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Single step non-thermal cleaning/sanitation of knives used in meat industry with ultrasound

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ABSTRACT

The combination of ultrasound (US) with chlorinated water (CW) and neutral detergent (ND) for simultaneous cleaning and sanitation of knives used during cattle slaughter was evaluated as a novel non thermal treatment. The US mode of operation, detergent concentration and time of treatment were studied and the results were compared with the conventional sanitation method used in meat industries. The conventional sanitation method promoted a decrease ($p < 0.05$) in the counts of mesophiles, *Enterobacteriaceae*, molds and yeasts, and a similar behavior was observed for US + CW (2.05 ± 0.08 mg/l of chlorine, and mode operation normal and sweep for 10 min) and US + CW + ND (5 ml/l and mode operation sweep for 5 min) methods. Nevertheless, when detergent concentration and sonication time were increased (20 ml/l, 15 min) a strong decrease ($p < 0.05$) in the counts of mesophiles, *Enterobacteriaceae*, *Staphylococcus aureus*, molds and yeasts. Knife blades presented appropriate hygienic-sanitary properties in such conditions based on the *Clean-Trace Surface Protein Plus*™ test swab, which were better than the results obtained from conventional method. Kinetic modeling of knife sanitation was performed according to the transfer of organic matter, nitrogen and phosphorus during the process indicated highest migration rate of residues for US + CW + ND method, reaching 1.61 mg/l·min. The hardness of knives' surface (Rockwell) was not changed by sonication using US + CW + ND method. These results indicate that both knife cleaning and sanitation processes could be performed in a unique step without the use of heat.

1. Introduction

Despite the technological advances in recent years in the meat industry, the maintenance of the hygienic-sanitary control of equipment and utensils used during processing is still a problem. Equipment and utensils can contaminate food if not properly sanitized, thereby reducing the shelf life and the safety of product. Some characteristics of the slaughtering process difficult the identification of the most appropriate way to perform sanitation procedures, and the meat industry in Brazil typically promoted periodic work stops to perform routine sanitation procedures of equipment and utensils (MAPA, 1997, 1998, 2005).

In accordance with Brazilian legislation, knife sanitation in the meat industry should be performed after each use, and handlers should have at least two of these tools during processing. The sanitation of such devices must be preceded by manual washing to remove the attached organic matter, with subsequent introduction in sterilizers at a temperature of 82.0 °C for at least 20 s or 82.2 °C for 15 s. Afterwards, the knife blades must be completely submerged in chlorinated water (2–5 mg/l of chlorine concentration) at a steady flow to prevent the accumulation of residues (MAPA, 2005; Eustace et al., 2007; Goulter, Dykes, & Small, 2008). Therefore, any decrease of water temperature and immersion time during sanitation could be considered as extremely dangerous, because thermophilic and even mesophilic microorganisms can survive in these temperature variations and could be transferred to carcasses (MAPA, 2005; Taormina & Dorsa, 2007; Goulter et al., 2008). Therefore, the use of sterilizers presented critical limitations, which include difficulty in maintaining water at a stable temperature, risk of burning of operators (because the utensils are often manually introduced in the water at 82.0 °C), and increased wear of the cutting blades (Dardni, 2008). In addition, the presence of a heating source in the ambient of production refrigerated to maintain the temperature is inconvenient, which lead to high energy expenditure and water condensing around the equipment.

The use of ultrasound (US) has been reported as an attractive process in the meat industry with positive effect on food processing and preservation (Cichoski et al., 2015), including the sanitation process (Dolatowski, Stadnik, & Stasiak, 2007; Broekman, Pohlmann, Beardwood, & de Meulenaer, 2010). The study conducted by Mason, Rierea, Vercet, and Lopez-Buesa (2005) reported that the US frequency may range from 20 to 100 kHz and the power may range from 0.2 to >2000 W/cm^2 during sanitation processes for equipment and utensils. Cavitation is the main mechanism of US responsible for the removal of

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organic impurities from surfaces (Jiranek, Grbin, Yap, Barnes, & Bates, 2008; Stanga, 2010; Otto et al., 2011). In addition to cleaning effect, US also presented disruption effects in some microorganisms. The effectiveness of microbial inactivation by US depends on the target microorganism, contact time, US frequency and amplitude, medium temperature and pH, and material composition and volume (Manas, Pagan, Raso, Sala, & Condon, 2000; Jiranek et al., 2008). Despite the availability of studies on the use of US for microbial inactivation (Salvia-Trujillo, Rojas-Graü, Soliva-Fortuny, & Martín-Belloso, 2014; Millan-Sango, McElhatton, & Valdramidis, 2015; Millan-Sango, Garroni, Farrugia, Van Impe, & Valdramidis, 2015), the applications of US for knives sanitation were not found.

Therefore, this study aimed to evaluate the effect of US on knives used in meat industry reaching a single step for both cleaning and sanitation. The treatment was performed at room temperature with and without detergent solutions prepared at different concentrations in potable chlorinated water. Different modes of US application were evaluated and the counts of mesophiles, *Enterobacteriaceae*, *Staphylococcus aureus*, molds and yeasts were performed after treatment. A swab test for verification of the presence of organic residues was also used to verify the efficiency of sanitation. The migration rate of organic residue from knives to solutions and the properties of the water used in the process were evaluated to establish a kinetic modeling of knives sanitation.

2. Material and methods

2.1. Knives

Ten professional knives (Tramontina, Carlos Barbosa, Brazil) used during cattle slaughter (after depletion of one animal) in a slaughterhouse under federal inspection in the central region of Rio Grande do Sul State, Brazil, were used. The experiments were replicated two times in two different days (n = 2). The professional knives consisted of a stainless steel blade (DIN 1.4110, 54–57 hardness on the Rockwell scale, HRc), and a polypropylene handle with antimicrobial protection (MICROBAN™), and they were certified by the National Sanitation Foundation (NSF). The knives measured 3 mm (thickness) × 130 mm (blade length) × 146 mm (handle length) and weighed around 94 ± 2 g (Tramontina, 2016).

2.2. Ultrasound application

The US bath (Elma Schmidbauer GmbH, Singen, Germany, model TI–H-5) with a maximum power output of 750 W at a frequency of 25 kHz and an amplitude of 100%, with 4.7 l of total capacity (240 × 130 × 150 mm) and a 3.5 l of working volume was used. Two modes of operation (normal and sweep) were used. The sweep function used allowed an electronic oscillation of the sound field in order to prevent the formation of zones of low performance in the ultrasonic bath. Five professional knives were used for each treatment, and their polypropylene handles were not fully submerged in the water because of the size of the US tank used in the study (Fig. 1).

2.2.1. Methods used for cleaning and sanitation of knives

2.2.1.1. Conventional method used in the meat industries. The knives were manually cleaned with sponges using neutral detergent and washed with chlorinated water (2.05 ± 0.8 mg/l). Afterwards, they were introduced in the sterilizer (Maqfort, Brazil) during 20 s at 82.0 °C.

2.2.1.2. US methods. Firstly, the knives were sonicated in a US bath (sweep and normal modes operation) using only potable chlorinated water (CW, 2.05 ± 0.8 mg/l, total volume of 3.5 l) at 20 °C. This experiment was called as US + CW. After, different knives were sonicated using the same conditions, but with different neutral detergent concentration (ND, 5, 10, 15 and 20 ml/l). This method was called US + CW + ND. The knives were sonicated during different time (0, 10, 15, 20, 25 and 30 min) for both US + CW and US + CW + ND methods. The same experiment was performed two times for evaluation. It is important to mention that the detergent (Ecolab™) used during the sanitation process presented a neutral pH (pH 7).

2.3. Sanitation evaluation

2.3.1. Microbiological analyses

The knives were collected in meat industry after slaughter and stored in a cooler box and immediately transported to university for evaluation. Microbiological analyses were performed up to 2 h after the collection after cleaning and sanitation by conventional and US methods. The samples were collected to perform the microbiological analyses according to the methods proposed by the APHA (2005). The method consists of rubbing a sterile and dampened swab with diluent solution (0.1% sterile peptone water) in a 10 cm^2 area outlined by a sterile template. Five replicates (n = 5) were used for each analysis.

To assess the efficiency of sanitation of professional knives, viable mesophilic aerobic microorganisms were quantified using plate count agar (PCA) medium at 36 °C for 48 h; molds and yeasts were quantified using potato dextrose agar (PDA) medium (25 °C for 5 days), and coagulase-positive *Staphylococcus aureus* were quantified using agar base Baird Parker medium (36 °C for 24 h). These methods were carried out according to the American Public Health Association (APHA, 2005) and Normative Instruction 62, an official method recommended by

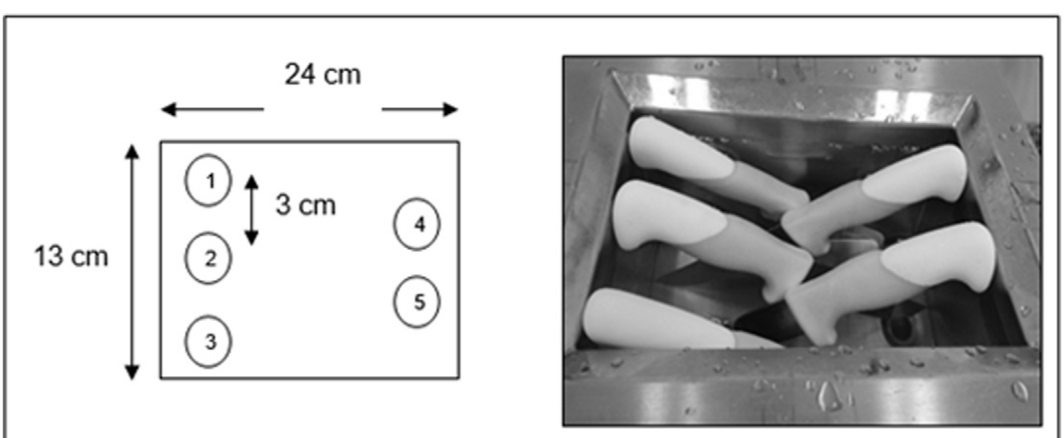

Fig. 1. Position of professional knives in the US bath when performing the sanitation process. Legend: 1–5 correspond to different knife positions.
Source: Elma (2016).