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ORIGINAL ARTICLE

Microbiological evaluation of feet-cutter disc for broiler with a self-washing system using heated and non-heated water

Avaliação microbiológica de disco corta-pés de frangos com sistema de autolavagem utilizando água aquecida e não aquecida

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Abstract

The increased worldwide demand for chicken meat requires constant automation of operating systems and the proper implementation of self-control programs by slaughterhouses. Thus, this study aimed to evaluate the efficacy of a self-washing system using heated water on reducing the load of public health concern bacteria on a broiler feet-cutter disc. In a three-month period, 84 samples (n = 42 per group) were collected for microbiological analysis from the feet-cutter disc with an operational self-washing process with Non-Heated Water (NHW) and Heated Water (HW). The logarithmic counts of Mesophilic Aerobics, Sulphite-Reducing *Clostridia* (SRC), *Escherichia coli* and *Staphylococcus aureus* in the NHW group were 1.82, 0.56, 0.31 and 0.14 Log_{10} CFU/cm^2, respectively, whereas in the HW group were 1.17, 0.04, 0.15 and 0.08 Log_{10} CFU/cm^2. *Salmonella* spp. was absent in all evaluated samples in both groups. The heated-water system reduced bacterial count, but statistical differences were solely observed for Mesophilic Aerobics and SRC. Nevertheless, its usage could be an additive in the operational procedure to avoid microbiological violations of food safety, in addition to being easy-to-implement and affordable for the industry.

Keywords: Cross-contamination; Hock; Poultry; Saw blade; Self-control program; Water jet.

Resumo

O aumento mundial da demanda por carne de frango exige constante automação de sistemas de operação e implementação adequada de programas de autocontrole pelos abatedouros. Assim, o objetivo do presente estudo foi avaliar a eficiência de sistema de autolavagem com água aquecida na redução da contagem de bactérias de interesse em saúde pública em disco corta-pés de frangos. Em um período de três meses, 84 amostras (n = 42, por grupo) foram colhidas para análises microbiológicas em disco corta-pés contando com um sistema operacional de autolavagem com água não aquecida (NHW) e água aquecida (HW). As contagens de Aeróbios Mesófilos, *Clostridium* Sulfito-redutor, *Escherichia coli* e *Staphylococcus aureus,* no grupo NHW, foram de 1,82, 0,56, 0,31 e 0,14 Log_{10} UFC/cm^2, respectivamente, enquanto que, no grupo HW, foram de 1,17, 0,04, 0,15 e 0,08 Log_{10} UFC/cm^2. *Salmonella* spp. foi

ausente em todas amostras avaliadas, em ambos os grupos. O sistema com água aquecida reduziu as contagens bacterianas, mas diferenças estatísticas foram observadas somente em Aeróbios Mesófilos e *Clostridium* Sulfito-redutor. Apesar disso, seu uso pode ser um adicional ao procedimento operacional para evitar a violação dos limites microbiológicos de segurança alimentar, além de ser um sistema de fácil implementação e de baixo custo.

Palavras-chave: Aves domésticas; Contaminação cruzada; Disco de serra; Jato de água; Jarrete; Programa de autocontrole.

Highlights

- Heating Water (HW) for self-washing systems in feet-cutter discs is easy-to-implement for the industry
- Bacterial load can be reduced by heated-water on a feet-cutter disc surface
- A self-washing system could be used in self-control programs, to avoid violation of food safety

1 Introduction

The food industry is constantly improving itself to minimize the occurrence of pathogens and contaminants to guarantee the quality of the final product that reach the consumer (Perez-Arnedo et al., 2020). The increased worldwide demand for chicken meat requires the automation of operating systems and the proper implementation of self-control programs (Nääs et al., 2015; Althaus et al., 2017; Esper et al., 2021).

In this scenario, the Standard Operating Sanitation Procedures (SOSP) plays a central role in several industrial process steps in order to monitor the hygienic-health conditions and to avoid the occurrence of cross or direct contamination (Brasil, 1996; Potter et al., 2012; Dias et al., 2017). As part of these procedures, equipment sanitation protocols often include dry cleaning process equipment disassembly, rinsing with heated water, and the addition of chemical compounds, such as appropriate disinfectants against microorganisms of interest (Marriott & Gravani, 2014). Thus, it prevents the formation of biofilms that protect the bacteria and favor their multiplication on equipment surfaces (Carpentier & Cerf, 1993; Potter et al., 2012).

Among these equipment, the industrial chicken feet-cutter increased the slaughter speed and reduced the carcasses handling thereupon the scalding and defeathering processes, considered a highly contaminated area (Rasschaert et al., 2007; Lehner et al., 2014; Althaus et al., 2017). Moreover, it has a self-washing system with a continuous water jet, which removes the residues from the cutting disc and prevents the formation of biofilm (Borges et al., 2018). As described in the current Brazilian legislation by means of the Regulation of Industrial and Sanitary Inspection of Products of Animal Origin (RIISPOA), one of the authorized sanitizing methods of utensils and equipment present in environments with immediate risk of contamination is washing with renewable and heated water systems at, at least, 82.2°C (Brasil, 2017). Thus, we hypothesized that heating the jetted water on the surface of a feet-cutter disc could reduce the bacterial count and be used as an addition to the self-control of poultry slaughterhouses. Taking into account the aforementioned issues, this study aimed to evaluate the bacterial load on feet-cutter discs at broiler slaughterhouses that use Heated Water (HW) in the self-washing system.

2 Materials and methods

2.1 Experimental design

The experiment was carried out in a commercial broiler abattoir with a daily slaughter capacity of 65,000 birds in a single working shift located in the eastern region of Santa Catarina state, in Brazil. Furthermore, on harvesting days, birds of Ross® lineage were slaughtered with an average age and weight of 39 days and 2.7 kg, respectively. The sampling was performed on the surface of the cutting disc of a broiler feet-cutting equipment (MAREL S/A, Garoabaer, Iceland), which has a maximum cutting capacity of 30,000 feet per hour. The removal of residues on its surface is carried out with a continuous jet of potable water at room temperature (24°C ± 1) during the entire cutting process.

The study was carried out to evaluate the operational self-washing process of the feet-cutter disc, which cuts the feet of all slaughtered birds. A total of 84 samples were collected and divided into two experimental groups (n = 42). In the Non-Heated Water (NHW) group (NHW; Figure 1A), the disc was washed continuously with a jet of water at room temperature (24°C ± 1). On the other hand, the equipment received a continuous jet of water at 85°C ± 1 in the HW group (HW; Figure 1B). To fit the heated self-washing system, a pump was installed to supply the washing hoses with heated water coming from the steam heat exchanger system.

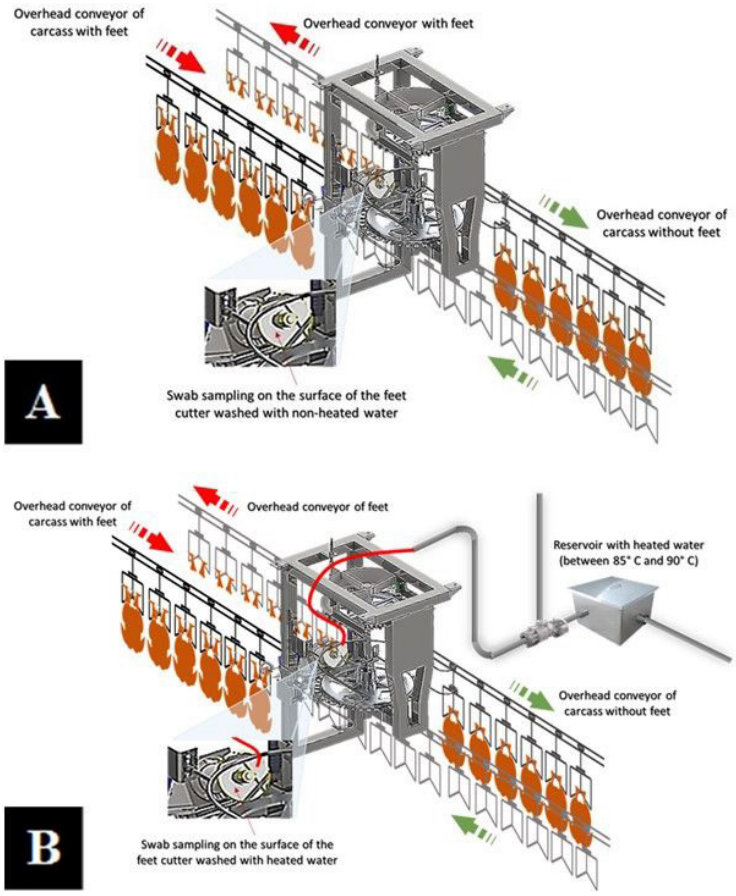

Figure 1. Schematic designs of the operational self-washing system of the feet-cutter disc with (A) non-heated and (B) heated water.

Samples were collected prior the slaughter (right after the pre-operational sanitation), during operational meal breaks (three breaks), and after the end of the slaughter (before pre-operational sanitation). For this, a sterile swab was scrubbed on the cutter disc's surface using a 10 cm^2 sterile area marker and conditioned within tubes containing 10 mL of 1% buffered peptone water solution (Neogen Corporation, Lansing, USA), which in turn were stored under refrigeration until the microbiological analysis.

2.2 Microbiological analysis

Microbiological analyses were performed by a governmental-accredited laboratory in accordance with current technical regulations. 3M™ Petrifilm™ Plates (3M™, Sumaré, Brazil) were used for *Salmonella* spp. (ISO-6579-1:2017) isolation and for the quantification at a ten-fold serial dilution of Mesophilic Aerobics (AOAC 990.12), Sulphite-reducing *Clostridia* (SRC) (ISO 15213:2003), *Escherichia coli* (AOAC 998.08) and *Staphylococcus aureus* (AOAC 2003.07) (International Organization for Standardization, 2003; 2017; Association of Official Analytical Chemists, 2019).

2.3 Statistical analysis

Statistical analyses and graphs from microbiological assays data were done using GraphPad Prism version 8.0.1 for Windows (GraphPad Software, La Jolla, CA, USA). Firstly, the microbiological counts were transformed into Log_{10} and normality of residues was assessed by means of D'Agostino-Pearson omnibus (K2) test. Then, data with normal distribution were submitted to the Paired t test, whereas non-Gaussian data were evaluated with Wilcoxon matched-pairs signed rank test. The results were considered statistically significant when the *P* value was less than 5% ($p < 0.05$). A Confidence Interval (CI) of 95% (CI95) was used in the graphs.

3 Results and discussion

Pathogens control methods in the food industry undergo constant improvements to ensure that industrial processes are within acceptable thresholds (Dias et al., 2017). For this, the use of chemical compounds or physical action are authorized (Northcutt et al., 2007; Potter et al., 2012; Micciche et al., 2018; Thomas et al., 2020) and the assess of bacterial load on equipment surfaces is essential to monitor the effectiveness of sanitization procedures throughout the whole process (ICMSF, 2011). In broiler slaughterhouses, the main microbiological indicators are the presence of Mesophilic bacteria, as an indicator of sanitizing degree; quantification of total coliforms and *E. coli* for faecal/environmental contamination; and finally, the quantification of *S. aureus* as an indicator of poor hygiene, handling and temperature control problems (González-Fandos & Dominguez, 2006; González-Miret et al., 2006; Rindhe et al., 2008; Milios et al., 2014; Maharjan et al., 2019).

The results of the microbiological quantification of the feet-cutter disc, using ambient (24°C ± 1) and heated (85°C ± 1) water are described in Figure 2. The logarithmic counts of Mesophilic Aerobics, SRC, *E. coli* and *S. aureus* in the NHW group were 1.82, 0.56, 0.31 and 0.14 Log_{10} CFU/cm^2, respectively, whereas in the HW group were 1.17, 0.04, 0.15 and 0.08 Log_{10} CFU/cm^2. *Salmonella* spp. was absent in all evaluated samples in both groups. The use of the heating system (HW) reduced the count of bacteria of public health concern, but statistical differences ($p < 0.05$) were observed solely for Mesophilic Aerobics and SRC.

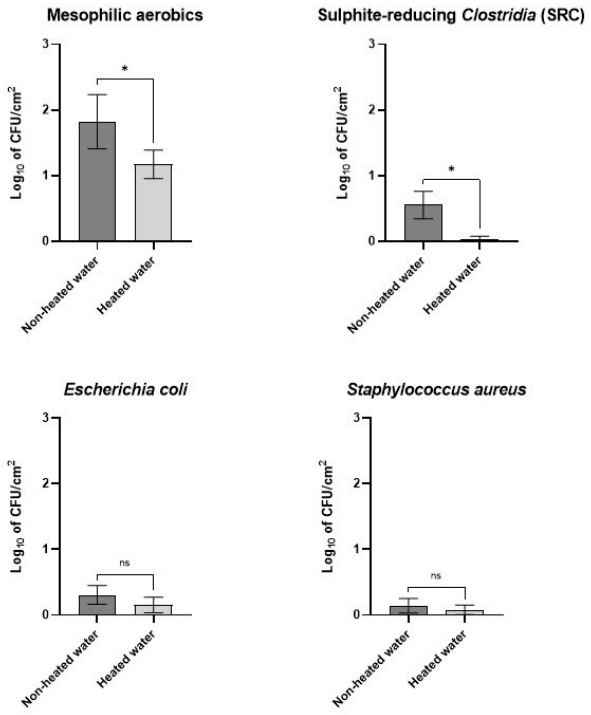

Figure 2. Microbiological quantification on the surface of the feet-cutter disc in a broiler slaughterhouse using a self-washing system with non-heated and heated water. *: means with statistically significant differences ($p < 0.05$); ns: not statistically significant ($p > 0.05$).

It is noteworthy that either intrinsic factors, such as rapid production rate, proximity of the carcasses and the equipment or processes as scalding, defeathering and evisceration, both favor the spread of microorganisms and hamper their control in slaughterhouses (Mead et al. 1993). According to legislation, equipment surfaces must be smooth and imperfection-free to be frequently and easily cleaned without compromising food hygiene (Brasil, 1996). Thus, the continuous cleaning of the feet-cutter disc is of outstanding importance, since it is located right after the defeathering machine outlet, considered a sector of high bacterial pressure. The use of running water as a physical cleaning mechanism reduces residues on the equipment surfaces (Borges et al., 2018). Furthermore, it proved to be an important mechanism to avoid cross-contamination when heated and maintains bacterial loads even lower.

The use of simple control methodologies can maximize the process, reduce the incidence of pathogens and still be affordable for the industry (Micciche et al., 2018). Therefore, it was demonstrated in the present study that the use of HW reduced bacteria of public health concern on the surface of equipment of high contact with the carcasses.

In a study conducted by Dillard et al. (2016) in slaughterhouses in the United States of America (USA), it could be evaluated the antimicrobial activity of immersing knives, hooks and pneumatic skinning saw in HW. The authors reported that the sanitizing effectiveness of the procedure depends on the time exposure and the size of the surface, which should be more than 10 seconds for larger surfaces. Similarly, Taormina & Dorsa (2007) experimentally inoculated *E. coli* O157:H7, *S.* Typhimurium DT104, *Clostridium perfringens* and *Lactobacillus* spp. on knife blades and subjected them to different temperatures with or without the use of disinfectants. It was observed that the longer the exposure time to HW, the greater was the reduction of bacterial counts. In the present study, the disk has large dimensions and it was possible to maintain it at high temperature (85°C ± 1) due to the continuous jet of HW, facilitating its constant exposure to high temperatures and therefore reducing the bacterial load on its surface.

Furthermore, there is a correlation between exposure time and temperature regarding the reduction of microorganisms on knives. Higher water temperatures (82°C for 1 s) require less immersion time, whereas lower temperatures require longer immersion periods (Goulter et al., 2008). Barbosa et al. (2016) evaluated biofilm formation on deboning knives submitted to several cleaning procedures and also demonstrated that a longer period of immersion in heated water is required against long time-formed biofilm to reduce *E. coli* contamination levels.

Thus, we observed herein that the constancy of the continuous jet combined with the high temperature of the heated water significantly favored the reduction of the microbiological load ($p < 0.05$), thus minimizing the possibilities of cross-contamination occurrence between the carcasses. Although the effectiveness of the process has been observed, the use of HW becomes an addition to the operational procedure since the food security thresholds implemented by current national and international marketing regulations were not exceeded in both groups (Agri-Food and Veterinary Authority, 2000; Brasil, 2017; National Standards of the People's Republic of China, 2014; Commision Regulation (EC), 2005; Standardization Organization for G.C.C (GSO), 2014; NB, 2017).

4 Conclusion

The use of a continuous self-washing system with heated water on the feet-cutter disc in broiler slaughterhouses did not statistically decreased the load of neither *E. coli* nor *S. aureus*, but reduced the levels of both Mesophilic Aerobics and Sulphite-Reducing *Clostridia*. Thus, it can be a tool for self-control programs to maintain the load of public health concern pathogens on the surface of the equipment below the food safety thresholds and by reducing potential cross-contamination.

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