<10	80
4	Wood	3	<10	30
24	Wood	3	<10	<10
48	Wood	3	<10	<10
0	Laminate	4	<10	1.5E+03
4	Laminate	4	<10	450
24	Laminate	4	<10	1.4E+03
48	Laminate	4	<10	260

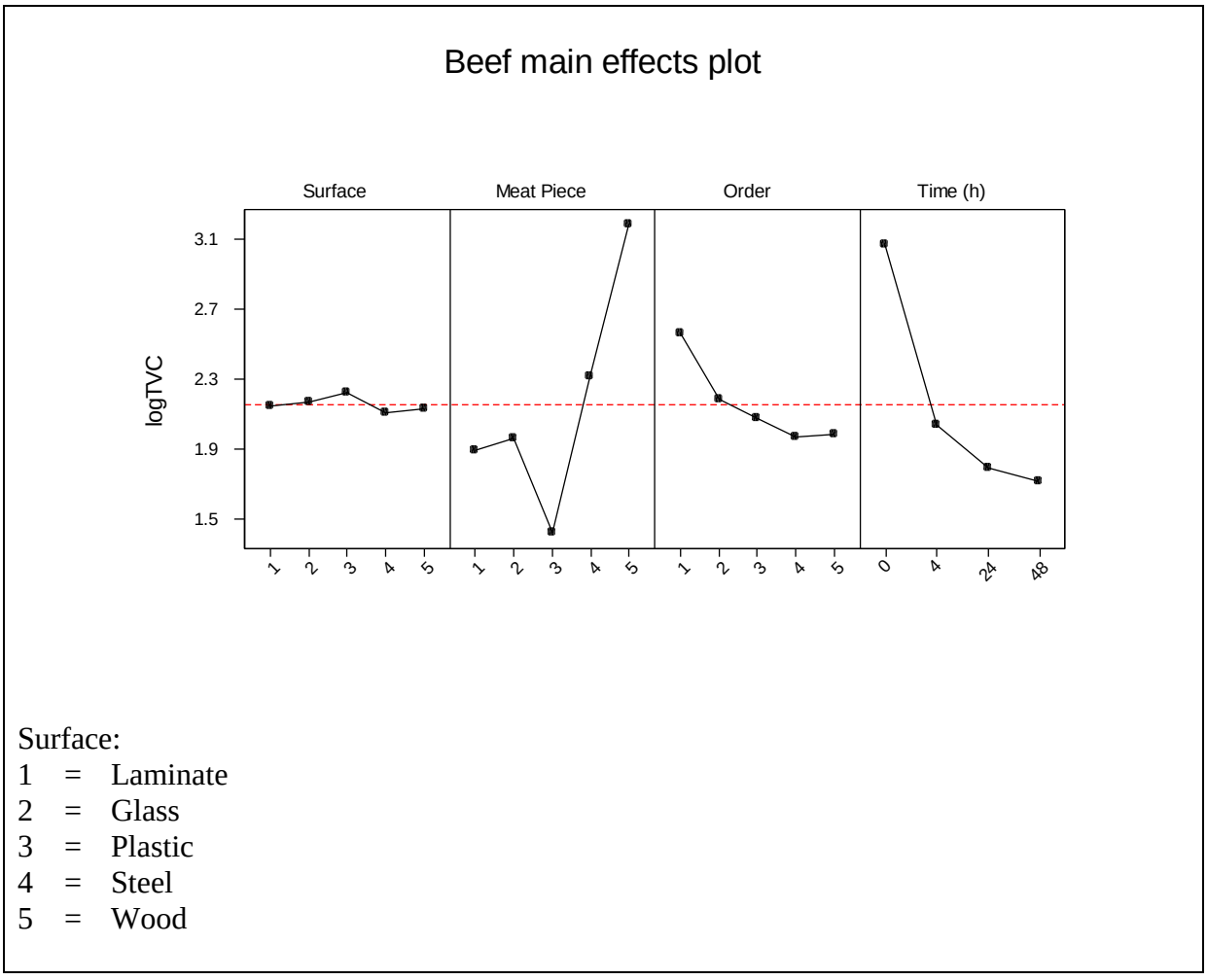
Table 2: Beef joint results (continued)

Time (h)	Surface	Meat Piece	Enterobacteriaceae cfu/25 cm^2	TVC cfu/25 cm^2
0	Glass	4	<10	490
4	Glass	4	<10	30
24	Glass	4	<10	60
48	Glass	4	<10	20
0	Plastic	4	<10	920
4	Plastic	4	<10	620
24	Plastic	4	<10	110
48	Plastic	4	<10	10
0	Steel	4	10	1.7E+03
4	Steel	4	<10	80
24	Steel	4	<10	40
48	Steel	4	<10	100
0	Wood	4	10	490
4	Wood	4	<10	1.7E+03
24	Wood	4	<10	240
48	Wood	4	<10	70
0	Laminate	5	<10	5.6E+03
4	Laminate	5	<10	1.0E+03
24	Laminate	5	<10	560
48	Laminate	5	<10	110
0	Glass	5	20	3.1E+04
4	Glass	5	<10	290
24	Glass	5	<10	3.3E+03
48	Glass	5	<10	300
0	Plastic	5	<10	1.2E+04
4	Plastic	5	<10	7.4E+03
24	Plastic	5	<10	1.9E+03
48	Plastic	5	<10	340
0	Steel	5	<10	2.4E+04
4	Steel	5	<10	790
24	Steel	5	<10	830

Table 2: Beef joint results (continued)

Time (h)	Surface	Meat Piece	Enterobacteriaceae cfu/25 cm^2	TVC cfu/25 cm^2
48	Steel	5	<10	
0	Wood	5	<10	3.2E+04
4	Wood	5	<10	630
48	Wood	5	<10	250

Figure 1



Surface:
1 = Laminate
2 = Glass
3 = Plastic
4 = Steel
5 = Wood

3.2 **Chicken breast fillets**

The results of this trial are given in Table 4. As can be seen for each meat piece, the Enterobacteriaceae level was lower than that of the TVC level and decreased during the storage trial in most cases to <10 cfu/25 cm^2.

With respect to individual meat pieces, meat piece 5 had a higher level of TVC and Enterobacteriaceae than the other meat pieces. The TVC levels were initially 10^4 - 10^6 cfu/25 cm^2.

There appeared to be only slight differences between each of the surfaces. However, there was a difference in both Enterobacteriaceae and TVC level throughout the sampling period. In some instances there was a 4 log decrease in TVC level.

These differences in TVC or Enterobacteriaceae level are illustrated in Figure 2.

3.2.1 Statistical analysis

The statistical analysis results are given below:

Table 3: Statistical analysis results

	P value	**Significance**
Surface	0.150	N/S
Meat piece	0.000	***
Order	0.041	*
Time	0.000	***
Surface x time	0.426	N/S
Meat piece x time	0.837	N/S
Order x time	0.607	N/S

The P values illustrate that the only statistically significant differences were the differences in TVC between meat pieces, order of placement of meat and time.

Table 4: Chicken fillet results

Time (h)	Surface	Meat Piece	Enterobacteriaceae cfu/25 cm^2	TVC cfu/25 cm^2
0	Laminate	1	540	3.1E+05
4	Laminate	1	<10	2.2E+03
24	Laminate	1	<10	450
48	Laminate	1	<10	30
0	Glass	1	4.5E+03	>1E+06
4	Glass	1	10	7.6E+03
24	Glass	1	<10	1.3E+04
48	Glass	1	<10	150
0	Plastic	1	1.0E+03	3.8E+05
4	Plastic	1	10	6.6E+03
24	Plastic	1	<10	5.1E+03
48	Plastic	1	<10	50
0	Steel	1	<10	<10
4	Steel	1	<10	2.5E+03
24	Steel	1	<10	990
48	Steel	1	NT	10
0	Wood	1	960	3.7E+05
4	Wood	1	<10	3.5E+04
24	Wood	1	<10	2.9E+03
48	Wood	1	<10	50
0	Laminate	2	70	4.4E+04
4	Laminate	2	<10	7.4E+03
24	Laminate	2	<10	560
48	Laminate	2	<10	20
0	Glass	2	600	1.6E+05
4	Glass	2	<10	7.4E+04
24	Glass	2	<10	2.1E+03
48	Glass	2	<10	590
0	Plastic	2	500	2.7E+05
4	Plastic	2	10	6.2E+04
24	Plastic	2	<10	1.3E+04
48	Plastic	2	<10	290
0	Steel	2	10	7.4E+04
4	Steel	2	<10	6.3E+04
24	Steel	2	<10	3.7E+03
48	Steel	2	NT	460
0	Wood	2	150	1.9E+05
4	Wood	2	20	1.2E+05
24	Wood	2	<10	3.6E+03

NT = not tested

Table 4: Chicken fillet results (continued)

Time (h)	Surface	Meat Piece	Enterobacteriaceae cfu/25 cm^2	TVC cfu/25 cm^2
48	Wood	2	<10	920
0	Laminate	3	6.0E+03	4.8E+05
4	Laminate	3	<10	6.6E+03
24	Laminate	3	<10	1.3E+04
48	Laminate	3	<10	50
0	Glass	3	390	2.5E+05
4	Glass	3	<10	4.0E+03
24	Glass	3	<10	2.2E+03
48	Glass	3	<10	170
0	Plastic	3	9.3E+03	>1E+06
4	Plastic	3	10	3.5E+04
24	Plastic	3	<10	5.8E+03
48	Plastic	3	<10	410
0	Steel	3	240	1.6E+05
4	Steel	3	<10	4.5E+03
24	Steel	3	<10	490
48	Steel	3	NT	30
0	Wood	3	1.7E+03	2.2E+05
4	Wood	3	<10	4.7E+04
24	Wood	3	<10	610
48	Wood	3	<10	20
0	Laminate	4	670	4.9E+05
4	Laminate	4	<10	7.4E+04
24	Laminate	4	<10	9.9E+03
48	Laminate	4	<10	490
0	Glass	4	20	6.3E+04
4	Glass	4	<10	4.8E+04
24	Glass	4	<10	1.8E+04
48	Glass	4	<10	1.5E+03
0	Plastic	4	60	2.1E+05
4	Plastic	4	10	50
24	Plastic	4	<10	1.1E+05
48	Plastic	4	<10	600
0	Steel	4	630	2.6E+05
4	Steel	4	<10	3.7E+04
24	Steel	4	<10	1.9E+05
48	Steel	4	NT	330
0	Wood	4	160	2.4E+05
4	Wood	4	<10	6.7E+04
24	Wood	4	<10	4.2E+03

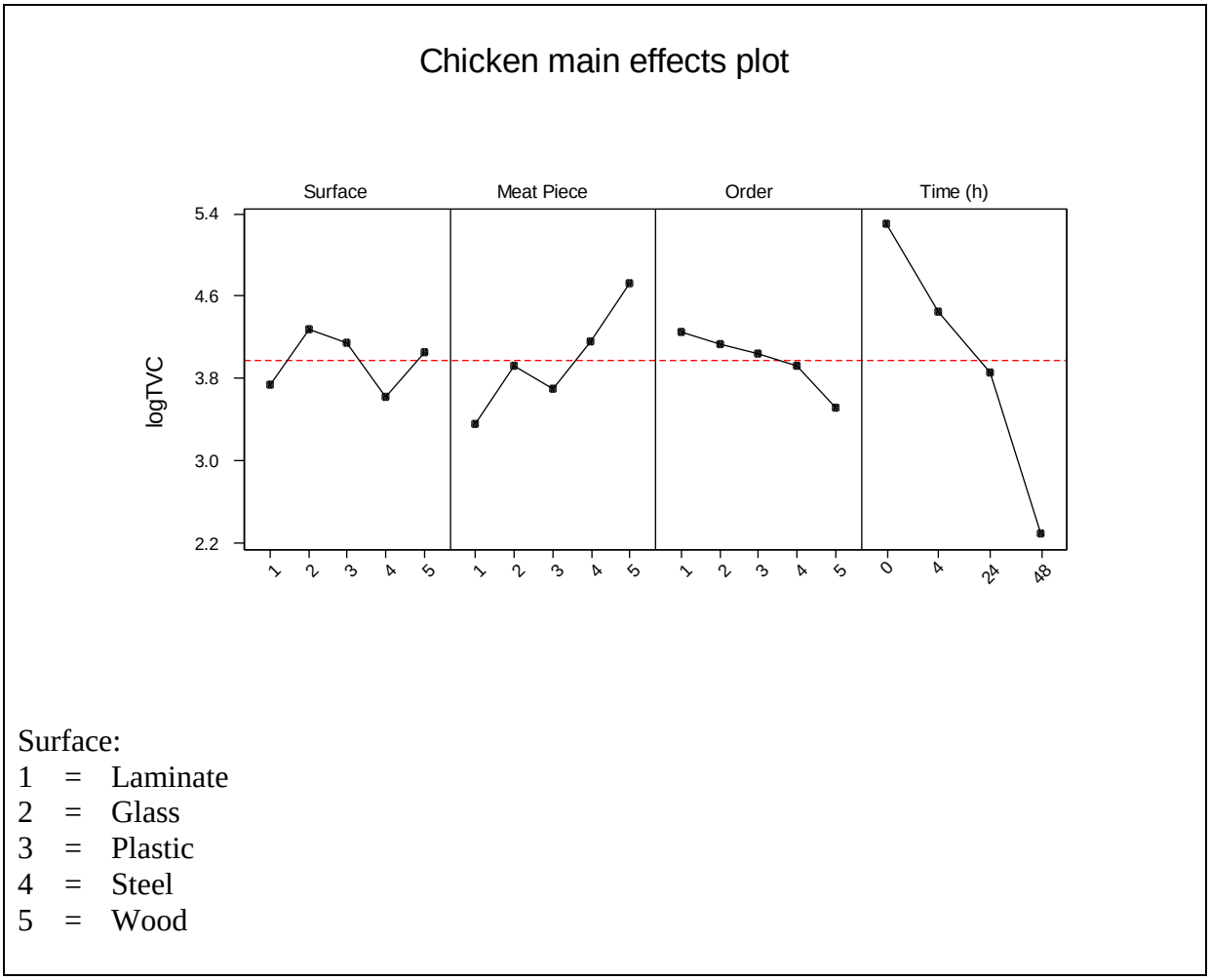
NT = not tested

Table 4: Chicken fillet results (continued)

Time (h)	Surface	Meat Piece	Enterobacteriaceae cfu/25 cm^2	TVC cfu/25 cm^2
48	Wood	4	<10	290
0	Laminate	5	5.8E+04	>1E+06
4	Laminate	5	3.5E+03	>1E+06
24	Laminate	5	360	3.1E+04
48	Laminate	5	<10	480
0	Glass	5	5.2E+03	5.5E+05
4	Glass	5	210	2.2E+05
24	Glass	5	10	2.1E+05
48	Glass	5	<10	770
0	Plastic	5	4.7E+04	>1E+06
4	Plastic	5	10	1.6E+05
24	Plastic	5	2.2E+03	2.4E+05
48	Plastic	5	<10	930
0	Steel	5	2.8E+04	>1E+06
4	Steel	5	8.5E+03	>1E+06
24	Steel	5	<10	>1E+03
48	Steel	5	NT	660
0	Wood	5	2.6E+05	>1E+06
4	Wood	5	310	1.5E+05
24	Wood	5	170	7.6E+04
48	Wood	5	<10	330

NT = not tested

Figure 2



Surface:
1 = Laminate
2 = Glass
3 = Plastic
4 = Steel
5 = Wood

3.3 **Lamb joint**

The results of this trial are given in Table 6. As can be seen for each piece of lamb, the Enterobacteriaceae level was lower than that of the TVC level. The Enterobacteriaceae level decreased in all cases during the trial to <10 cfu/25 cm^2.

The TVC level varied slightly between each meat piece but the initial levels were always >1 x 10^6 cfu/25 cm^2. After 48h, the levels were still high and exceeded 10^4 cfu/25 cm^2.

There was only a slight difference between the TVC level for each surface type, with a decrease in TVC level throughout time of approximately 0.4 log units. These differences are illustrated in Figure 3.

3.3.1 Statistical analysis

ANOVA values are given below:

Table 5: Statistical analysis results

	P value	**Significance**
Surface	0.542	N/S
Meat piece	0.000	***
Order	0.363	N/S
Time	0.000	***
Surface x time	0.232	N/S
Meat piece x time	0.001	***
Order x time	0.728	N/S

As can be seen (in Table 5), the difference in TVC level over time was statistically significant, as was the difference in meat piece. The interaction between meat piece and time was also statistically significant. The difference in TVC level between surfaces was not statistically significant.

Table 6: Lamb joint results

Time (h)	Surface	Meat Piece	Enterobacteriaceae cfu/25 cm^2	TVC cfu/25 cm^2
0	Laminate	1	2.5E+03	4.0E+06
4	Laminate	1	<10	8.0E+05
24	Laminate	1	<10	2.8E+06
48	Laminate	1	<10	2.1E+05
0	Glass	1	5.3E+04	1.2E+06
4	Glass	1	20	4.0E+06
24	Glass	1	<10	1.8E+06
48	Glass	1	<10	2.1E+06
0	Plastic	1	4.2E+03	4.0E+06
4	Plastic	1	<10	1.1E+06
24	Plastic	1	<10	1.0E+06
48	Plastic	1	<10	4.0E+05
0	Steel	1	1.2E+04	4.0E+06
4	Steel	1	<10	4.0E+06
24	Steel	1	<10	1.2E+06
48	Steel	1	<10	3.4E+05
0	Wood	1	960	2.5E+06
4	Wood	1	<10	4.0E+06
24	Wood	1	<10	1.8E+06
48	Wood	1	<10	2.5E+06
0	Laminate	2	10	4.0E+06
4	Laminate	2	<10	1.3E+06
24	Laminate	2	<10	1.5E+06
48	Laminate	2	<10	2.1E+05
0	Glass	2	90	1.8E+06
4	Glass	2	<10	2.2E+06
24	Glass	2	<10	1.0E+06
48	Glass	2	<10	2.2E+06
0	Plastic	2	3.6E+04	4.0E+06
4	Plastic	2	<10	4.0E+06
24	Plastic	2	<10	1.9E+06
48	Plastic	2	<10	5.4E+05
0	Steel	2	<10	1.4E+06
4	Steel	2	<10	1.8E+06
24	Steel	2	<10	6.0E+05
48	Steel	2	<10	2.4E+05
0	Wood	2	920	2.5E+06
4	Wood	2	<10	1.6E+06
24	Wood	2	<10	1.7E+06
48	Wood	2	<10	3.0E+06

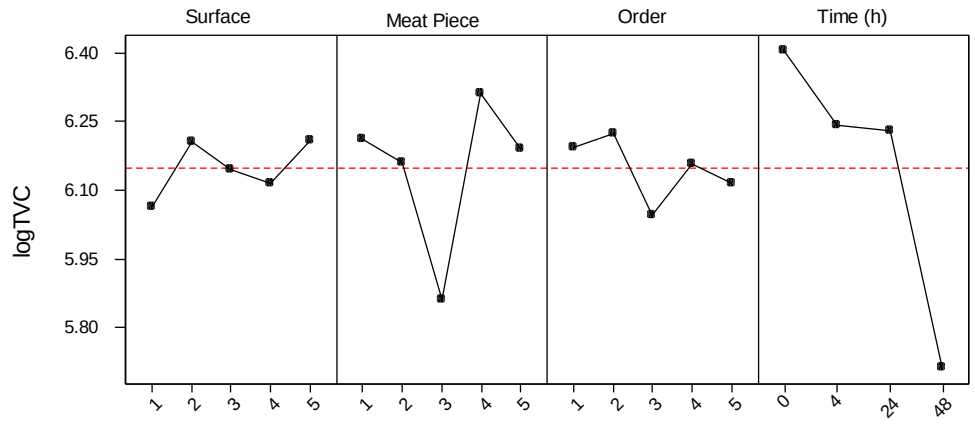
Table 6: Lamb joint results (continued)

Time (h)	Surface	Meat Piece	Enterobacteriaceae cfu/25 cm^2	TVC cfu/25 cm^2
0	Laminate	3	60	3.0E+06
4	Laminate	3	<10	9.2E+05
24	Laminate	3	<10	1.9E+06
48	Laminate	3	<10	9.1E+04
0	Glass	3	30	2.4E+06
4	Glass	3	<10	9.0E+05
24	Glass	3	<10	1.5E+06
48	Glass	3	<10	1.6E+04
0	Plastic	3	420	4.0E+06
4	Plastic	3	90	1.1E+06
24	Plastic	3	<10	9.2E+05
48	Plastic	3	<10	1.5E+05
0	Steel	3	560	2.0E+06
4	Steel	3	<10	1.5E+06
24	Steel	3	<10	4.0E+06
48	Steel	3	<10	4.5E+04
0	Wood	3	1.0E+04	2.0E+06
4	Wood	3	10	3.2E+05
24	Wood	3	<10	1.2E+06
48	Wood	3	<10	2.4E+05
0	Laminate	4	7.8E+04	2.4E+06
4	Laminate	4	1.3E+03	4.0E+06
24	Laminate	4	<10	1.3E+06
48	Laminate	4	<10	5.0E+05
0	Glass	4	2.4E+05	2.5E+06
4	Glass	4	40	1.5E+06
24	Glass	4	<10	4.0E+06
48	Glass	4	<10	2.8E+06
0	Plastic	4	1.6E+04	1.1E+06
4	Plastic	4	<10	2.0E+06
24	Plastic	4	<10	4.00E+06
48	Plastic	4	<10	6.1E+05
0	Steel	4	1.4E+03	1.8E+06
4	Steel	4	<10	4.00E+06
24	Steel	4	<10	1.3E+06
48	Steel	4	<10	3.0E+06
0	Wood	4	220	1.4E+06
4	Wood	4	<10	2.5E+06
24	Wood	4	<10	4.0E+06
48	Wood	4	<10	3.0E+06

Table 6: Lamb joint results (continued)

Time (h)	Surface	Meat Piece	Enterobacteriaceae cfu/25 cm^2	TVC cfu/25 cm^2
0	Laminate	5	20	3.2E+06
4	Laminate	5	<10	1.6E+06
24	Laminate	5	<10	1.5E+06
48	Laminate	5	<10	7.1E+05
0	Glass	5	510	2.2E+06
4	Glass	5	10	4.4E+06
24	Glass	5	<10	4.0E+06
48	Glass	5	<10	3.4E+05
0	Plastic	5	360	4.0E+06
4	Plastic	5	<10	1.1E+06
24	Plastic	5	<10	1.5E+06
48	Plastic	5	<10	1.3E+06
0	Steel	5	110	4.0E+06
4	Steel	5	<10	8.9E+05
24	Steel	5	<10	1.7E+06
48	Steel	5	<10	9.3E+05
0	Wood	5	120	3.2E+06
4	Wood	5	<10	1.8E+06
24	Wood	5	<10	8.1E+05
48	Wood	5	<10	4.3E+05

Figure 3



Surface:

1 = Laminate
2 = Glass
3 = Plastic
4 = Steel
5 = Wood

3.4 **Pork joint**

The results of the trial are given in Table 8. As can be seen, the Enterobacteriaceae levels were generally <10 cfu/25 cm^2.

The TVC level varied between each meat piece but the levels were generally between 10^2 and 10^3 cfu/25 cm^2. There was also a difference in TVC level throughout the 48 h test period with the levels decreasing by 0.3 to 0.5 log units, but this was not statistically significant.

There was only a slight difference between the TVCs level for each surface type. These differences are illustrated graphically in Figure 4.

3.4.1 Statistical analysis

The ANOVA results are given below:

Table 7: Statistical analysis results

	P value	**Significance**
Surface	0.284	N/S
Meat piece	0.000	***
Order	0.001	***
Time	0.056	N/S
Surface x time	0.909	N/S
Meat piece x time	0.514	N/S
Order x time	0.859	N/S

The P values indicate that only the differences between meat piece and order of meat placement were statistically significant.

Table 8: Pork joint results

Time (h)	Surface	Meat Piece	Enterobacteriaceae cfu/25 cm^2	TVC cfu/25 cm^2
0	Laminate	1	10	6.8E+03
4	Laminate	1	<10	1.8E+03
24	Laminate	1	<10	900
48	Laminate	1	<10	3.3E+03
0	Glass	1	50	9.9E+03
4	Glass	1	<10	1.4E+04
24	Glass	1	<10	3.1E+03
48	Glass	1	10	9.8E+03
0	Plastic	1	<10	6.2E+03
4	Plastic	1	<10	1.9E+03
24	Plastic	1	<10	3.4E+03
48	Plastic	1	<10	1.7E+03
0	Steel	1	<10	2.1E+03
4	Steel	1	<10	3.1E+03
24	Steel	1	<10	910
48	Steel	1	<10	4.6E+03
0	Wood	1	10	2.3E+04
4	Wood	1	<10	1.6E+03
24	Wood	1	<10	2.0E+04
48	Wood	1	<10	6.4E+03
0	Laminate	2	<10	1.2E+03
4	Laminate	2	<10	200
24	Laminate	2	<10	1.1E+03
48	Laminate	2	<10	2.1E+03
0	Glass	2	10	2.1E+03
4	Glass	2	<10	270
24	Glass	2	<10	740
48	Glass	2	<10	1.5E+03
0	Plastic	2	<10	2.3E+03
4	Plastic	2	<10	990
24	Plastic	2	<10	500
48	Plastic	2	<10	1.9E+03
0	Steel	2	<10	1.8E+03
4	Steel	2	<10	380
24	Steel	2	<10	2.9E+03
48	Steel	2	<10	4.1E+03
0	Wood	2	<10	680
4	Wood	2	<10	910
24	Wood	2	<10	3.5E+03
48	Wood	2	<10	7.7E+03

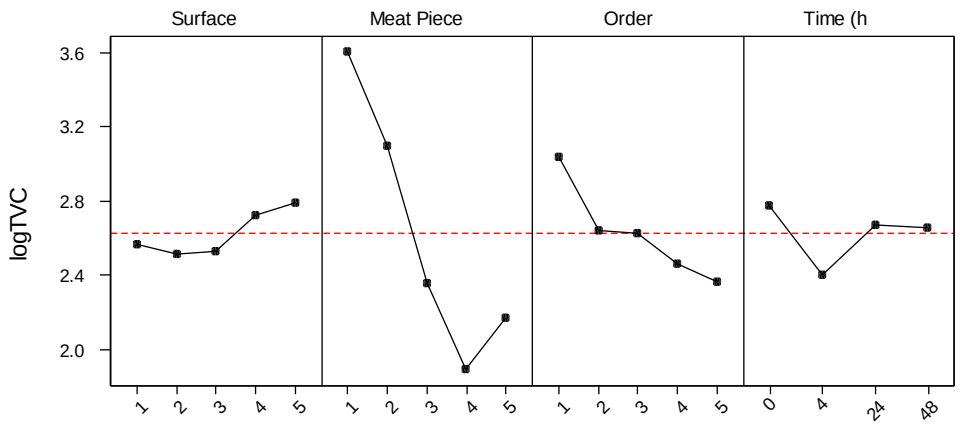
Table 8: Pork joint results (continued)

Time (h)	Surface	Meat Piece	Enterobacteriaceae cfu/25 cm^2	TVC cfu/25 cm^2
0	Laminate	3	<10	70
4	Laminate	3	<10	140
24	Laminate	3	<10	50
48	Laminate	3	<10	1.1E+03
0	Glass	3	<10	340
4	Glass	3	<10	10
24	Glass	3	<10	580
48	Glass	3	<10	250
0	Plastic	3	<10	530
4	Plastic	3	<10	130
24	Plastic	3	<10	1.9E+03
48	Plastic	3	<10	330
0	Steel	3	<10	70
4	Steel	3	<10	130
24	Steel	3	<10	640
48	Steel	3	<10	160
0	Wood	3	<10	510
4	Wood	3	<10	300
24	Wood	3	<10	330
48	Wood	3	<10	260
0	Laminate	4	<10	1.3E+03
4	Laminate	4	<10	180
24	Laminate	4	<10	320
48	Laminate	4	<10	150
0	Glass	4	10	180
4	Glass	4	<10	50
24	Glass	4	<10	60
48	Glass	4	<10	<10
0	Plastic	4	<10	10
4	Plastic	4	<10	<10
24	Plastic	4	<10	50
48	Plastic	4	<10	50
0	Steel	4	10	290
4	Steel	4	<10	180
24	Steel	4	<10	50
48	Steel	4	<10	30
0	Wood	4	<10	20
4	Wood	4	<10	440
24	Wood	4	<10	270
48	Wood	4	<10	250

Table 8: Pork joint results (continued)

Time (h)	Surface	Meat Piece	Enterobacteriaceae cfu/25 cm^2	TVC cfu/25 cm^2
0	Laminate	5	<10	310
4	Laminate	5	<10	60
24	Laminate	5	<10	200
48	Laminate	5	<10	60
0	Glass	5	<10	40
4	Glass	5	<10	180
24	Glass	5	<10	10
48	Glass	5	<10	90
0	Plastic	5	<10	650
4	Plastic	5	<10	60
24	Plastic	5	<10	190
48	Plastic	5	<10	120
0	Steel	5	<10	1.9E+03
4	Steel	5	<10	410
24	Steel	5	<10	680
48	Steel	5	<10	320
0	Wood	5	<10	200
4	Wood	5	<10	50
24	Wood	5	<10	200
48	Wood	5	<10	60

Figure 4



Surface:

1 = Laminate
2 = Glass
3 = Plastic
4 = Steel
5 = Wood

3.5 **All meat types**

3.5.1 Statistical analysis

All meat types were analysed together and the P values obtained are given below:

Table 9: Statistical analysis results

	P value	**Significance**
Surface	0.365	N/S
Meat piece	0.000	***
Order	0.000	***
Time	0.000	***
Surface x time	0.000	***
Meat piece x time	0.043	*
Order x time	0.000	***

The P value results illustrate that there was no statistical significant difference between surface type. However, the differences between meat type, meat piece, order and meat type/order and meat type/time interactions were statistically significant.

3.6 **Decline in log count over time**

A further analysis of the decrease over time of contamination from each meat type was carried out (Table 10).

Table 10: Decline in log TVC

Meat Type	Mean Log Count t = 0	Mean Log Count t = 48 h	Decline in Log TVC
Beef	3.1	1.7	1.4
Chicken	5.3	2.3	3.0
Lamb	6.4	5.7	0.7
Pork	2.8	2.7	0.1

There was little decrease in log TVC throughout the 48 h time period from pork, a slight decline in level from lamb, and a steady decline from beef, but the highest decline in log TVC level was observed from the chicken fillets.

3.7 **Excision results**

Table 11: TVC results (cfu/5 cm^2)

	Beef	Chicken	Lamb	Pork
1	7.1×10^4	2.1×10^7	1.5×10^8	3.8×10^4
2	110	9.2×10^6	3×10^7	3.4×10^4
3	850	5.2×10^6	4×10^7	1.4×10^3
4	290	4×10^6	3.1×10^8	8.9×10^3
5	3.4×10^3	4.3×10^7	4.9×10^7	4.6×10^3

Table 12: Enterobacteriaceae results (cfu/5 cm^2)

	Beef	Chicken	Lamb	Pork
1	<10	520	1.4×10^5	410
2	<10	6.9×10^4	9.9×10^4	290
3	<10	1.2×10^5	9.3×10^4	10
4	<10	8.3×10^4	3×10^5	260
5	<10	1.2×10^5	450	220

As can be seen, the TVC levels present in each of the meat types (Tables 11 -12) varied from 10^2 cfu/5 cm^2 for beef to 10^8 cfu/5 cm^2 for lamb. There was also variability between different pieces of the same meat type. There were also differences in the Enterobacteriaceae level, amongst the meat types, with <10 cfu/5 cm^2 present for the beef and 10^5 cfu/5 cm^2 for the lamb and chicken. Variability also occurred between the meat pieces.

This could explain why there were higher levels of bacteria present when lamb was used.

PART II

CONTAMINATION OF TYPICAL KITCHEN SURFACES WITH PATHOGENS

4. MATERIALS AND METHODS

4.1 *Salmonella* persistence study

The aim of this trial was to establish the persistence of *Salmonella* when inoculated onto a variety of typical kitchen surfaces.

Two strains of *Salmonella* were used in this trial:

Salmonella Typhimurium CRA 9278
Salmonella Enteritidis CRA 1001

The cultures were grown in meat juice. The meat juice was prepared by aseptically blending pieces of beef with sterile distilled water. The resultant juice was then collected in a sterile container. The meat juice was inoculated with the cultures and incubated at 37°C for 24 h to give a level of approximately 10^8/cfu/ml.

Small pieces, 2 cm by 2 cm, of each surface were cut. Plastic and wooden chopping boards were cut to size, as was a typical kitchen laminate and stainless steel. Glass coverslips were used to represent a glass surface. All the surfaces were new and unscored.

Pieces of each surface type were inoculated with a cocktail containing both of the *Salmonella* strains. The surfaces were sprayed evenly with approximately 0.1 ml of the inoculated meat juice. Replicates (5) of each surface type were swabbed using the swabbing technique. Swabbing was carried out at times 0, 4, 24 and 48 h.

A Sterilin cotton tip swab was dampened in 10 ml UQA. The corresponding area (25 cm^2) was swabbed and the swab placed in UQA. The UQA was then vortexed for 15 seconds prior to sampling.

The swabbing diluent was Buffered Peptone Water (BPW Oxoid CM509). The swabs were serially diluted and plated onto Xylose Lysine Deoxycholate Agar (XLD Oxoid CM929). These plates were incubated at 37°C for 24 h after which time all typical colonies were counted. Counts were present at all sampling times, therefore the presence/absence test was not performed.

4.2 *Salmonella* persistence study using new and abraded surfaces

The trial described in 4.1 (except 0.1 ml inoculated onto surface and spread using a sterile plastic spreader) was repeated using new surfaces and surfaces that had been scored by placing a weight (2.6 kg) onto sandpaper (120 grit) and pulling the paper across each of the chopping board surfaces. The surfaces were abraded to a degree that would still render them useable. The roughness of each of the surfaces was measured using a calibrated surface roughness measuring instrument (profileometer) (Rank Taylor Hobson Surtronic 3P).

4.3 **Non-toxigenic *E. coli* O157 persistence study**

The aim of this trial was to establish the persistence of non-toxigenic *E. coli* O157 when inoculated onto a variety of typical kitchen surfaces. Non-toxigenic strain ATCC 43888 was used in this trial. The culture was prepared in meat juice as described in 4.1 and the meat juice was incubated at 37°C for 24 h.

The trial was the same as for *Salmonella*, with the swabbing diluent being BPW. The enumeration was carried out using Sorbitol MacConkey Cefixime Tellurite Agar (CT-SMAC LabM Lab 161) incubated at 37°C for 24 h. After incubation, all typical colonies were counted.

The BPW containing the swabs was also incubated at 37°C for 24 h. If the enumeration plates contained no growth, the BPW broths were streaked onto CT SMAC and incubated at 37°C for 24 h in order to establish presence/absence.

4.4 ***Campylobacter* persistence study**

The aim of this trial was to establish persistence of *Campylobacter* when inoculated onto a variety of typical kitchen surfaces. *Campylobacter jejuni* (NCTC 11351) was inoculated into meat juice (prepared as detailed in 4.1) and incubated at 42°C for 5 days. The trial was then set up in the same way as for 4.1 except that the meat juice was inoculated onto each surface piece and spread across the surface using a sterile spreader.

The swabbing diluent was Preston Broth (Oxoid CM929, SR117, SR84 and lysed horse blood) and the enumeration agar was Campylobacter Blood-Free Selective Agar Base (CCDA, Oxoid CM739, SR155) incubated at 42°C for 2 to 5 days.

The swabs in Preston Broth were inoculated at 42°C for 24 h for presence/absence streaking. The streak plates were incubated at 42°C for 48 h.

A smaller scale repeat trial was set up. Triplicate pieces of laminate surface only were used.

4.5 **Statistical analysis**

The data was analysed using Analysis of Variance (ANOVA), the general linear model function in Minitab. A value of less than 0.001 indicated a 99.9% (***) statistically significant difference, 0.01 a 99% (**) statistically significant difference and 0.05 a 95% (*) statistically significant difference.

5. RESULTS

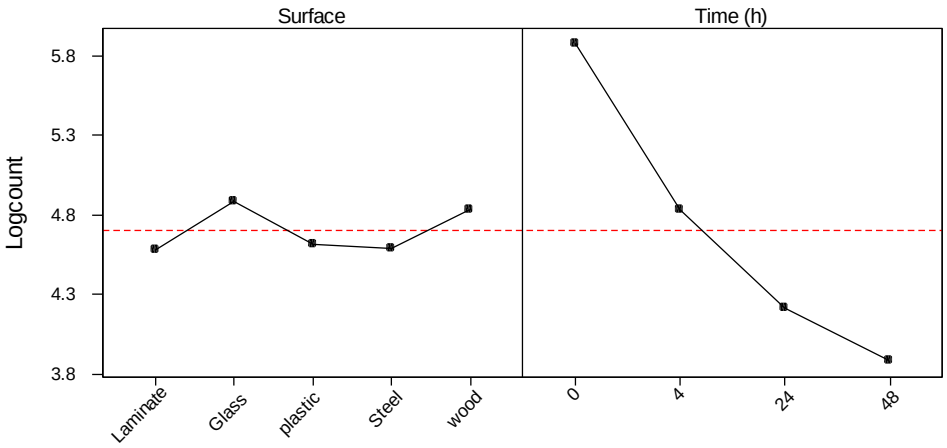
5.1 *Salmonella*

The results are given in Table 17. There was little difference between the initial inoculum level on any of the surface types with the mean values ranging from 3 x 10^5 to 1 x 10^6 cfu/4 cm^2.

It was also seen that there was little difference between any of the surface types throughout the trial, except that at 4 h the *Salmonella* level was slightly higher on the wood than the other surface types.

Overall there was an approximate 2 log reduction throughout the trial (Figure 5) and figure numbers by 4.

Figure 5



Statistical analysis indicated that there was evidence of a slight surface effect, but this was outside of the 95% confidence level. However, time was very significant, with *Salmonella* levels decreasing significantly throughout the 48 h test period Figure 6. Also, the interaction between surface and time was significant.

Table 13: Analysis of variance table for log count

Source	P	Significance
Surface	0.074	N/S
Time	<0.001	Very highly significant ***
Surface x time	0.017	Significant *

The difference between each surface was then analysed at each individual time point. The only significant difference was at 4 h.

Table 14: Statistical analysis results for each time point

Time point	P	Significance	Residual s.d
0	0.59	N/S	0.52
4 h	0.001	***	0.42
24 h	0.12	N/S	0.33
48 h	0.71	N/S	0.46

The mean values for each surface type at each time point are given below. These illustrate the similarities in log cfu/4 cm^2 *Salmonella* levels.

Table 15: Mean log values for each surface type

Surface	Laminate	Glass	Plastic	Steel	Wood
Time 0	5.74	6.20	5.92	5.79	5.74
Time 4 h	4.36	4.78	5.00	4.45	5.57
Time 24 h	4.22	4.45	3.95	4.33	4.12
Time 48 h	4.00	4.11	3.60	3.78	3.92

The average decrease in log count from time zero for the different surfaces are shown below.

Table 16: Log decrease results

Surface	Laminate	Glass	Plastic	Steel	Wood
Time 0 to 4 h	1.38	1.42	0.92	1.34	0.17
Time 0 to 24 h	1.52	1.75	1.97	1.46	1.62
Time 0 to 48 h	1.74	2.09	2.32	2.01	1.82

Figure 6: *Salmonella* survival on chopping boards

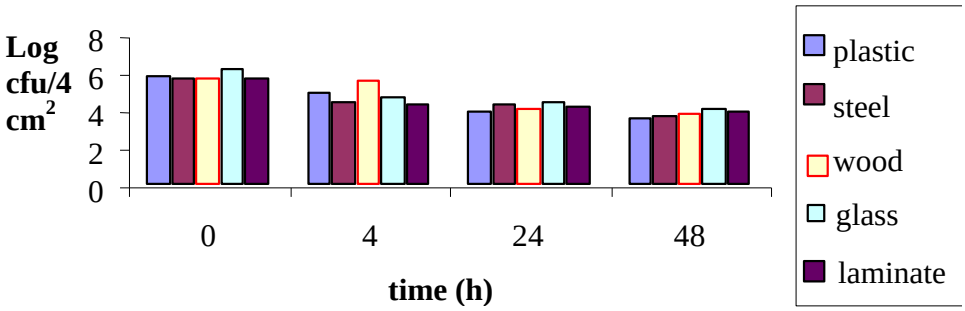


Table 17: *Salmonella* results (cfu/4 cm^2)

	0 h	4 h	24 h	48 h
Plastic	3.0E+05	2.5E+05	1.4E+04	1.2E+03
	4.0E+06	6.3E+04	2.2E+04	5.3E+03
	9.0E+05	1.4E+05	8.4E+03	2.5E+03
	9.0E+05	1.4E+05	1.1E+04	2.4E+04
	4.0E+05	3.4E+04	2.0E+03	2.6E+03
Steel	1.0E+06	5.0E+03	1.8E+04	9.1E+03
	2.0E+05	7.1E+04	2.5E+04	1.4E+04
	7.0E+04	3.5E+04	6.7E+03	2.4E+03
	3.0E+06	3.0E+04	2.4E+04	6.4E+03
	2.0E+06	4.9E+04	6.1E+04	4.0E+03
Wood	3.0E+05	3.3E+05	9.7E+03	4.6E+03
	6.0E+05	1.3E+06	7.4E+04	9.6E+03
	2.0E+05	1.8E+05	2.8E+04	4.0E+03
	2.0E+06	1.2E+06	3.0E+03	2.0E+04
	7.0E+05	8.0E+04	6.3E+03	1.1E+04
Glass	1.0E+06	1.3E+05	6.0E+03	6.1E+03
	5.0E+06	1.8E+05	8.7E+04	1.7E+04
	1.0E+07	4.0E+04	2.4E+04	6.6E+04
	4.0E+05	3.0E+04	1.7E+04	1.7E+04
	5.0E+05	2.8E+04	8.0E+04	3.2E+03
Laminate	4.0E+05	2.1E+04	6.0E+03	1.6E+04
	2.0E+05	5.0E+04	9.4E+03	6.5E+03
	4.0E+05	5.7E+04	1.8E+04	5.7E+03
	1.0E+06	1.7E+04	5.9E+04	3.0E+04
	1.6E+06	6.0E+03	2.0E+04	5.4E+03

5.2 *Salmonella* persistence on new and abraded surfaces

The surface roughness measurements are given in Table 20. As can be seen for all surface types, the abraded surface was rougher. This was most noticeable for the wood, glass and stainless steel. There was, however, considerable variation in the roughness values for the unabraded surfaces, particularly with the plastic.

Table 21 illustrates the data from this trial. It can be seen that wood and laminate had slightly higher initial levels than steel, wood and plastic. The levels then steadily decreased over the 48 h test period.

Also, it can be seen in Table 21 that in some cases the level of *Salmonella* was lower on the abraded surface than on the new surface. This is particularly the case for the wood surface. It may be that the abrasions prevent removal of bacteria via swabbing and so result in lower counts.

Statistical analyses were performed on the data (Table 18).

Table 18: Analysis of variance model for log counts

Source	P	Significance
Surface	0.06	Some evidence
Time (hours)	<0.001	***
New or Abraded	0.004	**
Surface x time	0.66	NS
New/Abraded x time	0.25	NS
New/Abraded x surface	0.017	**

There was no evidence that the difference between surfaces, or the effect of abrading, on log counts changed with time. However, the effect of abrading varied significantly according to the surface. This is shown below in Table 19.

Table 19: Mean log counts for new and abraded surfaces

Surface	New	Abraded	Difference	Significance
1 = laminate	5.43	5.42	-0.01	NS
2 = glass	5.53	5.13	-0.40	**
3 = plastic	5.35	5.34	-0.01	NS
4 = steel	5.25	5.15	-0.10	NS
5 = wood	5.48	4.67	-0.81	***

As can be seen, there was a statistically significant difference between new and abraded surfaces for wood and glass. There was no statistically significant difference for the laminate, plastic and steel surfaces.

Table 20: Surface roughness measurement

Surface	New (μM)	Abraded(μM)
Plastic	13.25	14.32
	9.18	11.73
	8.16	10.35
		13.8
		11.45
		10.65
		8.01
		9.84
		14.42
		10.46
Mean	10.20	11.50
Steel	0.01	0.4
	0.38	0.46
	0.37	0.7
		0.49
		0.55
		0.436
		0.463
		0.42
		0.4
		0.46
Mean	0.25	0.4779

Surface	New (μM)	Abraded(μM)
Wood	1.81	2.1
	0.91	3.13
	2.41	2.77
		4.01
		4.11
		3.81
		5.41
		3.36
		2.35
		1.56
Mean	1.71	3.26
Glass	0.02	0.03
	0.02	0.05
	0.02	0.15
		0.35
		0.04
		0.05
		0.03
		0.08
		0.18
		0.04
Mean	0.02	0.10
Laminate	2.02	2.20
	1.74	2.04
	1.63	1.91
		2.59
		1.47
		2.09
		1.63
		2.08
		2.72
		2.39
Mean	1.80	2.11

Table 21: *Salmonella* (cfu/4 cm^2) persistence on new and abraded surfaces

	New				Abraded			
Time (h)	**0**	**4**	**24**	**48**	**0**	**4**	**24**	**48**
Plastic	7.4E+06	4.9E+05	7.6E+04	1.3E+04	4.7E+06	2.3E+05	1.3E+04	1.2E+04
	5.4E+06	1.1E+06	1.5E+05	4.9E+04	1.2E+06	2.6E+05	3.5E+04	1.5E+04
	5.5E+06	5.1E+05	4.0E+04	1.1E+04	5.1E+06	5.3E+04	1.0E+05	5.0E+03
	8.1E+06	1.1E+06	1.7E+05	1.8E+04	8.5E+06	2.5E+05	5.3E+03	1.1E+04
	6.7E+06	7.8E+05	1.6E+05	1.1E+04	8.1E+06	1.9E+05	1.9E+04	1.0E+03
Steel	6.1E+06	4.5E+05	3.5E+04	3.6E+04	1.1E+07	5.0E+05	5.9E+04	3.5E+04
	7.6E+06	6.1E+05	2.4E+04	4.0E+03	7.3E+06	1.4E+05	9.7E+04	3.4E+04
	6.3E+06	4.3E+05	6.7E+04	3.0E+04	7.2E+06	2.1E+05	5.4E+04	3.0E+04
	3.1E+06	3.4E+05	1.4E+05	3.1E+04	8.3E+06	3.0E+05	6.8E+04	3.1E+04
	1.1E+07	4.4E+05	8.1E+04	1.8E+04	4.4E+06	5.6E+05	5.3E+04	1.2E+04
Wood	1.5E+07	4.6E+05	2.6E+04	1.9E+04	3.2E+06	2.7E+05	7.6E+04	1.2E+04
	1.5E+07	9.0E+05	1.9E+04	1.5E+04	2.1E+06	7.4E+05	5.7E+04	1.7E+04
	1.3E+07	6.3E+05	3.5E+04	2.0E+04	7.5E+06	1.1E+05	1.9E+05	8.0E+03
	1.1E+07	2.0E+05	2.0E+04	1.1E+04	6.2E+06	2.6E+05	3.3E+04	5.0E+03
	1.9E+07	4.5E+05	7.4E+03	8.0E+03	5.1E+06	1.9E+05	8.4E+04	4.0E+04
Glass	6.5E+06	6.1E+04	1.5E+04	9.0E+03	5.0E+06	4.3E+04	4.0E+04	3.5E+04
	1.1E+07	3.0E+05	1.6E+04	1.1E+04	5.6E+06	1.5E+05	3.6E+04	3.4E+04
	7.6E+06	2.7E+05	7.2E+03	1.8E+04	5.7E+06	1.1E+05	4.2E+04	3.0E+04
	6.7E+06	2.7E+05	*	6.0E+03	9.6E+06	2.5E+04	2.1E+04	3.1E+04
	9.3E+06	9.5E+05	5.3E+03	1.3E+04	7.1E+06	4.1E+04	4.0E+03	1.2E+04
Laminate	1.5E+07	3.8E+05	1.2E+04	2.3E+04	4.9E+06	2.7E+04	2.0E+04	4.0E+03
	1.2E+07	2.0E+05	5.4E+04	2.0E+04	1.8E+06	3.4E+04	1.5E+04	4.0E+03
	1.4E+07	3.1E+05	1.3E+04	2.9E+04	2.3E+06	2.9E+04	8.4E+03	1.9E+03
	1.4E+07	4.2E+05	2.3E+05	2.3E+04	2.6E+06	2.4E+04	9.6E+03	7.1E+03
	1.4E+07	2.3E+05	1.7E+04	5.6E+04	4.1E+06	6.1E+04	1.0E+04	2.5E+02

* = not tested

5.3 *E. coli* O157

The results are given in Table 26. There was little difference between the *E. coli* O157 levels on any of the surface types at any time point throughout the trial.

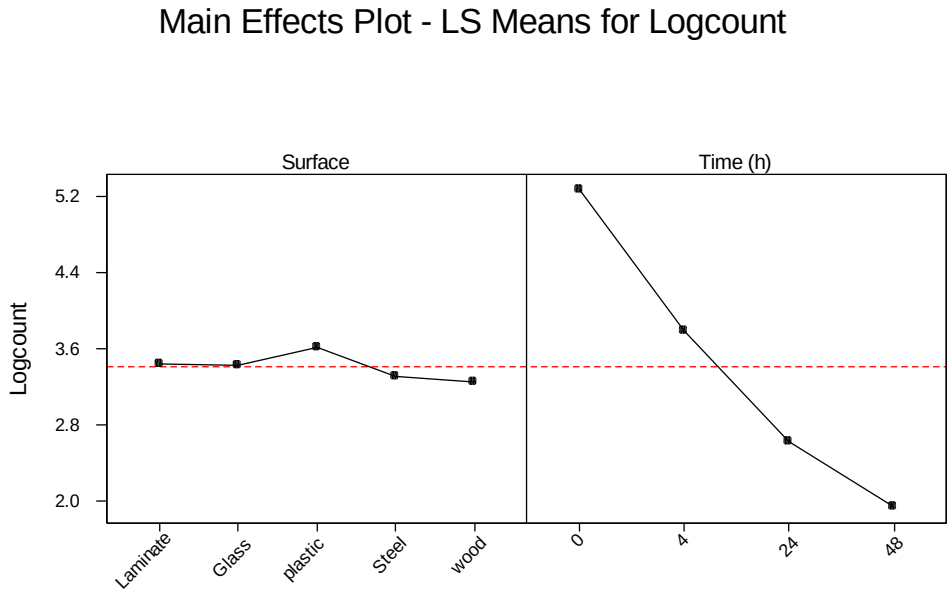
The statistical analyses (general linear model) indicated that there was no surface effect and no surface x time interaction. However, the time effect (reduction in *E. coli* O157 level over time) was statistically significant.

Table 22: Statistical results for *E. coli* O157 trial

Source	P	Significance
Surface	0.41	NS
Time	<0.001	***
Surface x time	0.52	NS

The main effects plot, Figure 7, illustrated that there had been over a 3 log reduction in *E. coli* O157 level over the 48 h test period. However, there was little difference in the level of *E. coli* O157 on the various surfaces.

Figure 7



Further analyses (Table 23) were carried out at each time point. The results indicated that there was no statistical difference between surfaces at any given test time.

Table 23: Statistical results at each time point

Time point	P	Significance
0	0.32	N/S
4 hrs	0.20	N/S
24 hrs	0.68	N/S
48 hrs	0.31	N/S

The mean values for each surface type at each time point (Table 24) and the log reduction at each time point (Table 25) further illustrate the similarities in *E. coli* O157 level on each surface type.

Table 24: Mean level at each time point (cfu/4 cm^2)

Surface	Laminate	Glass	Plastic	Steel	Wood
Time 0	5.22	5.23	5.25	5.64	5.01
Time 4 hrs	3.43	3.80	4.12	3.55	4.01
Time 24 hrs	2.81	2.79	2.96	2.32	2.25
Time 48 hrs	2.26	1.90	2.12	1.71	1.71

The mean decrease in log count between each of the time points was then determined.

Table 25: Mean log reduction (cfu/4 cm^2)

Surface	Laminate	Glass	Plastic	Steel	Wood
Time 0 to 4 h	1.79	1.43	1.13	2.09	1.00
Time 0 to 24 h	2.41	2.44	2.29	3.32	2.76
Time 0 to 48 h	2.96	3.33	3.13	3.93	3.30

Table 26: *E. coli* O157 results (cfu/4 cm^2)

	Time (h)			
	0	**4**	**24**	**48**
Plastic	2.3E+05	1.4E+04	1.5E+03	1.5E+02
	1.0E+05	2.1E+04	1.9E+03	4.0E+01
	4.0E+04	1.6E+04	1.0E+03	2.5E+02
	5.0E+05	6.5E+03	2.0E+01	2.8E+02
	3.7E+05	1.3E+04	1.1E+04	9.0E+01
Steel	2.4E+06	2.0E+02	1.0E+02	1.5E+02
	2.0E+05	1.0E+04	1.0E+03	9.0E+01
	2.0E+05	1.8E+03	2.2E+02	<10
	1.2E+05	1.1E+04	1.8E+03	5.0E+01
	1.3E+06	1.4E+04	<20	1.0E+02
Wood	1.4E+05	1.1E+04	1.0E+02	2.8E+02
	3.0E+05	2.5E+03	4.6E+02	6.0E+01
	7.6E+04	*	2.2E+03	2.0E+01
	1.6E+05	6.0E+03	8.8E+03	7.0E+01
	2.6E+05	1.0E+04	1.0E+02	1.3E+02
Glass	1.4E+05	4.0E+02	9.3E+03	4.8E+02
	5.0E+05	3.7E+03	3.6E+02	7.0E+01
	1.4E+05	5.1E+03	1.0E+02	5.0E+01
	9.0E+04	5.5E+03	6.0E+01	4.9E+02
	1.5E+05	3.4E+03	5.6E+03	2.5E+02
Laminate	1.4E+05	4.0E+02	9.3E+03	4.8E+02
	5.0E+05	3.7E+03	3.6E+02	7.0E+01
	1.4E+05	5.1E+03	1.0E+02	5.0E+01
	9.0E+04	5.5E+03	6.0E+01	4.9E+02
	1.5E+05	3.4E+03	5.6E+03	2.5E+02

* = not tested

5.4 *Campylobacter*

The initial large scale (all surfaces) trial had an inoculum level of *Campylobacter* of 10^2 - 10^3 cfu/4 cm^2. The 0 h results for each surface were all <100, as were the 4 h results. The 24 h and 48 h results were all <20. The presence/absence streaks at 4, 24 and 48 h indicated absence of *Campylobacter*.

The smaller scale trial results using only laminate surface showed that *Campylobacter* was only able to survive the initial inoculation procedure and was no longer present after 4 h (Table 27). The presence/absence tests also indicated that *Campylobacter* was not present after 4 h.

Table 27: *Campylobacter* results (small scale trial)

Time (h)	*Campylobacter* cfu/4 cm^2	Presence/Absence
0	2.40E+03	+ve
0	1.20E+04	+ve
0	2.4E+04	+ve
4	<10	-ve
4	<10	-ve
4	<10	-ve
24	<10	-ve
24	<10	-ve
24	<10	-ve
48	<10	-ve
48	<10	-ve
48	<10	-ve

6. CONCLUSIONS

The results indicate that, as would be expected, raw meat is able to transfer bacteria onto typical kitchen surfaces at levels of 10^2 - 10^5 cfu/25 cm^2. Other authors such as De Wit (1979) and Gilbert and Watson (1971) demonstrated the contamination of chopping boards during domestic preparation of raw meat.

This study also demonstrated that:

- There was variation between different pieces of the same meat type.
- There were differences between the various meat types, which may reflect the source of the meat, preparation practices, the elapsed time from slaughter and differing storage regimes.
- There was a significant reduction in the levels of bacteria present during the 48 h trial although it is important to note that relatively high numbers (10^2 - 10^5 cfu/25 cm^2) of TVC persisted throughout the 48 h period. In many cases, the largest decrease occurred after 24 h. Scott and Bloomfield (1990) found that Gram negative bacteria could persist up to 4 h and in some cases 24 h on solid laminate surfaces. In our studies, survival was demonstrated up to 48 h.
- There were no statistically significant differences in the persistence of meat microflora on chopping boards (plastic, glass or wood), laminate or stainless steel.
- The higher the initial contamination level the longer the persistence of greater numbers of bacteria, therefore the most highly contaminated meats will result in much higher levels of surface contamination over a longer time period.

The pathogen study demonstrated that:

- There was little difference between the five kitchen surface types tested when contaminated with *Salmonella* or *E. coli* O157.
- A 2 - 3 log reduction in inoculated *Salmonella* and *E. coli* O157 levels occurred over a 48 h test period. However, high levels (10^3 cfu/4 cm^2) still persisted. Other authors have also found that pathogens could survive on typical kitchen surfaces. Gough and Dodd (1998) studied the recovery of *Salmonella* Typhimurium from the surface of new and scored plastic and wooden chopping boards. They noted that recovery was better from plastic boards than wood and on new boards rather than scored ones. However, it was noted that although significant recovery occurred, there was no significant difference between recovery of *Salmonella* Typhimurium from plastic and wood chopping boards when food residues (chicken meat/fat) were present. A further study by Ak *et al*. (1994) also demonstrated that the presence of chicken fat enhanced

survival of some bacteria when inoculated onto wooden and plastic cutting boards. *Campylobacter,* however, did not survive the initial inoculation procedure.

- There was no significant difference in persistence of bacteria when various surface types were tested. This differed from previous studies, in which Everis *et al.* (2002) suggested that higher levels were obtained from swabbing steel compared with laminate during sequential transfer studies.

- There was little difference in levels of *Salmonella* recovered from new and abraded surfaces, except for the abraded wood surface, where lower levels of *Salmonella* were recovered.

7. IMPLICATIONS

The transfer of bacteria from raw meat to various typical kitchen surfaces has been demonstrated in this study. It appears that different meat types and different pieces of the same meat type transfer different levels of contamination, but this would be expected. However, the levels of contamination were in some cases high and despite a decline in levels over time, high levels of TVC still persisted.

The transfer of bacteria onto surfaces could lead to cross contamination issues if this surface was then used to prepare food which needed no further preparation. This cross-contamination could occur directly after meat preparation or for more than 48 h after initial preparation.

This first part of the study focussed on TVC and Enterobacteriaceae level and indicated the potential for pathogens such as *Salmonella* and *Campylobacter* to be transferred from raw meat to chopping board surfaces and persist for long periods of time.

It was demonstrated that cross-contamination of bacteria from raw meat to chopping boards can occur. It is, therefore, possible that pathogens could be spread in this manner and increase the risk of food poisoning. The pathogen study showed that inoculated *Salmonella* and *E. coli* O157 could survive for 48 h on typical kitchen surfaces, but that *Campylobacter* was not recovered easily. This is in contrast to Humphrey *et al*. (2001) in their study of the spread of *Campylobacter* in the kitchen environment suggested that food poisoning could be linked to spread of *Campylobacter* from raw poultry to kitchen surfaces. Cogan *et al*. (1999) suggested that cleaning regime is important and described work which indicated that 38% of chopping boards could be contaminated with *Campylobacter* straight after chicken preparation. However, cleaning with hot water and detergent decreased this to 5% and after use of chlorine based disinfectant, no *Campylobacter* was detected. They also found similar results for *Salmonella*. This indicated the importance of cleaning regimes and also highlighted the risk of cross-contamination. It has been demonstrated in this study that high levels (10^3 cfu/4 cm^2) of *Salmonella* and *E. coli* O157 could survive for 48 h on typical kitchen surfaces.

Therefore, this study highlights the need to ensure that chopping boards are thoroughly cleaned after use with raw meat. It has been demonstrated that in terms of transfer of bacteria onto the surface, none of the chopping boards tested were better than another. However, the various surfaces may differ in cleanability but this has not been covered in this study.

This study confirms the findings of Newsholme *et al.* (2002) where chopping boards and surfaces were identified as a potential source of cross-contamination.

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