CHAPTER 4
RESULTS

Before sampling, slaughtering procedures were observed in 10 pig slaughterhouses. In the hoisting slaughterhouse, pigs were stunned by electrical tongs, whereas in the 9 floor-dressing slaughterhouses, 2 slaughterhouses did stun animals by head-hitting with hammers whilst the 7 other slaughterhouses did not stun animals at all before bleeding. The floor-dressing slaughterhouses in Hanoi lack elementary animal welfare practice.

The total of 508 samples, consisting of 254 samples collected before cleaning and sanitation and 254 samples collected after cleaning and sanitation, were investigated for their number of Enterobacteriaceae. All samples were positive with Enterobacteriaceae.

4.1 Enterobacteriaceae counts altogether

The mean values of 508 Enterobacteriaceae positive samples were different between sampling sites as well as between individual slaughterhouses. The Enterobacteriaceae count data altogether are shown in Table 5 and Table 6.

4.1.1 Enterobacteriaceae counts before cleaning and sanitation

The mean values of Enterobacteriaceae from different areas and equipment altogether before cleaning and sanitation are shown in Table 5.

Table 5 Enterobacteriaceae counts altogether before cleaning and sanitation

SLH No.	1	2	3	4	5	6	7	8	9	10	Overall mean	Unit
Floor 2a*				4.46 (n=5)	4.24 (n=4)	4.25 (n=5)					*4.32*	$\log_{10}$ cfu/cm^2
Pig pen a	2.25 (n=5)	3.27 (n=5)	3.50 (n=5)	4.82 (n=5)	5.18 (n=4)	5.07 (n=5)	3.69 (n=5)	4.82 (n=5)	3.69 (n=5)	5.17 (n=5)	*4.15*	$\log_{10}$ cfu/cm^2
Floor 1a	3.03 (n=5)	2.87 (n=5)		4.41 (n=5)	4.87 (n=4)	4.46 (n=5)	2.76 (n=5)	2.85 (n=5)	2.89 (n=5)	3.54 (n=5)	*3.49*	$\log_{10}$ cfu/cm^2
Wooden board a	2.44 (n=5)	2.80 (n=5)								4.41 (n=5)	*3.22*	$\log_{10}$ cfu/cm^2
Scale a	2.16 (n=5)	1.63 (n=5)		4.75 (n=5)	4.43 (n=5)	4.39 (n=5)	1.81 (n=5)	2.71 (n=5)	2.22 (n=5)	2.84 (n=5)	*2.99*	$\log_{10}$ cfu/cm^2
Table a									1.99 (n=4)		*1.99*	$\log_{10}$ cfu/cm^2
Knife 1a			2.96 (n=5)	5.73 (n=5)	5.10 (n=5)	5.46 (n=5)	3.12 (n=5)	3.88 (n=5)	3.30 (n=5)	4.43 (n=5)	*4.25*	$\log_{10}$ cfu/ml
Knife 4a	3.22 (n=5)	3.44 (n=5)									*3.33*	$\log_{10}$ cfu/ml
Hook a			2.31 (n=5)					4.28 (n=3)			*3.30*	$\log_{10}$ cfu/ml
Knife 2a			2.91 (n=5)								*2.91*	$\log_{10}$ cfu/ml
Knife 3a							2.45 (n=5)	3.65 (n=5)	2.11 (n=5)		*2.74*	$\log_{10}$ cfu/ml
Saw a			2.01 (n=5)								*2.01*	$\log_{10}$ cfu/ml

(*a: before C&S)

Values are reported in $\log_{10}$ cfu/cm^2 for the first 6 sample sites and in $\log_{10}$ cfu/ml for the second 6 sample sites. The overall means for each sample site were used to rank the Enterobacteriaceae loads in descending order. 2 'clusters' of sample sites in regards to their Enterobacteriaceae contaminations are suggested: The summarized values for the direct 'animal-related' sites such as floors, pig pens and knives were noticeable higher, while lower average bacterial contaminations were noticed for the 'meat-processing' sites boards, scales, table, saw. Allowing for some variability, this pattern holds true for the majority of the 10 study slaughterhouses; only a small number of slaughterhouses (2 to 3) does indicate some 'systemic' trend towards overall lower values, although this effect was only exhibited for single individual, not for all sites. Slaughterhouse 1 overall showed a slightly better situation than the other 9 slaughterhouses. Comparison of contamination levels at different sample sites is limited by the fact that in all slaughterhouses only a maximum of 50% of the sites (6 of 12 sites) could be sampled.

4.1.2 Enterobacteriaceae counts after cleaning and sanitation

The average numbers of Enterobacteriaceae from identical areas and equipment sampled during the slaughter process (Table 5) were re-sampled in each slaughterhouse after cleaning and sanitation. Results are contained in Table 6.

Table 6 Enterobacteriaceae counts altogether after cleaning and sanitation

SLH	1	2	3	4	5	6	7	8	9	10	Overall mean	Unit
Floor 2b*				4.15 (n=5)	4.05 (n=5)	3.56 (n=5)					*3.92*	$\log_{10}$ cfu/cm^2
Pig pen b	2.01 (n=5)	2.61 (n=5)	2.16 (n=5)	3.95 (n=4)	4.02 (n=5)	4.12 (n=5)	3.02 (n=5)	3.55 (n=5)	1.93 (n=5)	4.53 (n=5)	*3.19*	$\log_{10}$ cfu/cm^2
Wooden board b	2.73 (n=5)	2.85 (n=5)								3.81 (n=5)	*3.13*	$\log_{10}$ cfu/cm^2
Floor 1b	1.76 (n=5)	2.18 (n=5)		4.36 (n=5)	4.45 (n=4)	3.69 (n=5)	2.76 (n=5)	3.19 (n=5)	2.44 (n=5)	3.29 (n=5)	*2.99*	$\log_{10}$ cfu/cm^2
Scale b	1.22 (n=5)	1.86 (n=4)		3.44 (n=5)	3.90 (n=4)	4.67 (n=5)	1.07 (n=4)	2.08 (n=5)	1.47 (n=5)	2.43 (n=5)	*2.43*	$\log_{10}$ cfu/cm^2
Table b									0.53 (n=4)		*0.53*	$\log_{10}$ cfu/cm^2
Knife 1b			1.84 (n=5)	5.18 (n=4)	5.22 (n=5)	4.96 (n=5)	2.11 (n=5)	3.91 (n=5)	3.02 (n=5)	3.75 (n=5)	*3.75*	$\log_{10}$ cfu/ml
Knife 3b							1.88 (n=5)	3.51 (n=5)	2.59 (n=5)		*2.66*	$\log_{10}$ cfu/ml
Hook b			1.44 (n=5)					3.65 (n=5)			*2.55*	$\log_{10}$ cfu/ml
Knife 4b	2.06 (n=5)	2.57 (n=5)									*2.31*	$\log_{10}$ cfu/ml
Knife 2b			2.15 (n=5)								*2.15*	$\log_{10}$ cfu/ml
Saw b			0.70 (n=5)								*0.70*	$\log_{10}$ cfu/ml

(*b: after C&S)

The table repeats the ranking of overall Enterobacteriaceae loads among sample sites of Table 5 for sites for which the bacterial loads were calculated in log_{10} cfu/cm^2 (upper part of table) and for bacterial numbers of sites in log_{10} cfu/ml (lower part). Cleaning and sanitation did reduce Enterobacteriaceae number somewhat but only to a low extent; mean numbers of log_{10} cfu/cm^2 were reduced between 0.09 and 0.96 log_{10} cfu/cm^2 and reductions of log_{10} cfu/ml were in the range of 0.08 to 0.75 log_{10} cfu/ml. For the notoriously highly contaminated sites floors and pig pens, average reduction was 0.7 log_{10} cfu/cm^2. On the other end of the scale (boards, scales, table), reductions were in the range of 0.5 log_{10} cfu/cm^2.

More important, the principal differentiation between higher contaminated 'animal-related' sites and somewhat lower contaminated 'meat-processing' sites was maintained despite cleaning. Obviously, some kind of overall 'cleaning' was undertaken, but no particular attention was paid to notorious risk sites.

4.2 Enterobacteriaceae counts between before and after cleaning and sanitation from the individual slaughterhouses

Enterobacteriaceae counts in different areas and on equipment of each slaughterhouse before and after cleaning and sanitation were compared using Student's *t*-test analysis. The results are shown in Tables 7a, 7b and 7c.

Table 7a Comparison of Enterobacteriaceae counts between before and after cleaning and sanitation (in $\log_{10}$ cfu/cm^2 resp.ml) in slaughterhouses 1, 2 and 3

SLH	**1**			**2**			**3**		
	a*	**b***	***p value***	**a**	**b**	***p value***	**a**	**b**	***p value***
Pig pen	2.25 (n=5)	2.01 (n=5)	*0.4787*	3.27 (n=5)	2.61 (n=5)	*0.1960*	3.50 (n=5)	2.16 (n=5)	*0.0388*
Floor 1	3.03 (n=5)	1.76 (n=5)	*0.0540*	2.87 (n=5)	2.18 (n=5)	*0.0532*			
Floor 2									
Wooden board	2.44 (n=5)	2.73 (n=5)	*0.5758*	2.80 (n=5)	2.85 (n=5)	*0.9381*			
Table									
Scale	2.16 (n=5)	1.22 (n=5)	*0.1742*	1.63 (n=5)	1.86 (n=4)	*0.5507*			
Knife 1							2.96 (n=5)	1.84 (n=5)	*0.0078*
Knife 2							2.91 (n=5)	2.15 (n=5)	*0.1725*
Knife 3									
Knife 4	3.22 (n=5)	2.06 (n=5)	*0.0671*	3.44 (n=5)	2.57 (n=5)	*0.0539*			
Hook							2.31 (n=5)	1.44 (n=5)	*0.0372*
Saw							2.01 (n=5)	0.70 (n=5)	*0.0290*

(*a: before C&S; *b: after C&S; p value by Student's *t*-test)

Table 7b Comparison of Enterobacteriaceae counts between before and after cleaning and sanitation (in $\log_{10}$ cfu/cm^2 resp.ml) in slaughterhouses 4, 5 and 6

SLH	**4**			**5**			**6**		
	a	**b**	***p value***	**a**	**b**	***p value***	**a**	**b**	***p value***
Pig pen	4.82 (n=5)	3.95 (n=4)	*0.4596*	5.18 (n=4)	4.02 (n=5)	*0.1517*	5.07 (n=5)	4.12 (n=5)	*0.0772*
Floor 1	4.41 (n=5)	4.36 (n=5)	*0.9372*	4.87 (n=4)	4.45 (n=4)	*0.4518*	4.46 (n=5)	3.69 (n=5)	*0.1492*
Floor 2	4.46 (n=5)	4.15 (n=5)	*0.5085*	4.24 (n=4)	4.05 (n=5)	*0.7464*	4.25 (n=5)	3.56 (n=5)	*0.1590*
Wooden board									
Table									
Scale	4.75 (n=5)	3.44 (n=4)	*0.2054*	4.43 (n=5)	3.90 (n=4)	*0.3437*	4.39 (n=5)	4.67 (n=5)	*0.5428*
Knife 1	5.73 (n=5)	5.18 (n=5)	*0.2341*	5.10 (n=5)	5.22 (n=5)	*0.6653*	5.46 (n=5)	4.96 (n=5)	*0.4616*
Knife 2									
Knife 3									
Knife 4									
Hook									
Saw									

Table 7c Comparison of Enterobacteriaceae counts between before and after cleaning and sanitation (in $\log_{10}$ cfu/cm^2 resp.ml) in slaughterhouses 7, 8, 9 and 10

SLH	7			8			9			10		
	a	**b**	***p value***	**a**	**b**	***p value***	**a**	**b**	***p value***	**a**	**b**	***p value***
Pig pen	3.69 (n=5)	3.02 (n=5)	*0.1079*	4.82 (n=5)	3.55 (n=5)	*0.0306*	3.69 (n=5)	1.93 (n=5)	*0.0039*	5.17 (n=5)	4.53 (n=5)	*0.0073*
Floor 1	2.76 (n=5)	2.76 (n=5)	*0.1323*	2.85 (n=5)	3.19 (n=5)	*0.5403*	2.89 (n=5)	2.44 (n=5)	*0.2743*	3.54 (n=5)	3.29 (n=5)	*0.5293*
Floor 2												
Wooden board										4.41 (n=5)	3.81 (n=5)	*0.1113*
Table							1.99 (n=4)	0.53 (n=4)	*0.0029*			
Scale	1.81 (n=5)	1.15 (n=5)	*0.0059*	2.71 (n=5)	2.08 (n=5)	*0.2406*	2.22 (n=5)	1.47 (n=5)	*0.0276*	2.84 (n=5)	2.43 (n=5)	*0.3674*
Knife 1	3.12 (n=5)	2.11 (n=5)	*0.2243*	3.88 (n=5)	3.91 (n=5)	*0.9354*	3.30 (n=5)	3.02 (n=5)	*0.5592*	4.43 (n=5)	3.75 (n=5)	*0.0787*
Knife 2												
Knife 3	2.45 (n=5)	1.88 (n=5)	*0.1973*	3.65 (n=5)	3.51 (n=5)	*0.7741*	2.11 (n=5)	2.59 (n=5)	*0.1717*			
Knife 4												
Hook				4.28 (n=3)	3.65 (n=5)	*0.6432*						
Saw												

In none of the 10 slaughterhouses, a significant reduction of Enterobacteriaceae was achieved after cleaning and sanitation. The best slaughterhouse was the hoisting one (No. 3), where cleaning and sanitation led to significant reduction of Enterobacteriaceae ($p<0.05$) at least at 4 of the 5 sampling sites. On the other end, no reduction at all was achieved in 5 of the 10 slaughterhouses at none of the sites. The other 4 slaughterhouses experienced only individual improvements at single (often only 1) sites.

4.3 Enterobacteriaceae in the hoisting system versus the floor-dressing system

The mean values of Enterobacteriaceae from the individual sample sites before cleaning and sanitation are shown in Tables 8a and 8b for the 10 pig slaughterhouses. Table 8a contains data for the single hoisting slaughterhouse, Table 8b summaries for the 9 floor-dressing slaughterhouses. The data was irrespective of the type of floor-dressing slaughterhouses.

Table 8a Means of Enterobacteriaceae colonies before and after cleaning and sanitation (in $\log_{10}$ cfu/cm^2 resp.ml) in the hoisting slaughterhouse

Site	n	Mean	95% CI*
Pen a*	5	3.50	2.65 – 4.35
Knife 1a	5	2.96	2.48 – 3.43
Knife 2a	5	2.91	2.54 – 3.28
Hook a	5	2.31	1.61 – 3.00
Saw a	5	2.01	1.38 – 2.65
Pen b*	5	2.16	1.00 – 3.32
Knife 1b	5	1.84	1.08 – 2.60
Knife 2b	5	2.15	0.85 – 3.44
Hook b	5	1.44	0.47 – 2.42
Saw b	5	0.70	0.20 – 1.20

(*a: before C&S; *b: after C&S; *CI: Confidence Interval).

For none of the sample sites, an overall effective reduction in the numbers of Enterobacteriaceae was achieved. The cleaning efficacy was particularly low with the trimming knife (average reduction from 2.91 to 2.15 = only 26%), highest with the saw (65% reduction), and only led to 38% reductions at the other sites (pen, knife 1).

Table 8b Mean values of Enterobacteriaceae before and after cleaning and sanitation (in $\log_{10}$ cfu/cm^2 resp.ml) in all 9 floor-dressing slaughterhouses

Site	n	Mean	95% CI*
Pen a*	44	4.20	3.84 – 4.56
Floor 1a	44	3.49	3.16 – 3.82
Floor 2a	14	4.32	3.85 – 4.80
Board a	15	3.22	2.48 – 3.95
Table a	4	1.99	1.13 – 2.84
Scale a	45	2.99	2.60 – 3.39
Knife 1a	35	4.43	3.98 – 4.89
Knife 3a	15	2.74	2.17 – 3.30
Knife 4a	10	3.33	2.72 – 3.95
Hook a	3	4.28	1.03 – 7.52
Pen b*	44	3.29	2.91 – 3.68
Floor 1b	44	2.99	2.61 – 3.38
Floor 2b	15	3.92	3.18 – 4.66
Board b	15	3.13	2.61 – 3.65
Table b	4	0.53	0.03 – 1.19
Scale b	42	2.43	1.96 – 2.91
Knife 1b	35	4.02	3.49 – 4.55
Knife 3b	15	2.66	1.99 – 3.34
Knife 4b	10	2.31	1.56 – 3.06
Hook b	5	3.65	1.27 – 6.04

(*a: before C&S; *b: after C&S; *CI: Confidence Interval).

In the floor-dressing slaughterhouses, cleaning and sanitation effect was poorer than in the hoisting slaughterhouse, the best average reduction was achieved with the meat cutting table (73% reduction), about 10% to 30% reduction of Enterobacteriaceae with the pig pen, floor for evisceration (floor 1), floor for carcass splitting (floor 2), weighing scale, eviscerating knife (knife 1), offal separating knife (knife 4) and hooks. Meanwhile, there was only 3% reduction with the wooden board and carcass splitting knife.

4.4 Enterobacteriaceae counts by seasons

The study was conducted in the wintertime (from December to January) in slaughterhouses No. 1, 2 and 3, and in the remaining slaughterhouses in the spring (from February to April).

Because of sampling reason, not all sample sites in floor-dressing slaughterhouses could be compared. Results for Enterobacteriaceae counts by these seasons are contained in Table 9. Reported are results for the summarized 9 floor-dressing slaughterhouses.

Table 9 Enterobacteriaceae counts in floor-dressing slaughterhouses by seasons (in $\log_{10}$ cfu/cm^2)

Site	Winter	Spring	*p value*
Pen a*	2.76 (n=10)	4.62 (n=34)	*0.0000*
Floor 1a	2.95 (n=10)	3.65 (n=34)	*0.0735*
Board a	2.62 (n=10)	4.41 (n=5)	*0.0073*
Scale a	1.90 (n=10)	3.31 (n=35)	*0.0021*
Pen b*	2.31 (n=10)	3.57 (n=34)	*0.0001*
Floor 1b	1.97 (n=10)	3.30 (n=34)	*0.0000*
Board b	2.79 (n=10)	3.81 (n=5)	*0.0429*
Scale b	1.53 (n=9)	2.68 (n=33)	*0.0054*

(*a: before C&S; *b: after C&S; p value by Independent t-test)

Enterobacteriaceae counts throughout were lower (in 7 of 8 sites significantly lower) in winter compared to spring. Cleaning, already identified as insufficient, did reduce numbers slightly in either season, but the major effect on Enterobacteriaceae loads was exerted by climatic conditions (lower temperature) in the winter. The winter season in consequence did exert a better effect on Enterobacteriaceae reductions than the cleaning and sanitation measures undertaken.

4.5 Enterobacteriaceae counts in different types of slaughterhouse

Five types of floor-dressing slaughterhouse as described in Table 2 were compared. Each of them acted slight differently as indicated in Table 10, the average Enterobacteriaceae counts at the sampling sites are differentiated for the 5 floor-dressing slaughterhouse types.

Table 10a Mean values of Enterobacteriaceae in 5 types of floor-dressing slaughterhouse before cleaning and sanitation (in $\log_{10}$ cfu/cm^2 resp.ml)

Type of SLH	**Pen a***	**Floor 1a**	**Floor 2a**	**Board a**	**Scale a**	**Knife 1a**	**Knife 4a**
1 (SLH 1)	2.25 (n=5)	3.03 (n=5)		2.44 (n=5)	2.16 (n=5)		3.22 (n=5)
2 (SLH 2)	3.27 (n=5)	2.87 (n=5)		2.80 (n=5)	1.63 (n=5)		3.44 (n=5)
3 (SLH 3)	4.82 (n=5)	4.41 (n=5)	4.46 (n=5)		4.75 (n=5)	5.73 (n=5)	
4 (SLH 7,8,9)	4.07 (n=15)	2.84 (n=15)			2.25 (n=15)	3.43 (n=15)	
5 (SLH 5,6,10)	5.14 (n=14)	4.25 (n=14)	4.25 (n=9)	4.41 (n=5)	3.89 (n=15)	5.00 (n=15)	
p value	*0.0000*	*0.0002*	*0.6662*	*0.0277*	*0.0000*	*0.0000*	*0.7106*

(*a: before C&S; p value by ANOVA test)

Type:

1 = rough floor, hot water use for scalding, low water pressure

2 = smooth floor, hot water use for scalding, low water pressure

3 = smooth floor, dipping of carcass for scalding, low water pressure

4 = smooth floor, dipping of carcass for scalding, high water pressure

5 = rough floor, dipping of carcass for scalding, low water pressure

The effect of 'management' of a slaughterhouse on the Enterobacteriaceae load was visible. In all floor-dressing slaughterhouses, particular problem sites like knives and floors were detected. However, individual slaughterhouses at individual sites and in total were worse than others; their bacterial load at all sampling sites was particularly high, obviously due to neglect of 'management'. Slaughterhouse types 3 and 5 were particularly poor in this respect.

Table 10b Mean values of Enterobacteriaceae in 5 types of floor-dressing slaughterhouse after cleaning and sanitation (in $\log_{10}$ cfu/cm^2 resp.ml)

Type of SLH	**Pen b***	**Floor 1b**	**Floor 2b**	**Board b**	**Scale b**	**Knife 1b**	**Knife 4b**
1 (SLH 1)	2.01 (n=5)	1.76 (n=5)		2.73 (n=5)	1.22 (n=5)		2.06 (n=5)
2 (SLH 2)	2.61 (n=5)	2.18 (n=5)		2.85 (n=5)	1.86 (n=4)		2.57 (n=5)
3 (SLH 3)	3.95 (n=4)	4.36 (n=5)	4.15 (n=5)		3.44 (n=5)	5.18 (n=4)	
4 (SLH 7,8,9)	2.83 (n=15)	2.50 (n=15)			1.57 (n=14)	3.01 (n=15)	
5 (SLH 5,6,10)	4.22 (n=15)	3.76 (n=14)	3.80 (n=10)	3.81 (n=5)	3.65 (n=14)	4.64 (n=15)	
p value	*0.0003*	*0.0001*	*0.6521*	*0.1366*	*0.0001*	*0.0012*	*0.4702*

(*b: after C&S; p value by ANOVA test)

Type:

1 = rough floor, hot water use for scalding, low water pressure

2 = smooth floor, hot water use for scalding, low water pressure

3 = smooth floor, dipping of carcass for scalding, low water pressure

4 = smooth floor, dipping of carcass for scalding, high water pressure

5 = rough floor, dipping of carcass for scalding, low water pressure

In re-sampling sites of slaughterhouses after cleaning and sanitation, the effect of missing or neglected ‘management’ (Table 10a.) is repeated. Again, differences for individual sites were apparent among the floor-dressing slaughterhouse types. More important, the slaughterhouse types 3 and 5, identified as particularly ‘unhygienic’ before, did not improve their hygienic situation with cleaning. These 2 types of floor-dressing slaughterhouse did maintain their status of having highest Enterobacteriaceae loads over all sampling sites. Effects of a particular efficient cleaning, suggested necessary from their pre-cleaning situation, were not visible for these two types.

4.5.1 Enterobacteriaceae loads in the hoisting slaughterhouse

In order to identify specific sites for Enterobacteriaceae contamination during the slaughtering process as well as after cleaning and sanitation in the hoisting slaughterhouse, the mean values at each sampling sites were compared (Table 11). Because the unit for Enterobacteriaceae counts in pig pen was in $\log_{10}$ cfu/cm^2, different to hooks, knife 1, knife 2 and saw (in $\log_{10}$ cfu/ml), therefore Enterobacteriaceae counts were compared on such equipment only.

The data in Table 11 are identical in Table 7a (SLH 3) and Table 8a, but data appear again in terms of comparison of Enterobacteriaceae counts between equipment in the hoisting slaughterhouse.

Table 11 Comparison of Enterobacteriaceae counts (EC) on equipment before and after cleaning and sanitation in the hoisting slaughterhouse (in $\log_{10}$ cfu/ml)

Equipment	**Hook a***	**Knife 1a**	**Knife 2a**	**Saw a**	***p1 value***
Mean of EC	2.31 (n=5)	2.96 (n=5)	2.91 (n=5)	2.01 (n=5)	*0.0106*
Equipment	**Hook b***	**Knife 1b**	**Knife 2b**	**Saw b**	***p1 value***
Mean of EC	1.44 (n=5)	1.84 (n=5)	2.15 (n=5)	0.70 (n=5)	*0.0400*
p2 value	*0.0372*	*0.0078*	*0.1725*	*0.0290*	

(*a: before C&S; *b: after C&S; p1 value by ANOVA test; p2 value by Student's *t*-test)

Here, the overall reduction of Enterobacteriaceae contamination, achieved by cleaning, was 40% (calculated from proportion of overall mean values of after cleaning and sanitation and before cleaning and sanitation). The statistical differences between sites before and after cleaning do not reflect the effect of the kind of cleaning carried out on the Enterobacteriaceae numbers: best effect with 65% reduction was achieved for the saw, reductions for hooks (43%), knife 1 (38%) and knife 2 (26%) were much lower.

4.5.2 Enterobacteriaceae counts in sites and on equipment within each type of floor-dressing slaughterhouse

Assessments for specific sites for Enterobacteriaceae contamination during the slaughtering process as well as after cleaning and sanitation were carried out for the floor-dressing slaughterhouses. The categorization of slaughterhouses into their 5 types was used for this purpose.

4.5.2.1 Type 1 slaughterhouse (rough floor, hot water use for scalding, low water pressure)

There was only one investigated slaughterhouse belonging to type 1.

Table 12a Comparison of Enterobacteriaceae counts (EC) by sites before and after cleaning and sanitation in type 1 floor-dressing slaughterhouse (in log_{10} cfu/cm^2)

Site	**Pen a***	**Floor 1a**	**Board a**	**Scale a**	***p1 value***
Mean of EC	2.25 (n=5)	3.03 (n=5)	2.44 (n=5)	2.16 (n=5)	*0.4271*
Site	**Pen b***	**Floor 1b**	**Board b**	**Scale b**	***p1 value***
Mean of EC	2.01 (n=5)	1.76 (n=5)	2.73 (n=5)	1.22 (n=5)	*0.0448*
p2 value	*0.4787*	*0.0540*	*0.5758*	*0.1742*	

(*a: before C&S; *b: after C&S; p1 value by ANOVA test; p2 value by t-test)

Overall cleaning efficiency was 22%. For no site statistically significant reductions in the bacterial loads could be recorded. Reductions were 11% for the pig pen, 42% for the eviscerating floor and 44% for the scale. For the wooden board, Enterobacteriaceae numbers after cleaning were even higher than during the slaughter process.

4.5.2.2 Type 2 slaughterhouse (smooth floor, hot water use for scalding, low water pressure)

There was one slaughterhouse belonging to type 2 in this study.

Table 12b Comparison of Enterobacteriaceae counts (EC) by sites before and after cleaning and sanitation in type 2 floor-dressing slaughterhouse (in log_{10} cfu/cm^2)

Site	**Pen a***	**Floor 1a**	**Board a**	**Scale a**	***p1 value***
Mean of EC	3.27 (n=5)	2.87 (n=5)	2.80 (n=5)	1.63 (n=5)	*0.0462*
Site	**Pen b***	**Floor 1b**	**Board b**	**Scale b**	***p1 value***
Mean of EC	2.61 (n=5)	2.18 (n=5)	2.85 (n=5)	1.86 (n=4)	*0.2440*
p2 value	*0.1960*	*0.0532*	*0.9381*	*0.5507*	

(*a: before C&S; *b: after C&S; p1 value by ANOVA test; p2 value by t-test)

In type 2, only 10% reduction of Enterobacteriaceae was achieved. Low reductions of 20% for the pen and 24% for the eviscerating floor were recorded. The obvious poor execution of cleaning is underlined by the fact that Enterobacteriaceae loads of the board and scale were even increased as an effect of the cleaning, rather than reduced.

4.5.2.3 Type 3 slaughterhouse (smooth floor, dipping of carcass for scalding, low water pressure)

There was one visited slaughterhouse belonging to type 3.

Table 12c Comparison of Enterobacteriaceae counts (EC) by sites before and after cleaning and sanitation in type 3 floor-dressing slaughterhouse (in $\log_{10}$ cfu/cm^2)

Site	**Pen a***	**Floor 1a**	**Floor 2a**	**Scale a**	***p1 value***
Mean of EC	4.82 (n=5)	4.41 (n=5)	4.46 (n=5)	4.75 (n=5)	*0.9090*
Site	**Pen b***	**Floor 1b**	**Floor 2b**	**Scale b**	***p1 value***
Mean of EC	3.95 (n=4)	4.36 (n=5)	4.15 (n=5)	3.44 (n=5)	*0.8524*
p2 value	*0.4596*	*0.9372*	*0.5085*	*0.2054*	

(*a: before C&S; *b: after C&S; p1 value by ANOVA test; p2 value by t-test)

In type 3 slaughterhouse, Enterobacteriaceae loads in total for the 4 sample sites were only reduced by 14%. Site-specific reductions, none of them statistically significant, were 18% for the pig pen, a very low 1% for the eviscerating floor (floor 1), 7% for the carcass splitting floor (floor 2) and 28% for the carcass weighing scale.

4.5.2.4 Type 4 slaughterhouse (smooth floor, dipping of carcass for scalding, high water pressure)

In the study, there were three slaughterhouses belonging to type 4. All of them are modern slaughterhouses, but they used floor dressing method for pig slaughtering instead of overhead rail system because of their saving expenditure on energy, maintenance and hygiene measures.

Table 12d Comparison of Enterobacteriaceae counts (EC) by sites and equipment before and after cleaning and sanitation in type 4 floor-dressing slaughterhouse (in $\log_{10}$ cfu/cm^2 resp.ml)

Site	**Pen a***	**Floor 1a**	**Scale a**	***p1 value***
Mean of EC	4.07 (n=15)	2.84 (n=15)	2.25 (n=15)	*0.0000*
Site	**Pen b***	**Floor 1b**	**Scale b**	***p1 value***
Mean of EC	2.83 (n=15)	2.50 (n=15)	1.57 (n=14)	*0.0002*
p2 value	*0.0001*	*0.2482*	*0.0009*	
Equipment	**Knife 1a**	**Knife 3a**	**Hook a**	***p1 value***
Mean of EC	3.43 (n=15)	2.74 (n=15)	4.28 (n=3)	*0.0394*
Equipment	**Knife 1b**	**Knife 3b**	**Hook b**	***p1 value***
Mean of EC	3.01 (n=15)	2.66 (n=15)	3.65 (n=5)	*0.4066*
p2 value	*0.1766*	*0.7513*	*0.6432*	

(*a: before C&S; *b: after C&S; p1 value by ANOVA test; p2 value by t-test)

For type 4 slaughterhouses, comparisons were carried out for 6 sampling sites. Only 17% reduction is recorded for this type among all sample sites. p-values for pen and scale note that Enterobacteriaceae counts statistically were significantly reduced, the percentage reductions at these 2 sites, however, were only 30%. Average reduction rates for the other sites were 12% for floors 1, 12% for knives 1, 3% for knives 3 and 15% for hooks.

4.5.2.5 Type 5 slaughterhouse (rough floor, dipping of carcass for scalding, low water pressure)

There were also three floor-dressing slaughterhouses belonging to type 5. Respective comparisons for the last slaughterhouse type are contained in Table 12e. Cleaning led to an overall reduction in the number of Enterobacteriaceae of only 12%. A particular low reduction of only 6% was recorded for scales, reductions, in descending order, for pens, board, floors 1 and floors 2 were 18%, 14%, 12% and 11%, respectively.

Table 12e Comparison of mean values of Enterobacteriaceae (EC) by sites before and after cleaning and sanitation in type 5 floor-dressing slaughterhouse (in $\log_{10}$ cfu/cm^2)

Site	**Pen a***	**Floor 1a**	**Floor 2a**	**Board a**	**Scale a**	***p1 value***
Mean of EC	5.14 (n=14)	4.25 (n=14)	4.25 (n=9)	4.41 (n=5)	3.89 (n=15)	0.0034
Site	**Pen b***	**Floor 1b**	**Floor 2b**	**Board b**	**Scale b**	***p1 value***
Mean of EC	4.22 (n=15)	3.76 (n=14)	3.80 (n=10)	3.81 (n=5)	3.65 (n=14)	0.6854
p2 value	*0.0171*	*0.9850*	*0.3596*	*0.1113*	*0.2699*	

(*a: before C&S; *b: after C&S; p1 value by ANOVA test; p2 value by t-test)