The Use of Hypochlorous Acid Generated by Electrolysis for the Treatment of Pathogens and Spoilage Microorganisms on Meat Products

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Story in Brief

The USDA-FSIS has encouraged the use of novel antimicrobial agents in the food industry to combat the presence of pathogenic microorganisms as food contaminants in food processing environments. One 'old' technology that is experiencing re-examination in food safety applications is anolytic (acidic) electrolyzed water generated by the electrolysis of brine solutions to produce hypochlorous acid that is often referred to as 'electrolyzed water'. Hypochlorous acid is allowed for use as a sanitizer on food contact surfaces and for use on raw beef, but it has not yet been approved for direct application on ready-to-eat meats.

Our objectives were to examine the use of hypochlorous acid (i.e. produced as 'electrolyzed water') for reduction of pathogens (*Listeria monocytogenes*) and spoilage organisms (*Leuconostoc mesenteroides*) that are of concern to safety and quality in the manufacturing and processing of ready-to-eat meats (i.e., Canadian Bacon and beef chubs).

Electrolyzed water was produced at concentrations of 200 - 500 ppm with a commercial generator (SanAquel LLC, Bristow, OK) and diluted to free chlorine levels at levels between 20-50 ppm, the allowable limit on fresh meat carcasses. Samples were sprayed with an electrolyzed water solution by use of either a manual pump sprayer or industry type sprayer at 20 psi of pressure. Spray rinses that dripped off the products were also collected during each application for microbial testing to determine the amount of viable cells present.

Electrolyzed water showed a reduction of up to 1.7 logs when compared to controls. When compared to a sterile water rinse, electrolyzed water showed up to 0.50 greater log reduction of surface-inoculated microorganisms. We recovered cells in rinse water using sterile water at 10^4 cfu/ml whereas microorganisms tested in recaptured electrolyzed water rinse solutions were not recovered at detectable levels ($< 10^0$ cfu/ml). Chlorine-based sanitizing solutions are currently allowed on a variety of food products as well as raw meats and companies are currently petitioning for use on ready-to-eat meats. The ability to spray hypochlorous acid mists throughout a process may help to eliminate pathogens and spoilage organisms in near 'real-time' as opposed to waiting 8 hours until the start of a sanitation shift.

Key Words: *Listeria monocytogenes*, Electrolyzed Water, Ready-To-Eat Meat, Hypochlorous Acid

Introduction

Listeria monocytogenes is a psychrotrophic, intracellular bacterium which is pathogenic to humans and animals. It is capable of causing severe infections like septicemia, encephalitis, and meningitis, especially in immunocompromised individuals, newborns and pregnant women (Bubert et al., 2001). Several large outbreaks of listeriosis have been associated with contaminated vegetables, milk, and ready-to-eat (RTE) meat products on which the bacteria can

multiply even at low temperatures. In the U.S., an estimated 2,500 persons become seriously ill with listeriosis of which approximately 500 die each year (CDC, 2005).

Pathogens may pose the biggest threat to human health but they are not necessarily the most common issue affecting meat processors. On a day-to-day basis, most food processors are affected by spoilage microorganisms that may affect the quality of their foodstuffs in a short period of time. Contamination of products with spoilage microorganisms often results daily in major profit losses for many food processors. One common RTE meat spoilage organism is *Leuconostoc mesenteroides*. These bacteria produce a 'slime' (i.e. dextran) on meat products containing sucrose.

Our objective has been to examine the application of electrolyzed water to eliminate or reduce foodborne pathogens such as *L. monocytogenes* or spoilage organisms such as *Leuconostoc mesenteroides* from meat products.

Materials and Methods

An electrolyzed water (EW) generator was provided by SanAquel LLC (Bristow, OK) but was originally distributed by Integrated Environmental Technologies Ltd. (Little River, SC). The generator electrochemically converts a saline solution into two separate solution streams from the anode and cathode designated as anolyte and catholyte, respectively. The anolyte electrolyzed water solution (AEW) contains hypochlorous acid which is the active antimicrobial agent. The AEW is a strong oxidant with a free chlorine content reaching as high as 500 ppm and a pH range of 6 - 7.

For all experiments, full strength AEW solution was diluted using distilled and deionized water in order to obtain free chlorine levels at or near the levels allowed by USDA-FSIS and FDA. Free chlorine was measured using the DPD-FEAS digital titration method provided by Hach Instruments (Loveland, CO). Total chlorine was measured using a sodium thiosulfate digital titration meter (Hach Instruments). Along with total and free chlorine, each diluted solution was tested for pH, oxidative reduction potential (ORP), and conductivity. The pH and ORP were determined using an Oakton Combination meter (Vernon Hills, IL) while the conductivity was measured using the Oakton Con 6 conductivity meter.

Logs of Canadian bacon were received from a local manufacturer. The Canadian bacon was encased in a permeable fibrous cellulose casing. The second product used in testing was a cured beef product produced at the Food and Agricultural Products Center at Oklahoma State University. The logs were cut to usable sizes (approx. 4"-6"). Edible dye was used to mark off a 5 x 5 sq cm area on each of the samples. To this area, 100 µL on an inoculum was added and spread evenly with a sterile gloved finger. Depending on the experiment, the inoculum consisted of either a four strain mixture of *L. monocytogenes* or a slime-producing strain of *Leuconostoc mesenteroides* isolated from contaminated product. After inoculation, the samples were allowed to sit for 30 minutes at refrigerated temperatures before further processing.

Treatments were sprayed onto the samples using either a handheld spraying device or an industrial liquid pressurized sprayer (Fig 1). Treatments times were 15, 30, or 60 second sprays. For comparison purposes, the treatment solutions used were distilled water, diluted bleach, or

diluted AEW. The samples were strategically placed in a retainer in order to capture the rinse solutions during spraying so that microbial viability in rinse solutions may also be determined.

Figure 1. Equipment used for spraying electrolyzed water onto meat products. Handheld manual sprayer (left) and automated pressurized sprayer (right).

Following treatments, the sample areas were removed from the Canadian Bacon log or beef chub and placed into a stomacher bag along with 10 mL of buffered peptone water (BPW). The sample was then stomached for two minutes on a normal setting. After stomaching, the sample was serially diluted and plated. Samples inoculated with *L. monocytogenes* were plated on Tryptic Soy Agar (TSA) while slime contaminant inoculated samples were plated on De Man, Rogosa, and Sharpe (MRS) agar.

Results and Discussion

The first experiment used a handheld sprayer to compare the effects of three spray solutions. Each sample was inoculated with *L. monocytogenes* before being sprayed for 30 seconds. The bleach solution contained 26 ppm of free chlorine while the electrolyzed water solution contained 20 ppm of free chlorine. The results show that although the electrolyzed water treatment did not have a greater reduction than the water or bleach rinse there were no detectable bacteria in the electrolyzed water rinse off solutions. (Fig 2)

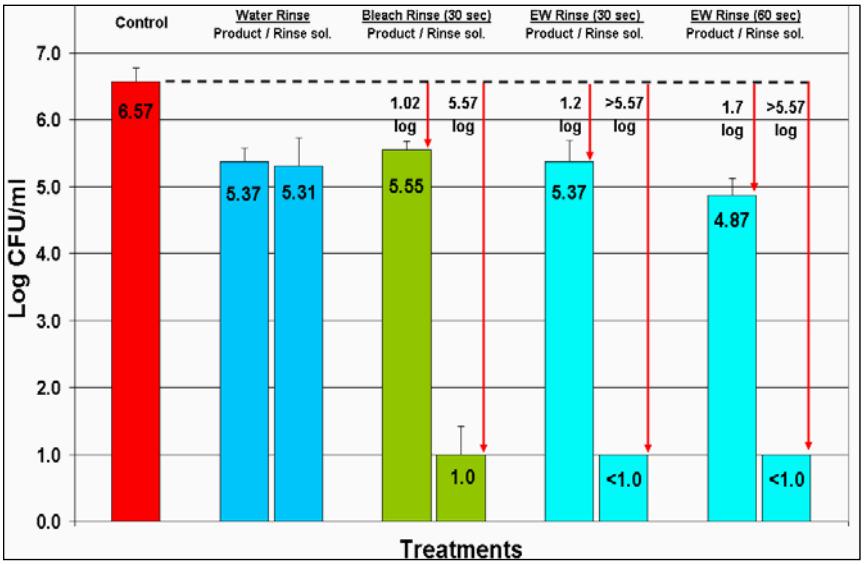

Figure 2. Encased Canadian Bacon inoculated with *L. monocytogenes* and sprayed using a handheld sprayer with water, bleach (sodium hypochlorite), or electrolyzed water (hypochlorous acid).

Another set of trials employed the use of a handheld sprayer but instead of using Canadian bacon the product tested was a cured beef chub. The samples were again inoculated with *L. monocytogenes*. Two spray treatments were used as comparisons, distilled water and electrolyzed water. The electrolyzed water was at 33.8 ppm of free chlorine. Figure 3 shows the graphical representation of the bacteria remaining on the treated product while Figure 4 shows the amount of viable organisms present in the rinse off solutions.

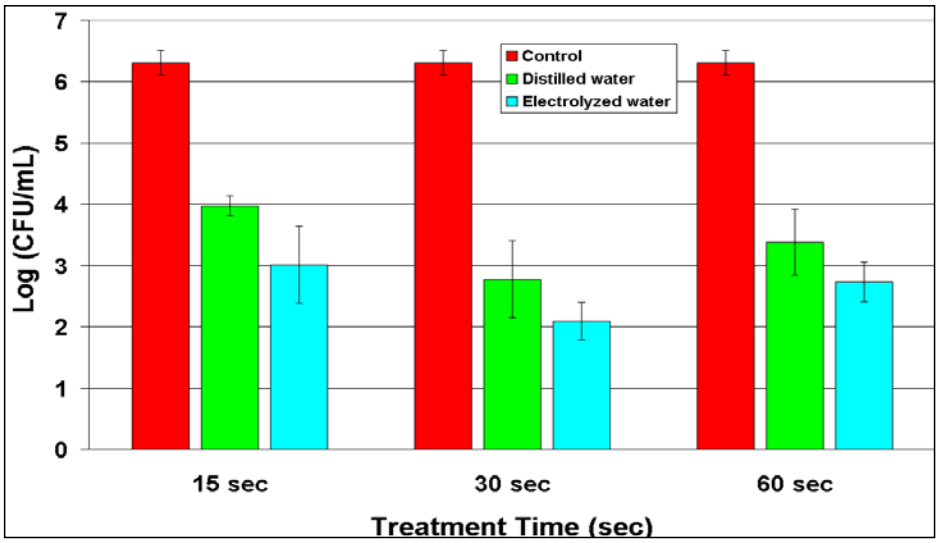

Figure 3. Manual spray rinse on beef chubs inoculated with *L. monocytogenes*.

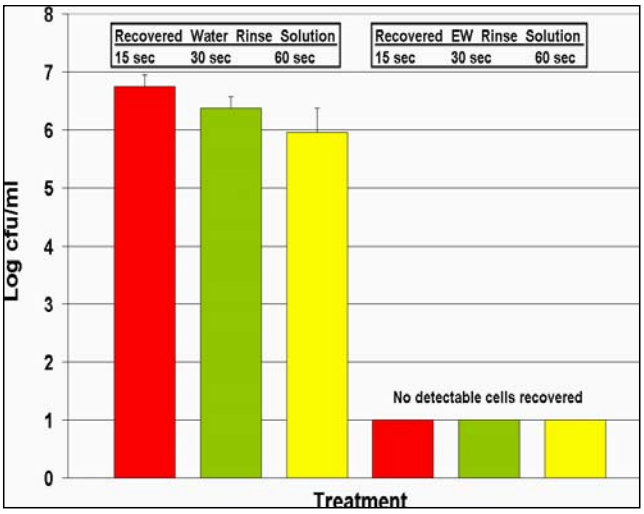

Figure 4. Levels of *L. monocytogenes* in rinse solutions recovered from spray-treated beef chubs.

In additional trials, cured beef chubs were inoculated with *Leuconostoc mesenteroides* a troublesome slime contaminant on RTE meat products. The samples were sprayed with either electrolyzed water at 33.8 ppm or distilled water. Each sample was sprayed for 15, 30, or 60 seconds. The electrolyzed water spray reduced the number of viable organisms remaining on the product by as great as 3.85 logs. Electrolyzed water eliminated 1.0 log greater level or organisms than did the distilled water.

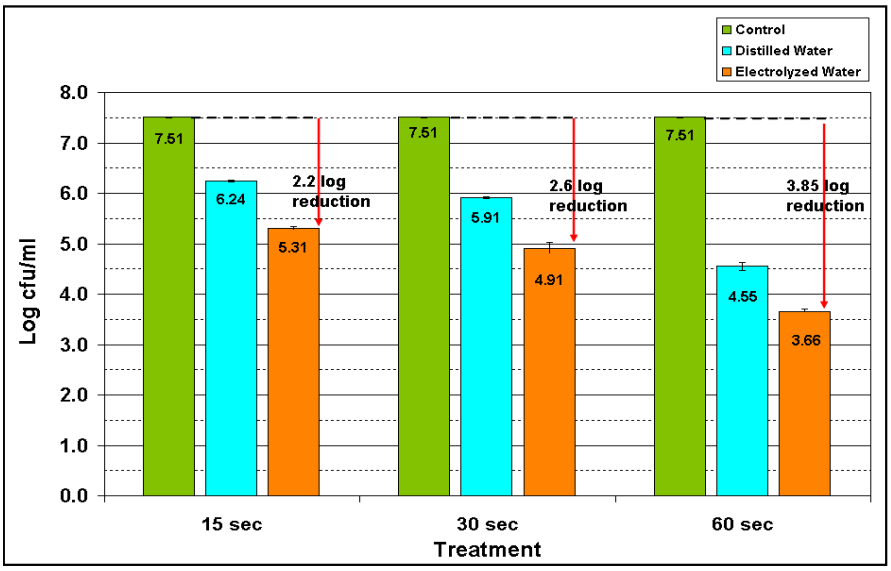

Figure 5. Rinse treatment of beef chubs inoculated with *Leuconostoc mesenteroides* (slime contaminants).

Conclusion

In any facility there is a potential for bacterial cross contamination. The results presented above make a good case for the use of electrolyzed water on RTE meats in order to prevent reduce or eliminate pathogens and spoilage microorganisms from sensitive meat products. The results

show that there were no detectable microorganisms in the electrolyzed water rinse solutions, demonstrating that these treatments reduce the opportunity for these organisms to be spread throughout the processing environment. This however was not the case with products treated with regular water. The surviving organisms in the regular water could attach to employees' apparel and be tracked throughout a plant environment. An electrolyzed water spray can be used to reduce the amount of bacteria on the product and the chance for cross contamination.

Literature Cited

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