BACTERIAL CONTAMINATION DURING THE PIG SLAUGHTERING PROCESS

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SUMMARY
The pig slaughtering process at a commercial abattoir was studied in order to evaluate how several processing stages affected the microflora on pig carcasses and how the pig spoilage flora was reflected by different bacterial analyses.

The bacterial counts reduced during scalding and flaming while increased during dehairing and brushing - water-spraying. The psychrotrophic count reflected the rind spoilage flora which could be detected as early as at the stage of exsanguination. The meat spoiling Pseudomonas spp. could be detected at the stage of exsanguination by the Pseudomonas count. The part of Pseudomonas spp. in the microflora increased during the slaughtering process. The total mesophilic count did not reflect the spoilage flora.

INTRODUCTION

During the pig slaughtering process, the microflora on the carcasses is affected by the processing stages with respect to bacterial reduction, contamination and composition (Gerats et al., 1989). In order to improve the hygienic quality of pork, it is important to evaluate how the spoilage flora is affected by the processing stages (Roberts, 1980).

The quality control of the slaughtering processes is usually based on analysis of the total mesophilic count, enumerating all microorganisms present (Johanson et al., 1983; Snijders, 1988). During cold storage, it is only a minor part of all bacteria present that is a potential spoilage bacteria, i.e. will proliferate and as a consequence spoil the product (Blickstad & Molin, 1983). Consequently, if the total mesophilic count is to be of any value in the estimation of the hygienic quality, it should reflect a particular flora. For example, the spoilage flora of aerobically stored refrigerated meat is dominated by Gram-negative psychrotrophic bacteria such as Pseudomonas spp. (Enfors et al., 1979; Blickstad & Molin, 1983), i.e. for evaluating how the processing stages affect the hygienic quality of meat to be stored aerobically, it is important to use a bacteriological analyses reflecting the number of psychrotrophic Pseudomonas.

The present study was performed in order to evaluate how several processing stages in a commercial abattoir affect the microflora on pig carcasses and how the spoilage flora is reflected by different bacterial analyses.

MATERIALS AND METHODS

The pig slaughtering process at a commercial abattoir was studied. Over a period of five production days, a total of twenty-five pigs were sampled during the slaughtering process. Surface samples were taken from the rind tissue of foreparts using an excision method: using a cork borer, pieces of two centimeters in diameter were taken from the neck, shoulder and belly. A total of eight pieces - representing a total area of 25 cm^2 - were pooled, thus representing one sample and one carcass. Samples taken after scalding and flaming consisted, for practical reasons, of two to four pieces, representing an area of 6.3-12.6 m^2.

Samples were taken after the following production stages: exsanguination; scalding (hanging scalding using condensed water vapour at 62°C for 8-10 minutes); dehairing; flaming (at 900°C); brushing and water-spraying;

evisceration; inspection; final water-spraying.

On one production day, the five foreparts were cut off and stored aerobically at +3°C in plastic bags. Samples were taken at the end of storage (total mesophilic count about 10^8 cfu/cm^2) by excising 25 cm^2 from the rind tissue.

The samples were shaken for 30 minutes at 4°C with 25 ml of physiological saline solution supplemented by 0.1% (w/v) peptone and 0,1% (w/v) Tween 80. The total mesophilic count was determined on Tryptone Glucose Extract agar (TGE; Oxoid) incubated at 25°C for 3 days; the total psychrotrophic count on TGE agar incubated at 4°C for 10 days; the Enterobacteriaceae count on Violet Red Bile Dextrose agar (VRB; Oxoid, supplemented with 1% glucose) incubated at 37°C for 1 day; the Pseudomonas count on Cephaloridine-Fucidin-Cetrimide agar (CFC; Mead & Adams, 1977) incubated at 25°C for 2 days, after flooding with tetramethyl-p-phenylene-diamine dihydrochloride coloured, i.e. oxidase positive colonies were counted.

Colonies on TGE-plates (total mesophilic count and total psychrophilic count) and CFC-plates (Pseudomonas count) were isolated from the stages of exsanguination and final water-spraying and after storage of foreparts. Twenty colonies were isolated from each plate. From plates with less than twenty colonies, all colonies were isolated.

The isolates were tested for Gram reaction (KOH method; Gregersen, 1978). The Gram negative isolates were divided into family or genus according to Blickstad & Molin (1983) using examination of morphology and motility (phase contrast microscope), oxidase reaction (Kovacs, 1956), anaerobic and aerobic breakdown of glucose (Hugh & Leifson, 1953) and pigmentation on TGE-plates. Pseudomonas were further examined for assimilation of malonate and D-xylose in Palleroni-Duodoroff-medium (Palleroni-Duodoroff, 1972) and acid production from maltose in Hugh-Leifson medium (Hugh & Leifson, 1953) and divided into species according to Table 1.

RESULTS AND DISCUSSION

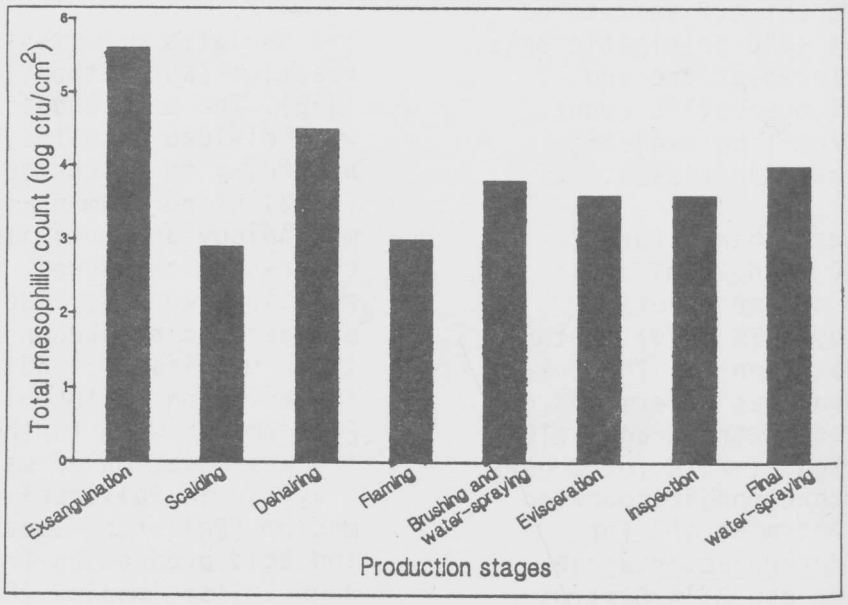
The total mesophilic count of the carcasses fluctuated throughout the slaughtering process, as shown in Figure 1. The count reduced by 2.7 log cfu/cm^2 during the hanging scalding process (62°C for 8-10 minutes). The carcasses were recontaminated in the dehairing machine; the total mesophilic count increased by 1.6 log cfu/cm^2. In the flaming oven (900°C) the bacterial count reduced once again, this time by 1.5 log cfu/cm^2. The carcasses were then brushed and

Table 1. Criteria used for the separation of Pseudomonas spp. into species.

Species	Acid production from maltose	Assimilation of malonate	Assimilation of D-xylose
Pseudomonas lundensis	+	-	-
Pseudomonas fluorescens	-	+	v
Pseudomonas fragi	v	-	+

+: positive reaction
-: negative reaction
v: variable reaction

Figure 1. Total mesophilic count of pig carcasses after different processing stages. (Mean value of twenty-five carcasses from five production days).



sprayed with water resulting in an increase by 0.8 log cfu/cm^2 of the total mesophilic count. In conclusion, the total bacterial reduction in this "unclean" part of the slaughtering line was about 1.8 log cfu/cm^2 (from 5.6 to 3.8 log cfu/cm^2) which is about the same reduction as Snijders et al (1984) found in their investigation.

The processing stages in the "clean" part of the slaughtering line, i.e. evisceration, carcass splitting, inspection and final water-spraying, did not substantially affect the total mesophilic count. At the end of the slaughtering process, the bacterial load of the carcasses was 4.0 log cfu/cm^2.

Table 2. Microbial counts of pig carcasses after different processing stages.

Processing stage	Microbial counts (log cfu/cm^2)			
	Total mesophilic count[1]	Total psychrotrophic count[2]	Enterobacteriaceae[1]	Pseudomonas[3]
Exsanguination	5,6	4,1	2,8	1,8
Scalding	2,9	1,2	<0,4	<0,4
Dehairing	4,5	1,9	1,7	1,1
Flaming	3,0	0,8	<0,4	<0,4
Brushing and water-spraying	3,8	1,1	0,4	1,0
Evisceration	3,6	1,0	0,3	0,8
Inspection	3,6	1,1	0,4	1,0
Final water-spraying	4,0	1,1	0,8	1,1

1) Mean value of twenty-five carcasses from five production days
2) Mean value of ten carcasses from two production days
3) Mean value of fifteen carcasses from three production days

The counts of mesophilic bacteria, psychrotrophic bacteria, Enterobacteriaceae and Pseudomonas are shown in Table 2. The psychrotrophic counts increased and decreased at the same processing stages as the total mesophilic count. The total reduction of the psychrotrophic count along the processing line (3.0 cfu/cm^2) was, however, more pronounced than the reduction of the mesophilic count. This can partly be explained by the more heat sensitive nature of the psychrotrophic bacteria compared to the mesophiles, leading to a more pronounced reduction of the psychrotrophs during scalding and flaming. Also the counts of Enterobacteriaceae and Pseudomonas coincided with the increases and decreases of the mesophilic and psychrotrophic counts. The count of Enterobacteriaceae reflects the hygiene during the evisceration process according to Gerats et. al (1981). In this investigation, there was no increase in the Enterobacteriaceae count at the stage of evisceration, indicating that the evisceration process was satisfactorily performed.

The spoilage flora of rind tissue of foreparts stored at +3°C consisted of about equal parts of Gram-positive bacteria, Moraxella/Kingella spp., Pseudomonas spp., Acinetobacter spp., and Vibrionaceae spp. (Table 3). Thus, the spoilage flora of rind tissue differs from that of meat tissue which is dominated by Pseudomonas spp. (Enfors et al, 1979; Blickstad & Molin, 1983)

For evaluating at which slaughtering stages the psychotrophic microflora adhered to the carcasses, isolates were taken from the psychrotrophic counts measured at the first and last processing stages. In table 3, it is shown that Gram positive bacteria, Moraxella/Kingella spp. and Acinetobacter spp. constituted a significant part of the psychrotrophic count as early as at the stage of exsanguination. Pseudomonas spp. were present at the stage of exsanguination as well, although in lower numbers than the psychrotrophs, since they were not retrieved from the psychrotrophic count but from the Pseudomonas count. The identification of

Table 3. The composition of the microbial flora by different plate count media on the stages of exsanguination and final water-spraying sampled on one production day and on aerobically stored foreparts sampled on two production days.

Organism	Distribution (%)						
	Exsanguination			Water-spraying after the slaughter line			Storage of foreparts
	Mesophilic count	Psychrotrophic count	Pseudomonas count	Mesophilic count	Psychrotrophic count	Pseudomonas count	Mesophilic count
P. fluorescens			15		25	36	8
P. fragi			3				7
P. lundensis			13		5		3
Pseudomonas spp	1		10	2		9	1
Enterobacteriaceae	2		32	1			1
Moraxella/Kingella	19	38	3	28	10		20
Vibrionaceae			21			55	15
Acinetobacter	10	12		10	10		18
Flavobacterium				20	15		
Gram positives	68	50		39	25		23
Spore formers			3		10		4
Yeast							
Number of isolates	100	100	62	98	20	76	99
Count (log cfu/cm^2)	5.8	4.3	1.9	3.8	0.5	1.3	7.8

isolates taken from the Pseudomonas count showed that even Vibrionaceae spp. could be detected at the stage of exsanguination. Thus, the rind spoilage bacteria could be retrieved as early as at the stage of exsanguination.

Pseudomonas spp., which is the dominating spoilage flora of aerobically stored refrigerated meat could, as mentioned above, be detected as early as at the stage of exsanguination, although in lower numbers than the psychrotrophs. At the end of the slaughtering line Pseudomonas spp. constituted a significant part of the flora found on the psychrotrophic count (final water-spraying, Table 3). This indicates that Pseudomonas spp. contaminated the carcasses during the process and, as shown in table 2, that the Pseudomonas count was not reduced to the same degree as the psychrotrophic count during the slaughtering process. The presence of psychrotrophic Pseudomonas spp. on carcasses at the end of the slaughtering line is likely to adversely effect the final shelf-life of the cut meat. During chilling of the carcasses, these bacteria may increase in number. Furthermore, Pseudomonas are able to become established as a resident flora in the chilling rooms (Newton et al., 1978) being a source of contamination. It is thus crucial for meat hygiene to find the origin of psychrotrophic Pseudomonas spp. along the slaughtering line.

The total aerobic count is frequently used as a measure of the hygiene of slaughtering processes (Ingram & Roberts, 1976, Hudson et al; 1987; Snijders, 1988). For evaluating how the processing effects the hygienic quality of meat, the bacteriological analysis used should reflect the presence of a pertinent flora. In the present study, it was demonstrated that the total mesophilic count did not reflect how the number of meat spoilage Pseudomonas spp. was affected by the slaughtering process since they constituted only a minor part of the total mesophilic count (Table 3). P. fluorescens, P. fragi and P. lundensis - the dominating Pseudomonas species on spoiled meat (Molin & Ternström, 1986) - could not be isolated at all from the TGE-agar. Consequently, the total mesophilic count is not a pertinent analysis for evaluating how the processing stages affect the shelf-life of the meat. However, the total mesophilic count can be of value in the detection of the rind spoilage flora, since a great part of the rind spoilage bacteria - except for Pseudomonas spp. - could be detected by this analysis, as shown in table 3. Furthermore, the total mesophilic count may also be of value in the detection of great abnormalities during a production day, but should not be used for evaluation of the effects of technical improvements on shelf-life.

The psychrotrophic count was more satisfactory than the mesophilic count for detection of the rind spoilage flora since even the Pseudomonas spp. was detected using this method. However, for detection of the meat spoilage flora, further investigation is needed in order to evaluate whether there is a correlation between the spoilage of rind tissue and meat tissue, i.e. if the psychrotrophic count demonstrates the spoilage of meat tissue as well.

The Pseudomonas count was analysed on Cephaloridine-Fucidin-Cetrimide agar (CFC). Identification of isolates from the CFC-agar showed that only 41-45% of the isolates belonged to Pseudomonas spp. The CFC-flora was dominated by Vibrionaceae spp. and Enterobacteriaceae spp. (Table 3).

CUNCLUSIONS

* The bacterial counts reduced during scalding and flaming while increased during dehairing and brushing - water-spraying.

* The rind spoilage flora could be detected as early as at the stage of exsanguination.
* The meat spoiling Pseudomonas spp. could be detected at the stage of exanguination and the part of Pseudomonas spp. in the microflora increased during the slaughtering process.
* The total mesophilic count did not reflect the spoilage flora.
* The psychrotrophic count reflected the rind spoilage flora.
* The Pseudomonas count reflected the meat spoilage flora.

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