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Short Communication

Considerations for post-lethality treatments to reduce *Listeria monocytogenes* from fully cooked bologna using ambient and pressurized steam

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Abstract

During processing of ready-to-eat (RTE) deli meats, any secondary processing procedures such as peeling and cutting introduce the distinct possibility of cross-contamination between equipment, personnel, and food. To eliminate or reduce pathogens such as *Listeria monocytogenes* and ensure food safety, RTE deli meats can be pasteurized prior to or after packaging. In this study, ambient steam in-package pasteurization was compared with pressurized steam prepackaging pasteurization to reduce *L. monocytogenes* from fully cooked RTE bologna. The bologna (14 cm diameter × 1.5 cm thickness) samples were surface-inoculated to contain about 8 $\log_{10}$ of *L. monocytogenes*. To achieve 2 log reductions for *L. monocytogenes*, the bologna samples needed to be treated for about 10 s in pressurized steam at 131 °C or for about 2.5 min in ambient steam at 100 °C. The pasteurization time using pressurized steam treatment was about 75–90% shorter than using ambient steam treatment. Pressurized steam treatment may be integrated into a vacuum packaging unit to effectively eradicate *L. monocytogenes* from RTE meats just prior to sealing the retail packages to further reduce the treatment time, avoid post-treatment recontaminations by pathogens, and improve food safety without detrimentally affecting meat quality.
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1. Introduction

Many of today's concerns for pathogens such as *Campylobacter jejuni*, *Escherichia coli* O157:H7, *Listeria monocytogenes*, and *Cyclospora cayetanensis* were not recognized as causes of foodborne illnesses about 20 years ago (Mead et al., 2000). Foodborne illness bears a high cost to the US economy and results in thousands of deaths each year. According to the estimate by the Centers for Disease Control and Prevention, foodborne diseases cause approximately 76 million illnesses, 325,000 hospitalizations, and 5000 deaths in the United States each year, in which about 14 million illnesses, 60,000 hospitalizations, and 1800 deaths are caused by known pathogens (Mead et al., 2000).

Three pathogens, *Salmonella, L. monocytogenes*, and *Toxoplasma*, are responsible for 1500 deaths in US each year with *L. monocytogenes* responsible for about 500 deaths among 2500 illnesses (Mead et al., 2000). About 99% of listerosis cases reported in US were transmitted by foods (USDA-FSIS, 2003a). *L. monocytogenes* accounts for 28% food-related death and the case-fatality of listerosis was 20–30%—the second highest among bacterial diseases (Mead et al., 2000).

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L. monocytogenes is a pathogenic bacterium found in soil, water, and vegetation and on the surface of equipment, floor, and walls and is often carried by healthy animals as well as humans (USDA-FSIS, 2003a).

L. monocytogenes easily spreads by direct food contact with a contaminated surface, possesses a relatively high resistance to heat and salt concentration, and can grow at refrigeration temperatures as low as 2 °C or under low oxygen tension such as found in vacuum-packaged RTE meats (USDA-FSIS, 2003a; Samelis et al., 2002). While the cooking processes currently applied by the US meat and poultry industry generally meet United States Department of Agriculture Food Safety and Inspection Service (USDA-FSIS) requirements, the processing steps after cooking such as peeling, sorting, loading, slicing, packaging, etc., are potential sources of recontaminations for pathogens such as *L. monocytogenes*. A USDA-FSIS survey published in 2001 showed that 1–10% of retail RTE meat and poultry products was contaminated with *L. monocytogenes* (Levine et al., 2001).

Illness outbreaks associated with *L. monocytogenes* in RTE meats have prompted governmental regulatory agencies to impose a new rule on October 6, 2003 for *L. monocytogenes* reductions (USDA-FSIS, 2003b). This new rule requires that all establishments that produce RTE meat and poultry products that are exposed to the environment after lethality treatments will need to develop written programs, such as Hazard Analysis and Critical Control Point (HACCP) systems, Sanitation Standard Operating Procedures (Sanitation SOPs), and other prerequisite programs, to control *L. monocytogenes* (USDA-FSIS, 2003b).

While various methods have been used to control recontaminations from *L. monocytogenes*, each method has some key disadvantages. For example, one option for controlling *L. monocytogenes* is to handle products in aseptic environments. Although sanitation policies have helped to improve sanitary conditions in RTE meat and poultry processing plants, true aseptic conditions are extremely difficult to achieve (Levine et al., 2001; Tompkin, 2002). *L. monocytogenes* cannot be completely eliminated from RTE meat and poultry processing environment using present technologies (Berrang et al., 2002; Tompkin, 2002). The potential contaminations of *L. monocytogenes* on RTE meat and poultry products presents a food safety threat and has promoted interest in applying post-cook pasteurization treatment prior to or after packaging to reduce *L. monocytogenes* incidences among RTE meats.

Post-cook pasteurization by steam or hot water was used to reduce *Salmonella* or *Listeria* from RTE meat and poultry products (Gill et al., 2001; Kozempel et al., 2000; Muriana et al., 2002; Murphy et al., 2001a; Murphy and Berrang, 2002a, b; Murphy et al., 2002a–c, 2003a–d). Considering large volumes of varieties of RTE meats on the market today, the industry is in need of information that could help RTE meat and poultry processors choose a simple and cost-effective post-lethality treatment alternative that is feasible to their processes to improve food safety without negatively affecting quality of their products.

The objective of this study was to compare the effectiveness of in-package ambient steam treatment with prepackaging pressurized steam treatment as commercial alternatives on reducing *L. monocytogenes* from fully cooked bologna. Although high temperature short time (HTST) treatment has been applied in treating liquid foods such as fruit juice, pressurized steam pasteurization has not been commercially used in treating RTE meats due to the difficulties of commercial implementation when using a stand-alone pressurized steam cooker for RTE meat products and re-exposure issues after pasteurization treatment prior to retail packaging. From this study, we propose to apply prepackage pressurized steam pasteurization technology in each of individual vacuum packaging chambers of a packaging machine to reduce *L. monocytogenes* from RTE meat products and minimize the re-exposure time of the treated meats to processing environment before final retail packaging of RTE meats is completed.

2. Material and methods

2.1. Product

Fully cooked bologna logs (14 cm diameter × 30 cm length) were obtained in plastic packages (0.2 mm thickness) from a processor. The bologna samples were analysed to contain about 28% fat, 15% protein, 5% carbohydrate, 1% sodium salt, and 50% moisture. The ingredients of the bologna was consisted of pork, mechanically separated chicken, dextrose, corn syrup, salt, beef, water, flavorings, granulated onion, and granulated garlic. The formulations of the bologna were proprietary to the processor. The packaged bologna logs were kept at −20 °C and thawed at 4 °C for about 24 h prior to each use.

2.2. Culture preparation

Six strains of *L. monocytogenes* (ARS#V105, ARS#V67, ARS#V72, ARS#V113, ARS#V125, and LCDC 81-861 4b) were obtained on the slants containing tryptic soy agar (TSA) plus 0.6% yeast extract (YE) from M.E. Berrang at USDA-ARS-RRC (Athens, GA) and M.G. Johnson at the University of Arkansas (Fayetteville, AR). From each slant, a loopful of each culture was transferred to 10 ml tryptic soy broth (TSB) plus 0.6% YE in a test tube and then incubated at 35 °C

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