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Review

Antibacterial activity of decontamination treatments for pig carcasses

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A B S T R A C T

Prevention or reduction of carcass contamination with food-borne pathogens during slaughter is of particular importance. Antimicrobial intervention technologies are therefore gaining increasing interest in the slaughter process. In this review, we screened the available recent literature on the decontamination of pig carcasses and appraised the antibacterial activity of treatments. Compared to poultry and beef carcasses, data on decontamination treatments for pig carcasses are so far limited and mainly physical and chemical interventions were investigated. Physical treatments were on the one hand part of the normal pig slaughter process. Dependent on time and temperature conditions, the bactericidal effect of scalding was shown in several studies, whereas the effect of singeing or chilling differed widely. On the other hand, interventions as hot water spraying, steam treatment or ultraviolet light were additionally applied with the specific objective of carcass decontamination. Hot water spraying and steam treatment thereby yielded bacterial reductions ranging from 1.0 to 2.1 orders of magnitude. Chemical interventions primary included lactic and acetic acid. Under commercial conditions, lactic acid treatment yielded bacterial reductions ranging from 0.2 to 1.0 orders of magnitude.

Contents

1. Introduction

In the European Union, pork is the most frequently consumed meat (Devine, 2003). The consumer demands fresh, tasty, healthy and wholesome food products and food safety is considered self-evident an absolute prerequisite (Havelaar et al., 2010). With regard to meat production, healthy food animals were recognized in recent years as carriers of pathogens of human illness. Prevention or reduction of carcass contamination with food-borne pathogens during the slaughter process is therefore of particular importance. However, despite all efforts targeted on maintenance of good hygiene practices during meat production, complete prevention of such contaminations can hardly be warranted (Spescha, Stephan, & Zweifel, 2006; Zweifel, Fischer, & Stephan, 2008).

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Pig slaughter operations before evisceration commonly involve scalding, mechanical dehairing, singeing and polishing (Borch, Nesbakken, & Christensen, 1996). The skin is thereby commonly not removed from the carcasses. This is in contrast to the slaughter of cattle or sheep where the process of dehiding constitutes a major source of carcass contamination (Antic et al., 2010; Biss & Hathaway, 1995; Sheridan, 1998). Therefore, hide decontamination treatments are of special interest in the slaughter of cattle and sheep (Biss & Hathaway, 1998; Loretz, Stephan, & Zweifel, 2011; Sheridan, 1998). With regard to the slaughtering of pigs, the mentioned process stages of scalding, dehairing, singeing and polishing result in pig carcass surfaces, which are visibly clean and largely free of hair (Gill et al., 2000). However, despite this appearance, pig carcasses might be highly contaminated with bacteria (Gill, Bedard, & Jones, 1997; Gill & Bryant, 1993) and therefore the surface of pig carcasses constitutes an important contamination source during subsequent slaughtering and dressing. Antimicrobial intervention technologies are therefore gaining interest in the pig slaughter process in order to reduce bacterial contamination levels through implementation of decontamination treatments or antimicrobial procedures for inhibition or retardation of microbial growth (Aymerich, Picouet, & Monfort, 2008; Sofos, 2008). Compared to dehided beef or sheep carcasses, the pig carcass surface might be relatively smooth and thereby facilitates the antibacterial efficacy of decontamination treatments.

The aim of the present survey was to review the literature on the decontamination of pig carcasses by antibacterial treatments. For this purpose, ScienceDirect (http://www.sciencedirect.com) and PubMed (http://www.pubmed.com) were searched using the keywords decontamination pig/pork, decontamination pig/pork carcass, carcass intervention pig/pork and carcass decontamination. Moreover, literature in the available studies was crosschecked. Based on titles and abstracts, studies covering antibacterial interventions on pig carcasses and carcass surface parts (separated outer surface parts of carcasses) were selected, whereas investigations mainly addressing growth inhibition or processed meat were not considered. For the present survey, studies published between January 1991 and July 2010 were considered. To appraise the antibacterial activity, bacterial counts before and after interventions were compared. Thereby, the efficacy was evaluated for a variety of bacteria, but aerobic bacteria, *Escherichia coli* and Enterobacteriaceae were most frequently used.

2. Antibacterial activity of decontamination treatments for pig carcasses

Decontamination treatments for carcasses basically comprise physical, chemical and biological treatments (Bolder, 1997; Dinçer & Baysal, 2004; Huffman, 2002; Koohmaraie et al., 2005). In the studies reviewed for the decontamination of pig carcasses mainly selected physical and chemical interventions were investigated. In comparison, a greater variety of treatments including biological interventions has been evaluated for the decontamination of beef and poultry carcasses (Loretz, Stephan, & Zweifel, 2010; Loretz et al., 2011).

2.1. Physical decontamination treatments

The reviewed physical decontamination treatments for pig carcasses were on the one hand part of the normal pig slaughter process (e.g. scalding or singeing), whereas other physical methods were additionally applied with the specific objective of pig carcass decontamination (e.g. steam or ultraviolet light). However, compared to the various interventions used for the decontamination of beef and poultry carcasses, only a few methods were investigated for the specific decontamination of pig carcasses. For example, the use of interventions such as irradiation, dry heat or ultrasound has so far not been reported for pig carcass decontamination.

2.1.1. Scalding and singeing

Scalding and singeing are mostly part of the normal pig slaughter process. Although their primary intention is not the reduction of bacterial contamination, these slaughter process stages might contribute to the decontamination of pig carcasses. In this context, it must be considered that the bactericidal effect depends on the process parameters and the obtained reductions might be offset during the following process stages such as dehairing or polishing.

The bactericidal effect of scalding, which is affected by time and temperature conditions, has been shown in several studies (Bolton et al., 2002; Borch et al., 1996; Gill & Bryant, 1992; Pearce et al., 2004; Rivas, Vizcaíno, & Herrera, 2000; Spescha et al., 2006;). For example, scalding (59–62 °C, 5.0–8.5 min) reduced aerobic bacteria, coliforms and Enterobacteriaceae by 3.1–3.8, 3.5–3.8 and 1.7–3.3 log CFU cm^{-2}, respectively (Pearce et al., 2004; Spescha et al., 2006). In general lower reductions were obtained when scalding and dehairing were applied as a combined process. In the study of Bolton et al. (2002), the combined scalding-dehairing process yielded reductions of aerobic bacteria by 1.3 log CFU cm^{-2}. Furthermore, Rahkio, Korkeala, Sippola, and Peltonen (1992) investigated the effect of pre-scalding brushing on the contamination level of pig carcasses. Bacterial contamination of brushed carcasses was slightly higher than on un-brushed controls throughout the slaughter process. It was hypothesized that this might be due to laceration of the carcass skin by the brushes and subsequent protection of penetrated microbes during singeing (Rahkio et al., 1992).

Although bacterial reductions have been reported on pig carcasses after singeing, published data on the effect of singeing differ widely (Bolton et al., 2002; Bryant, Brereton, & Gill, 2003; Gill & Bryant, 1992; Pearce et al., 2004; Rahkio et al., 1992; Rivas et al., 2000; Spescha et al., 2006; Yu et al., 1999). In several studies, reductions of aerobic bacteria, coliforms and Enterobacteriaceae were mainly in the range from 1.8 to 2.8 orders of magnitude (Bolton et al., 2002; Pearce et al., 2004; Rahkio et al., 1992; Spescha et al., 2006; Yu et al., 1999). Differences in bacterial reductions among different carcass sites were probably related to uneven exposure to flames (Spescha et al., 2006). Yu et al. (1999) investigated the efficacy of two singeing steps. The first singeing step after first polishing thereby reduced aerobic bacteria and coliforms by 1.2–2.1 log CFU cm^{-2}, whereas the second singeing step after second polishing yielded reductions between 0.5 and 1.6 log CFU cm^{-2}.

2.1.2. Chilling

The antibacterial activity of air chilling on red meat carcasses is mainly based on the surface desiccation achieved by high air velocity (Spescha et al., 2006). In particular with regard to the inactivation of *Campylobacter*, this surface desiccation effect seems of major importance (Epling, Carpenter, & Blankenship, 1993). Conventional air chilling of carcasses (single-stage chilling process) can be supplemented by precedent blast chilling using freezing air and high air velocity (Nesbakken, Eckner, & Røtterud, 2008; Savell, Mueller, & Baird, 2005). Moreover, spray chilling is also known as chilling procedure for carcasses (Savell et al., 2005; Strydom & Buys, 1995).

On inoculated pig carcass surface parts, blast chilling (6.1 m s^{-1}, –20 °C, 3 h) followed by conventional air chilling (0.5 m s^{-1}, 4 °C, 21 h) yielded reductions of coliforms, *E. coli* and *Campylobacter (C.) coli* in the range from 1.9 to 4.0 log CFU cm^{-2}, of aerobic bacteria in the range from 1.4 to 2.1 log CFU cm^{-2} and of *Listeria monocytogenes* and *Salmonella* Typhimurium in the range from 0.4 to 1.1 log CFU cm^{-2} (Chang, Mills, & Cutter, 2003). Using only conventional air chilling (0.5 m s^{-1}, 4 °C, 24 h) showed slightly lower reductions than the combination with blasting, but graduations between the mentioned bacteria were comparable (Chang et al., 2003).