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Microbiological Contamination of Carcasses Related to Hygiene Practice and Facilities on Slaughtering Lines

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Rahkio, M. and H. Korkeala: Microbiological contamination of carcasses related to hygiene practice and facilities on slaughtering lines. Acta vet. scand. 1996, 37, 219–228. – The purpose of the study was to investigate the association between the hygienic practice of slaughterhouse workers and the microbiological contamination level of carcasses. In 5 Finnish slaughterhouses the workers' hygienic practice was observed and the carcasses were sampled by the swabbing method. The overall means ($\log_{10}$ cfu cm^{-2}) of the aerobic plate count in pork and beef carcasses were 3.23 and 2.65, respectively. Hygienic practice was found to be associated with the carcass contamination level, especially the disinfection frequency. In those slaughterhouses, where the disinfection frequency was low, the contamination level of carcasses was high. Designing slaughtering lines so as to make hygienic working possible is evidently very important. However, the enforcement of hygienic practice, such as the regular disinfection of working tools, is also important in reducing the microbiological contamination of carcasses.

slaughterhouse; working methods; pork; beef.

Introduction

It has been shown by many studies that slaughtering under strict sanitary conditions reduces the bacterial contamination of the carcasses *(Hess & Lott* 1970, *Smulders & Woolthuis* 1983, *Chandran et al.* 1986, *Dixon et al.* 1991). *Gerats et al.* (1982), however, pointed out that most studies of slaughtering hygiene have been carried out under experimental or laboratory-like conditions. According to *Gerats et al.* (1982), the slaughtering methods used in these studies are too complex to be adopted in daily practice, and thus seldom result in permanent improvements in slaughter hygiene. To reduce the level of carcass contamination, more research is needed concerning working methods suitable for practical use. According to *Schutz* (1991) the occurrence of hygienic faults and of a high level of microbiological contamination of carcasses in slaughterhouses are due, not to an absence of hygiene equipment or to failure to use what equipment there is, but rather to faulty slaughter techniques. The spread of pathogens can also be reduced by developing slaughter technique. Especially the technique of removing tonsils from pigs *(Christensen & Lüthje* 1994) and of enclosing the rectum *(Andersen et al.* 1991) has reduced the pathogen contamination. According to *Gerats* (1990), there is an association between slaughter technique and the hygienic practice of workers. Those workers who commit many slaughter mistakes neglect hygienic practices. *Gerats et al.* (1981) have found an association between the number of *Enterobacteriaceae* in pig carcasses and hygiene practices connected with slaughter mistakes during evisceration.

The hygiene practice of slaughterhouse workers is regulated in many countries by laws, *(Anon.* 1990, *Schutz* 1991, *Anon.* 1994). The laws do not always distinguish between critical operations and those that have little effect on the hygiene *(Huis in't Veld et al.* 1994). The enactment and fulfilling of these regulations assume more information concerning the current daily hygienic practice of workers. According to findings reported by *Gerats et al.* (1982) and *Stolle & Reuter* (1989) washing and disinfection with hot water seldom take place, and both a strong hygienic disposition and easy access to hygienic facilities are important for hygienic behaviour in slaughterhouses *(Gerats et al.* 1982, *Tazelaar* 1987). However, there are no findings showing an association between daily hygienic routine, excluding slaughter mistakes, and the microbiological contamination of carcasses.

The purpose of this study was to explore the daily hygienic routine of workers, such as washing and disinfection, throughout the entire slaughtering line and to clarify the association between daily hygienic practice and the level of microbiological contamination of the carcasses.

Materials and methods

Working methods

The total number of workers observed in 5 different slaughterhouses was 80, i.e. 15 in slaughterhouse A, 31 in B, 10 in C, 14 in D and 10 in E. In slaughterhouse B, both cattle and pigs were slaughtered continuously during the study; the 2 lines had different workers. In addition to these 2 lines there was a separate line for sows in slaughterhouse B. Sows were not slaughtered continuously, and the workers on this line came from other working points. In the other slaughterhouses there was one line in operation, and the same workers slaughtered both cattle and pigs. These workers were observed separately on both the beef and the pork line. There were no separate lines for sows in slaughterhouses A, C, D and E. The number of observed workers was 26 in pork lines, 47 in beef lines, and 7 in sow line. The workers were observed during several periods of about 15 min each. At least 10 carcasses were handled during each observation period. The workers were observed by the same person (MR).

The hygienic practice of the workers was estimated as the frequency of washing hands, knives and other working tools, and the frequency of disinfecting knives and other working tools with hot water. 12 workers had automated washing for their tools combined with desinfection. These practices were recorded on a three-point scale; after each carcass, after every other carcass, and less often. Incorrect slaughtering technique, such as damaging the intestinal canal, unskilful use of the knife or unhygienic behaviour such as touching the carcasses unnecessarily or nose picking were also recorded. The results of the observations were analysed between the unclean and clean part of the line and between critical and non-critical working points. The division between the unclean and clean part of the line was according to *Snijders et al.* (1984a). Skinning and evisceration were chosen to represent critical working points during slaughter, as suggested by *Mackey & Roberts* (1990).

Hygiene routines, such as the placement of washing basins and facilities for disinfection of knives and other tools, were recorded on a two-point scale: placement close to the working point, so that the worker did not have to move in order to reach the facilities, and placement remote from the working point, necessitating one or more steps in order to reach them. The working time was recorded in terms of the piling up of carcasses at the working point. Working space was measured according to whether the

worker had contact with the walls or other surfaces while operating on the carcass.

Sampling

After observation of the workers' hygienic practices, the contamination level of carcasses was measured in the same 5 slaughterhouses (A, B, C, D, E). Samples were taken from the brisket and shoulder in the beef carcasses and from the neck and abdomen in the pig carcasses after slaughtering before chilling. In slaughterhouse B, sows from separate sow lines were also sampled.

Of the total number of 660 samples, 322 were pork samples, 308 beef samples and 30 sow samples. The samples were taken by a modified version of the moisture swab technique of *Lasta & Fonrouge* (1988). Sterile moisture swabs (3 cm long and 1 cm in diameter) were rubbed over the marked area of 25 cm^2 after another. Area was marked with sterile metallic template, swabs were cut off with sterile scissors and placed in 25 ml of 0.1% peptone water. A 10-fold dilution was made in physiological saline. In order to avoid variation due to swabbing technique, all the samples were taken by the same person (MR). The contamination of the carcasses was determined by plate count agar (Difco, Detroit, USA) for total bacterial count according to *Rahkio et al.* (1992), 72 h at 25°C. When there was no growth in the lowest dilution (10^{-1}), the count was estimated as 5; this estimation accounted for 9 out of 660 samples (1.4%).

Statistical analysis

The statistical analysis of carcass contamination was performed by the two-sample t-test of *Statistical Analysis System* (1985). The association between hygienic practice and carcass contamination was studied by Friedman's rank order analysis of variance *(Danzart* 1987, *Ranta et al.* 1991) with *Statistix* (1992). The averages of hygiene practice observations were summarised as hygiene index and bacterial counts as carcass contamination index. The rank order of the slaughterhouses was based in these 2 indexes. Statistical tests were performed with logarithmic transformations of bacterial counts ($\log_{10}$ cm^{-2}). The statistical analyses of the association between hygienic practice and hygienic facilities were carried out by the two-by-two tables test of *Statistix* (1992). Because of the low expected values, Yates' corrected Chi^2-values were used in determining the statistical significance.

Results

Contamination of carcasses

Results concerning the level of carcass contamination are shown in Table 1. Both beef and pork carcasses were least contaminated in slaughterhouse B. Pork carcasses were significantly ($p<0.05$) more contaminated in slaughterhouses E and C than in other slaughterhouses. Beef carcasses were significantly ($p<0.05$) more contaminated in slaughterhouse E than in the others. The overall mean and standard deviation ($\log_{10}$ cfu cm^{-2}) of the aerobic plate count of sow carcasses from the separate sow line in slaughterhouse B was 3.93 ± 0.17 for neck and 4.39 ± 0.27 for abdomen. The abdominal site of sows slaughtered on this line was thus significantly ($p<0.05$) more contaminated than neck site.

Hygienic practice of workers

Table 2 shows the hygienic practice of workers on the pork and beef lines in 5 slaughterhouses. Two out of the 73 workers (3%) were inexperienced in using the knife. These 2 workers were beginners in slaughtering work; however, they did not damage the carcass. Four workers (5%) behaved in an unhygienic manner, touching the carcasses unnecessarily with the knife. No mis-

Table 1. Mean and standard deviation of bacterial counts (log_{10} cfu cm^{-2}) in pig and beef carcasses at different slaughterhouses.

Slaughterhouse	Pork			Beef		
	No[1]	Neck	Abdomen	No	Shoulder	Brisket
A	30	$3.44\pm.47_{b}$	$3.32\pm.46_{bc}$	30	$2.82\pm .70_{c}$	$3.35\pm.80_{c}$
B	37	$2.23\pm.49_{a}$	$2.72\pm.39_{a}$	37	$1.21\pm .74_{a}$	$1.80\pm.74_{a}$
C	30	$3.75\pm.35_{c}$	$3.22\pm.32_{b}$	30	$2.74\pm .62_{c}$	$3.37\pm.51_{c}$
D	30	$3.42\pm.40_{b}$	$3.26\pm.69_{bc}$	30	$2.21\pm .78_{b}$	$2.84\pm.53_{b}$
E	34	$3.66\pm.49_{b}$	$3.52\pm.40_{c}$	27	$3.14\pm1.32_{c}$	$3.75\pm.59_{d}$
Total	161	$3.27\pm.73_{A}$	$3.20\pm.53_{A}$	154	$2.36\pm1.10_{A}$	$2.95\pm.95_{B}$

[1] Number of samples.
[a-d] Means within a column with different subscripts are significantly different ($p<0.05$).
[A-B] Means within a row with different subscripts are significantly different ($p<0.05$).

takes in slaughter technique, such as penetration of the intestine, were observed.

The hands and the knife were washed often; washing of the other tools, and disinfection of knife or tools, on the other hand, were rare (Table 2). Washing of the hands and knife was most infrequent in slaughterhouses C and D, disinfection of the knife in slaughterhouses C and E. Washing of the tools was most infrequent in slaughterhouses C and E, disinfection in A, C and E. Thirty-six workers on the beef and pork lines used tools other than the knife, and 5 of them operated with 2 or more tools. These 5 workers were never seen to disinfect their tools. Twelve workers had tools with automatic washing and disinfection. The disinfection practices of workers in different working places are shown in Table 3. Only one (5%) of the workers disinfected his tools frequently in the clean part of the line, whereas five (24%) did so in the unclean part. The washing practices did not vary between working places. On the separate sow line, the workers practised hygiene more seldom than the same workers on the beef and pork line. 43% washed their hands and 40% washed their knife after at least every other carcass, whereas 81% and 78% did so on the beef and pork lines. None of the workers on the sow line disinfected their knife after each carcass, whereas 24% did so on the beef and pork line.

Effect of accessibility on hygienic practice

The accessibility of washing facilities was not associated with either the frequency of washing of hands and knife or the frequency of washing of tools when the worker had more than one tool (Table 4). Of the workers with one tool, those who had easy access to washing facilities washed their tools more often than those whose access was more difficult (Table 4). The sufficiency of working space had a same kind of influence on the washing frequency of tools. Of the workers with one tool, those who had non-cramped working point washed their tools more often than those who had cramped working point ($Chi^2 = 4.46$, $p<0.05$). The accessibility of disinfection facilities did have a positive effect on the workers' practices concerning disinfection of the knife and other tools (Table 5). In addition to this the sufficiency of working space was associated with the disinfection frequency of the knife, too ($Chi^2 = 6.40$, $p<0.05$). The disinfection frequency of the knife was also associated with sufficiency of time ($Chi^2 = 11.05$, $p<0.05$).

Table 2. Hygienic practice of workers on pork and beef lines in 5 slaughterhouses.

Hygienic practice /slaughterhouse	Frequency[1]			
	Frequent		Seldom	
Washing hands				
A	15[2]	(100%)	0	(0%)
B	20	(84%)	4	(16%)
C	6	(60%)	4	(40%)
D	8	(57%)	6	(43%)
E	10	(100%)	0	(0%)
All	59	(81%)	14	(19%)
Washing knife				
A	13	(87%)	2	(13%)
B	17	(81%)	4	(19%)
C	5	(63%)	3	(37%)
D	8	(57%)	6	(43%)
E	10	(100%)	0	(0%)
All	53	(78%)	15	(22%)
Disinfection of knife				
A	2	(13%)	13	(87%)
B	9	(43%)	12	(57%)
C	0	(0%)	8	(100%)
D	4	(28%)	10	(72%)
E	1	(10%)	9	(90%)
All	16	(24%)	52	(76%)
Washing other working tools				
A	1	(100%)	0	(0%)
B	3	(30%)	6	(67%)
C	0	(0%)	7	(100%)
D	2	(40%)	3	(60%)
E	0	(0%)	7	(100%)
All	6	(21%)	23	(79%)
Disinfection of working tools				
A	0	(0%)	5	(100%)
B	3	(27%)	8	(72%)
C	0	(0%)	8	(100%)
D	3	(33%)	6	(67%)
E	0	(0%)	8	(100%)
All	6	(15%)	35	(83%)

[1] Washing or disinfection at least after every or every other carcass (frequent) or more seldom (seldom).
[2] Number and percentage (in parenthesis) of workers.

Table 3. Disinfection practice of slaughterhouse workers according to line and working point.

Hygienic practice	Frequency[1]			
	Frequent		Seldom	
Disinfecting knife				
Line				
Pork	4	(17%)	19	(83%)
Beef	12	(27%)	33	(73%)
Part of line				
Unclean	4	(12%)	29	(88%)
Clean	12	(34%)	23	(66%)
Working point				
Critical	6	(27%)	16	(73%)
Non-critical	10	(22%)	36	(78%)
Disinfecting working tool				
Line				
Pork	1	(11%)	8	(89%)
Beef	5	(16%)	27	(84%)
Part of line				
Unclean	5	(24%)	16	(76%)
Clean	1	(5%)	19	(95%)
Working point				
Critical	2	(15%)	11	(85%)
Non-critical	4	(14%)	24	(86%)

[1] Hygienic practice at least after every or every other carcass (frequent) or more seldom (seldom).

Effect of hygienic practice on carcasses

An association was observed between washing and disinfection and carcass contamination. According to Table 6, both carcass contamination and hygienic practice of workers ranked the slaughterhouses in the same way.

Discussion

Both pork and beef carcasses in slaughterhouse B were cleaner than those in the other slaughterhouses and the contamination level was lower compared to results achieved by the swabbing method and published previously in other countries *(Johanson et al.* 1983, *Snijders et al.* 1984b, *Lasta & Fonrouge* 1988). The contamination level of beef carcasses at slaughterhouse B was the same as that reported at Japanese exporting slaughterhouses with a very good hygienic standard, according to *Konuma et al.* (1994).

The level of contamination found in sow carcasses on the separate line at plant B was much higher than the level of contamination of pork carcasses in this study and other studies *(Snijders et al.* 1984b, *Rahkio et al.* 1992). The contamination level of sow carcasses was nearly the same as that reported by *Kitchell et al.* (1973) in the 1970s. The machinery of the separate sow line in slaughterhouse B was from an old pork line used in the 1970s. This suggests that since the 1970s hygienic improvement has taken place in the machinery of the pork line and former pork slaughtering line is not suitable for slaughtering sows. On the other hand, the same workers who practised good hygiene when working on the beef and pork line did not

Table 4. Effect of accessibility of washing facilities on frequency of washing tools.

Washing frequency[1]	Workers with one tool other than knife			Workers with more than one tool other than knife		
	Location of tool washing facilities			Location of tool washing facilities		
	Next to working point	Distant from working point[2]	Total	Next to working point	Distant from working point[2]	Total
Frequent	6 (22%)	1 (4%)	7 (26%)	6 (19%)	1 (3%)	7 (22%)
Seldom	5 (19%)	15 (56%)	20 (74%)	10 (31%)	15 (47%)	25 (78%)
Total	11 (41%)	16 (59%)	27	16 (50%)	16 (50%)	32
Chi^2-test value	5.60 ($p<0.05$)			2.93 ($p>0.05$)		

[1] Washing tools at least after every other carcass (frequent) or more seldom than after every other carcass (seldom).
[2] Worker has to take one or more steps to reach the washing facilities.

do so on the sow line. The cramped working position and the old-fashioned and unhygienic equipment (unpublished data) probably affect the workers' hygienic motivation.

In spite of the fact that no actual slaughter errors were observed, there are still deficiencies in the hygienic practices of workers. About 80% of the workers wash their hands and knives regularly. The disinfection of knife and tools takes place much less often. The hands are probably washed because of the inconvenience of working with dirty and bloody hands, and the knife gets washed at the same time. Neglecting to wash or disinfect the tools does not immediately cause such inconvenience. From the hygienic point of view it was noteworthy that in the clean part of the line, where hygiene should be as strict as possible, disinfection of tools was less frequent than in the unclean part of the line. The present findings indicate that disinfection of the knife and tools seems to be more dependent on the accessibility of facilities and opportunities than is the washing of hands and knife. *Gerats et al.* (1982) found that in particular the cleaning and disinfection of knives was associated with the facilities within reach. In the

Table 5. Effect of accessibility of disinfection facilities on disinfection frequency of knife and tools.

Disinfection frequency[1]	Knife			Other tools than knives		
	Location of disinfection facilities			Location of disinfection facilities		
	Next to working point	Distant from working point[2]	Total	Next to working point	Distant from working point[2]	Total
Frequent	14 (19%)	2 (3%)	16 (22%)	5 (16%)	1 (3%)	6 (19%)
Seldom	27 (37%)	30 (41%)	57 (78%)	7 (22%)	19 (59%)	26 (81%)
Total	41 (56%)	32 (44%)	73	12 (38%)	20 (62%)	32
Chi^2-test value	6.62 ($p<0.01$)			4.75 ($p<0.05$)		

[1] Disinfecting knife and tools at least after every other carcass (frequent) or more seldom than after every other carcass (seldom)
[2] Worker has to take on or more steps to reach disinfection facilities.

Table 6. Mean ranks of beef and pork carcass contamination and hygienic practice at 5 slaughterhouses.

Slaughterhouse	Carcass contamination	Hygienic practice	Carcass contamination and hygienic practice
A	3.5[1]	2.6[2]	9.1[3]
B	1.0	1.8	1.8
C	3.5	4.7	16.5
D	2.3	3.0	6.8
E	4.8	2.9	13.7
Significance of Freedman's test	$p<0.01$	$p<0.05$	$p<0.001$

[1] The mean ranks of the 5 slaughterhouses have theoretical values from one to 5. A value of 5 means that the slaughterhouse has the most contaminated pork and beef carcasses.

[2] The mean ranks of the 5 slaughterhouses have theoretical values from one to 5. A value of 5 means that hygienic practices are least frequent.

[3] The mean ranks of the 5 slaughterhouses have theoretical values from one to 25. A value of 25 means that the slaughterhouse has the most contaminated pig and beef carcases and hygienic practices are least frequent.

present study, the disinfection of knife and other tools was affected by access to disinfection facilities, the disinfection of knives alone also by sufficiency of working space and time. The washing of tools depends on the accessibility of washing facilities, on the sufficiency of working space and on the number of tools the worker uses. If the worker uses more than one tool, he is more likely to neglect washing them than if working with one tool. This means that if one worker is responsible for several steps in the slaughtering process, he will neglect washing his tools. This may be one reason why the carcasses are generally dirtiest in small slaughterhouses *(Johanson et al.* 1983, *Fliss et al.* 1991, *Hogue et al.* 1993), where the workers usually work with more than one tool, and working space is not always adequate.

Since the frequency of slaughtering mistakes, unskilful use of the knife and touching of the carcasses is so low, the effect of that kind of poor slaughtering technique on the carcass contamination level in the present study can be excluded. However, in general skinning and evisceration technique must be paid attention to because the primary sources of contamination are bacteria from skin and rectum. The hygienic practice of workers, in particular disinfection practice, seems to be associated with carcass contamination. In those slaughterhouses and lines where disinfection of tools is rare, the carcasses are most contaminated. The present study suggests that the regular disinfection of working tools in slaughterhouses is very important and affects the level of carcass contamination. The practice of disinfection by the workers should be encouraged by education and by offering better disinfection facilities within easy reach. The general design of slaughtering lines should take hygienic and ergonomic points of view into account.

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Sammanfattning

Sambandet mellan den mikrobiologiska kontaminationen av slaktkroppar och hygienen vid hanteringen av slaktkroppar i slakterier

Sambandet mellan slaktkropparnas bacteriologiska kvalitet och hygienen vid hanteringen av slaktkroppar undersöktes i 5 finländska slakterier. Slaktkropparnas kontamination undersöktes med hjälp av swabb-metoden. Den genomsnittliga kontaminationsnivån (log_{10} cfu cm^{-2}) var 3.23 hos svin- och 2.65 hos nötkropparna. Suggornas kroppar hade en högre kontaminationsnivå. Hygienen vid hantering av slaktkroppar undersöktes genom att anteckna hur ofta arbetarna tvättade sina händer och steriliserade arbetsredskapen. Sina händer tvättade 81% och kniven 78% av arbetarna regelbundet medan bara 21% av dem rengjorde de övriga arbetsredskapen regelbundet. Arbetsredskapen brukade inte heller steriliseras alltför ofta; bara 24% av arbetarna steriliserade kniven och 15% de övriga redskapen regelbundet. Det fanns ett klart samband mellan slaktkropparnas mikrobiologiska kontaminationsnivå och arbetshygienen i slakterierna. I sådana slakterier där arbetsredskapen steriliserades regelbundet hade slaktkropparna en lägre kontaminationsnivå än i de övriga slakterierna. Det är viktigt att planera slaktlinjen så att kötthanteringen kan utföras så hygieniskt som möjligt. Lika viktigt är att kötthanteringpersonalen uppmuntras att regelbundet sterilisera alla arbetsredskap för att på så sätt bidra till att minska den mikrobiologiska kontaminationen av slaktkroppar.

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