

**Abstract** Campylobacter excretion and diversity was investigated in three cohorts of 20 pigs from three different pig herds, respectively. Feces were collected from all pigs in the herd and after transport during lairage. Carcass swab samples were collected from all pigs pre- and post-chilling. All pigs (n=60) excreted Campylobacter in the herd and in the lairage. The typical excretion levels were between log 4/g and log 5.5/g feces. Pre-chilling more than 90% of carcasses were positive for Campylobacter. Post-chilling Campylobacter was isolated from only 17.5% of carcasses. Excretion levels of Campylobacter did not increase during transport and lairage. Twenty C. coli serotypes and three C. jejuni serotypes were identified. Indistinguishable C. jejuni serotype 2 isolates were detected in pigs from one farm at all sampling occasions, indicative of carcass contamination. C. jejuni was isolated more often post-chilling, relative to C. coli.

**Introduction** Campylobacter is the most common cause of zoonotic human enteritis in Denmark with an incidence of 66 per 100,000 inhabitants in 2003 (Anonymous, 2004). The majority (90%) of human cases is caused by C. jejuni, and is attributed mainly to poultry. Of the remaining cases, 5% are diagnosed as C. coli and these are assumed to originate mainly from pork. Many studies have shown C. coli prevalences of >90% in pigs, including Denmark (Nielsen et al, 1997; Boes et al, 2005). However, pigs are not entirely free of C. jejuni, which can be isolated from pig feces (Boes et al, 2005) and pig carcasses (Dalsgaard et al, 1999).

Because most pigs are infected with Campylobacter and may excrete high numbers of bacteria in their feces, there is a risk of carcass contamination during the slaughter process. However, the number of viable Campylobacter bacteria on the carcass surface is reduced significantly when exposed to low temperatures and desiccation during the chilling process. On the other hand, transport and lairage of finisher pigs may stress the animals to such an extent that they excrete increased levels of Campylobacter in their feces at time of slaughter.

To generate data for a quantitative risk assessment for Campylobacter, to be performed by the Danish Institute for Food and Veterinary Research, a cohort study was carried out. The first objective was to investigate if Campylobacter excretion levels in finisher pigs ready for slaughter, changes during transport and lairage. Secondly, a possible effect on Campylobacter contamination on pig carcasses was investigated. Thirdly, the diversity of Campylobacter isolates detected in feces and on carcasses was assessed.

**Materials and Methods** Three herds producing finisher pigs were selected for the study. In two of these herds, both C. jejuni and C. coli had been detected in finishers during a previous study, whereas in the third herd, only C. coli had been isolated (Boes et al, 2005). In each herd, a cohort of 20 pigs ready for shipping was selected and marked.

Each cohort of pigs was sampled on four occasions:

1) individual fecal samples from all pigs in the herd on the day before shipping;
2) individual fecal samples from all pigs 1 hour after arrival in the lairage at the slaughterhouse;
3) individual carcass samples from all pigs after evisceration but before chilling;
4) individual carcass samples from all pigs 24 hours after chilling.

Carcass samples were taken by swabbing 1400 cm² of one side of the carcass with a gauze tampon moistened with peptone buffer. All samples were kept at ambient temperatures and sent to the laboratory immediately after collection.
Feces as well as swab samples were examined for *Campylobacter* using quantitative methods, including species identification and serotyping. Subsequently, selected isolates were subjected to pulse-field gel electrophoresis (PFGE) typing.

**Results**

The *Campylobacter* prevalence combined for the three cohorts at the four sampling occasions is shown in Figure 1. All 60 pigs excreted *Campylobacter* in their feces both in the herd and in the lairage. The pre-chilling carcass prevalence of *Campylobacter* was also high (90.7%), but after chilling the overall prevalence had decreased to 17.5%.

The quantitative level of *Campylobacter* bacteria on pig carcasses both pre- and post-chilling was very low, making enumeration difficult. Therefore, quantitative *Campylobacter* estimates were only obtained for both fecal sampling occasions. *Campylobacter* excretion was almost constant before and after transport to the abattoir. On average, the excretion level decreased from log 5.08/g feces on-farm to log 4.90/g feces at the abattoir. This decrease was non-significant.

The relative distribution of *Campylobacter* species recovered from feces and carcasses is shown in Table 1. The distribution of *C. jejuni* and *C. coli* changed slightly during the slaughter process. Post chilling, more samples (30%) contained *C. jejuni* compared to feces and pre-chilling (20%), and of these the majority were only positive for *C. jejuni*.

Serotyping of 180 *C. coli* isolates revealed a large diversity: 20 different *C. coli* serotypes were identified, among which serotypes 5, 11, 24, 25, 46, 48 and 54 were the most common. In contrast, serotyping of 49 *C. jejuni* isolates revealed only three different *C. jejuni* serotypes: 2, 23, and 35. Serotype 23,36 was detected in pigs from all three farms, whereas serotype 2 was only found in one farm. Only serotype 2 was found on all four sampling occasions. Serotype 35 was found only on carcasses.

PFGE typing showed that serotype 2 isolates from one farm all were indistinguishable. However, these isolates were not identical to four other serotype 2 isolates found in cattle in the same herd in a previous study (Boes et al, 2005). Serotype 23,36 isolates found in fecal samples from pigs from the two remaining farms were indistinguishable within farms, but not identical to serotype 23.36 isolates found in the previous study.

**Discussion**

In accordance with many other studies including a recent Danish study (Boes et al, 2005), our study showed a very high *Campylobacter* prevalence in finisher pigs. Furthermore, our results show that individual pigs may be excreting considerable amounts of *Campylobacter* bacteria in their feces, typically between log 4 and log 5.5 bacteria/g feces, which poses a risk of carcass contamination during slaughter. However, post-chilling *Campylobacter* prevalence had decreased considerably, indicating that the chilling process is detrimental for the majority of *Campylobacter* bacteria.

Our hypothesis that transport and lairage of finisher pigs are stress factors that may trigger increased *Campylobacter* excretion in feces was not confirmed in this study. If anything, excretion levels seemed to decrease slightly after transport. However, this result is based on relatively few animals from a small number of farms and should therefore be interpreted with some caution.
Possible changes in excretion patterns could be masked by variation over time or differences in detection due to variable transport time to the laboratory.

The relative distribution of *Campylobacter* species during transport and slaughter was relatively constant, although post-chilling slightly more *C. jejuni* was isolated. Interestingly, post-chilling samples more often contained *C. jejuni* only, which may suggest that *C. jejuni* perhaps is more resistant to chilling compared to *C. coli*. However, further research is needed to clarify this.

In concordance with a previous Danish study (Boes et al, 2005) we found a large diversity among *Campylobacter* isolates, with especially *C. coli* showing many different serotypes. The large majority of serotypes, including those of *C. jejuni*, were serotypes commonly found in pigs in Denmark (Nielsen et al, 1997). PFGE analysis of *C. jejuni* isolates showed that specific serotypes could be isolated from the same pigs throughout the slaughter process, indicative of contamination of the carcass. However, isolation of other *C. jejuni* serotypes from carcasses but not from feces suggests that cross-contamination from other pigs on the same slaughter line cannot be ruled out.

**Conclusions**
- All pigs excrete *Campylobacter* in their feces
- Individual excretion levels vary between log 4/g and log 5.5/g feces
- Transport and lairage did not increase *Campylobacter* excretion of pigs
- *C. jejuni* may be more resistant to chilling than *C. coli*
- *Campylobacter* in feces can cause contamination of the carcass or cross-contamination of other carcasses on the slaughter line

**References**


<table>
<thead>
<tr>
<th>Species</th>
<th>Feces (herd)</th>
<th>Feces (lairage)</th>
<th>Carcass (pre)</th>
<th>Carcass (post)</th>
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<tr>
<td><em>C. coli</em></td>
<td>80.0</td>
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<td><em>C. coli</em> + <em>C. jejuni</em></td>
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<td><em>C. jejuni</em></td>
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<td>0</td>
<td>8.5</td>
<td>20.0</td>
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</tbody>
</table>

Table 1. Relative distribution (%) of *Campylobacter* species in cohorts of pigs from farm to slaughter.