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# Effects of slaughter operations on the microbiological contamination of broiler carcasses in three abattoirs

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ABSTRACT

Broiler carcasses from three abattoirs were examined at selected stages of slaughter for indicator bacteria and *Campylobacter* spp. (pooled neck and breast skin samples). Before scalding, total viable counts (TVC) and *Campylobacter* counts from carcasses ($n = 48$) averaged out at 7.7 log CFU/g and 3.6 log CFU/g, respectively. After scalding ($n = 90$ at this and the following stages in each abattoir), mean values from the abattoirs ranged from 6.0 to 6.5 log CFU/g for TVC and 2.3 to 3.3 log CFU/g for *Campylobacter*. The abattoir-specific differences were probably related to varying scalding parameters (temperature/time exposition). Plucking reduced TVC (on average by 1.5 log CFU/g), whereas *Campylobacter* counts slightly increased. *Enterobacteriaceae*/*Escherichia coli* counts from plucked carcasses of the three abattoirs ranged from 2.9 to 3.3 log CFU/g. After evisceration, washing and chilling, minor changes occurred, albeit certain abattoir-specific effects were evident. In the chiller, mean TVC, *Enterobacteriaceae*/*E. coli* counts and *Campylobacter* counts from the abattoirs ranged from 4.2 to 4.4 log CFU/g, 2.8 to 3.5 log CFU/g and 2.5 to 3.4 log CFU/g, respectively. Such abattoir-specific data form the basis for implementing targeted and sustainable measures at selected stages of the poultry slaughter process (cost-benefit analysis).



## 1. Introduction

In terms of meat production, strict adherence to good practices of slaughter hygiene, along with risk-based preventive measures (HACCP approach), is crucial to ensure public health protection and meat quality. In the European Union (EU), food hygiene legislation (Reg. [EC] No. 852/2004 and 853/2004) places the onus for compliance on food business operators and a risk-based verification of slaughter hygiene conditions is required (Reg. [EC] No. 2073/2005 and 1441/2007). For assessment of slaughter process performance, operations increasing or decreasing microbial loads on carcasses must be identified (Brown et al., 2000; Milios, Drosinos, & Zoiopoulos, 2014; Zweifel, Capek, & Stephan, 2014). This is of special interest in Europe because current legislation only permits the use of potable water to reduce microbial contaminations on broiler carcasses.

The modern slaughter of poultry is a complex, rapid and highly automated process. With regard to slaughtered broilers, contamination of carcasses with *Campylobacter* spp. poses a major challenge. *Campylobacter* spp. is the leading cause of acute bacterial gastroenteritis in most developed countries (EFSA/ECDC, 2014). Handling and consumption of poultry is thereby considered a major source for human disease (Boysen et al., 2014; EFSA, 2010a; Friedman et al., 2004; Kittl, Heckel, Korczak, & Kuhnert, 2013). Healthy broilers are often carriers of *Campylobacter jejuni* and carcasses might become contaminated during slaughter (EFSA, 2010b). Various risk assessments indicate that reductions of *Campylobacter* counts on broiler carcasses cause significant decreases in associated human cases (EFSA, 2011; Nauta et al., 2009; WHO/FAO, 2009). Moreover, it was shown that certain poultry abattoirs are more successful than others in containing *Campylobacter* contamination of carcasses (EFSA, 2010c; Habib, Berkvens, et al., 2012).

The aim of the present study was to investigate the effects of certain poultry slaughter process stages on the microbiological contamination of broiler carcasses (quantitative analysis of indicator bacteria and *Campylobacter* spp.) in three large-scale Swiss abattoirs. In addition, such data might be used for the determination of quantitative process hygiene criteria, as currently discussed for *Campylobacter* (Comin et al., 2014; EFSA, 2011; Nauta, Sanaa, & Havelaar, 2012).

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## 2. Materials and methods

### 2.1. Abattoirs and slaughter process

This study was based on investigations carried out during four months (January 2014 to April 2014) in three large-scale Swiss poultry abattoirs. Abattoirs A and C each comprised one slaughter line, whereas two lines were present in abattoir B. Most processing steps were automated. First, broilers were stunned and exsanguinated. In abattoir A, $CO_2$ stunning was applied, followed by manual hanging and bleeding (130 s). In abattoirs B and C, broilers were manually shackled, electrically stunned (water bath) and exsanguinated (180 s). Subsequently, broilers were scalded (immersion) and plucked. All three abattoirs used soft scalding systems. Scalding comprised four segments in abattoir A (50.7–51.8 °C, on average 51.4 °C; 200 s), three segments on each slaughter line in abattoir B (51.7 °C; 205 s on line 1, 229 s on line 2) and one single segment in abattoir C (52.7–53.6 °C, on average 53.1 °C; 120 s). Plucking consisted of different segments (abattoir A: five segments, 70 s; abattoir B: two segments on each slaughter line, 39 s (line 1), 37 s (line 2); abattoir C: two segments, 47 s). After transfer to the evisceration line, intestines were drawn out of the body's cavity (vent cutter, opener, eviscerator), the neck was removed and washing steps removed visible dirt. Washing steps used potable water at 12–13 °C in abattoirs A and B and at about 18 °C in abattoir C. Washing comprised four wash stations in abattoir A, one wash station on each line in abattoir B and two wash stations in abattoir C. Finally, carcasses were chilled (air chilling). Abattoir A applied two pre-chilling steps of 40 min each, followed by another chilling step of 90 min. Abattoirs B and C used one chilling step (abattoir B: 95 min on line 1 or 125 min on line 2; abattoir C: 100 min).

### 2.2. Sampling

For the microbiological process analysis, broiler carcasses were investigated at five stages of slaughter: after scalding, after plucking, after evisceration, after washing and in the chiller (abattoir A: after pre-chilling, abattoirs B and C: at the end of chilling). The age of the sampled broilers ranged from 30 to 37 days in abattoir A (mean: 34.6 days), 28–39 days in abattoir B (mean: 35.1 days) and 30–40 days in abattoir C (mean: 34.3 days). At each abattoir, sampling comprised 10 sampling days and a total of 30 broiler flocks. Flocks selected at each sampling day were slaughtered in the morning, at midday and in the afternoon. At each process stage and abattoir, 90 carcasses were examined. Different carcasses from a certain flock were thereby selected randomly at each processing step. A carcass sample consisted of pooled neck and breast skin (EFSA, 2010b). Each carcass sample was packed in a sterile stomacher bag and transported to the laboratory chilled.

In additional examinations, the microbiological status of broiler carcasses before scalding and of scalding water was investigated. A carcass sample consisted of pooled neck and breast skin including attaching feathers. Each carcass sample was obtained using sterile forceps and scissors, packed in a sterile stomacher bag and transported to the laboratory chilled. Of the 48 carcasses sampled before scalding (two sampling days at each abattoir), 12 originated from abattoir A (4 flocks), 24 from abattoir B (12 carcasses from 4 flocks per slaughter line) and 12 from abattoir C (4 flocks). Scalding water samples (about 10 ml) were collected from each scalding tank using sterile tubes and transported to the laboratory chilled. Of the 156 scalding water samples, 60 originated from abattoir A (15 per scalding tank), 81 from abattoir B (line 1: 12 per scalding tank; line 2: 15 per scalding tank) and 15 from abattoir C. Sampling comprised five sampling days at each abattoir and scalding water samples were collected in the morning, at midday and in the afternoon.

### 2.3. Total viable counts (TVC), Enterobacteriaceae, Escherichia (E.) coli and Campylobacter spp.

Pooled neck and breast skin from each carcass (about 10 g) were homogenized for 60 s in 100 ml of 0.85% saline solution using a stomacher. For the microbiological process analysis, suspensions (and dilutions) were plated with a spiral plater (Eddy Jet, IUL SA, Barcelona, E) onto Plate Count Agar (Oxoid AG, Pratteln, CH; 72 h, 30 °C), Violet Red Bile Glucose Agar (Becton Dickinson AG, Allschwil, CH; 48 h, 30 °C, anaerobic conditions), Rapid *E. coli* 2™ Agar (Bio-Rad Laboratories AG, Reinach, CH; 24 h, 37 °C) and CampyFood® Agar (bioMérieux SA, Geneva, CH; 48 h, 40 °C, microaerophilic conditions). Suspensions (and dilutions) from samples obtained from carcasses before scalding and scalding water samples were analyzed by spreading 0.1 ml on the surface of Plate Count Agar (Oxoid AG; 72 h, 30 °C) and CampyFood® Agar (bioMérieux SA; 48 h, 40 °C, microaerophilic conditions).

Counts of each sample were expressed as log CFU/g or log CFU/ml. Quantitative analysis was based on counts above the detection limit and results were compared by reference to mean log values ($\bar{x}$). Mean values differing by <0.5 log units were regarded as similar for practical purposes. Statistical analysis was performed using JMP 11.0 (SAS Institute Inc., Cary, NC, USA). The level of significance was set at $\alpha = 0.05$. Analysis of variance and the Tukey HSD test were used to analyze differences in bacterial counts between sequential process stages, abattoirs, slaughter/sampling times and scalding segments.

## 3. Results

### 3.1. TVC, Enterobacteriaceae and E. coli results from broiler carcasses during the slaughter process

After scalding, mean log TVC from the three abattoirs ranged from 6.0 to 6.5 log CFU/g (Table 1). Carcasses from abattoir A thereby yielded higher results than those from abattoirs B and C ($P < 0.05$). At the following stages of slaughter (from plucking to chilling), mean log were reduced ($P < 0.05$) after plucking (by 1.2–1.7 log CFU/g at abattoirs) and washing (by 0.2–0.4 log CFU/g at abattoirs), whereas evisceration and chilling did not cause significant changes. Between abattoirs, mean log TVC of a certain process stage differed by ≤0.3 log CFU/g, albeit some differences after plucking (abattoir A/B versus C), after evisceration (abattoir A versus C) and in the chiller (abattoir A versus B) were significant ($P < 0.05$). In the chiller, mean log TVC from the three abattoirs ranged from 4.2 to 4.4 log CFU/g (Table 1). With regard to the time of slaughter (morning, midday, afternoon), mean log TVC from chilled carcasses differed by ≤0.3 log CFU/g within each abattoir ($P > 0.05$). In abattoir B, further analysis of the TVC results from the two slaughter lines showed significant TVC differences (*t*-test, $P < 0.05$) after scalding, plucking and washing, but only mean values after plucking differed by >0.5 log CFU/g (higher values on line 2). In the chiller, results from the two slaughter lines were comparable (mean log TVC line 1: 4.3 log CFU/g, mean log TVC line 2: 4.5 log CFU/g).

With regard to *Enterobacteriaceae* and *E. coli*, only results from four process stages were analyzed (after plucking, after evisceration, after washing, in the chiller). Results after scalding were not comparable because applied detection limits varied between the three abattoirs. After plucking, mean log *Enterobacteriaceae* and *E. coli* counts from the three abattoirs ranged from 3.1 to 3.3 log CFU/g and 2.9 to 3.1 log CFU/g, respectively (Table 1). Carcasses from abattoir A thereby yielded higher results than those from abattoirs B and C ($P < 0.05$). At the following stages of slaughter, mean values differed by ≤0.3 log CFU/g from those of the preceding