Control of *Listeria monocytogenes* in Vacuum Packaged Frankfurters Sprayed with Lactic Acid alone or in Combination with Sodium Lauryl Sulfate

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ABSTRACT

United States Department of Agriculture Food Safety and Inspection Service (USDA-FSIS) regulations require that processors employ lethal or inhibitory antimicrobial alternatives in potentially contaminated ready-to-eat (RTE) products that allow growth of *Listeria monocytogenes*. This study evaluated the effect of lactic acid (LA, 5% v/v) and sodium-lauryl-sulfate (SLS, 0.5 % w/v), alone or in combination (LA/SLS), as spraying solutions to control *L. monocytogenes* on frankfurters. Frankfurters (two replicates, three samples per treatment) were inoculated with a 10-strain composite of *L. monocytogenes* to a level of 4.8±0.1 log CFU/cm², and sprayed (10 s, 20 bar, 23±2°C) with the antimicrobials or distilled water (DW) after or before (only DW and LA/SLS) inoculation, vacuum-sealed and stored at 4°C for 90 days. Samples were analyzed for pathogen (PALCAM) and total microbial counts (TSAYE) during storage. Spraying with LA or SLS after inoculation reduced the numbers of *L. monocytogenes* by 1.8±0.5 and 2.0±0.5 log CFU/cm², respectively, while DW removed only 1.2±0.1 log CFU/cm². Using LA/SLS reduced pathogen populations by 1.8±0.4 log CFU/cm² when applied before and 2.8±0.2 log CFU/cm² when applied after inoculation. Frankfurters sprayed with DW or left untreated showed an increase in pathogen counts after 14 days and reached approximately 7.0 log CFU/cm² at 52 days of storage. Pathogen counts were suppressed for more than 35 days on frankfurters treated with LA alone or the combination LA/SLS before or after inoculation; however, SLS did not have a bacteriostatic effect when used alone. The combination of LA/SLS at the concentrations tested effectively controlled *L. monocytogenes* on frankfurters especially when applied after inoculation. Spraying of frankfurters with a combination of LA and SLS may be considered as an antilisterial alternative in RTE meat and poultry products as required by USDA-FSIS regulation.

INTRODUCTION

Listeria monocytogenes is a gram-positive psychrotrophic foodborne pathogen that is widely distributed in nature, and its presence in ready-to-eat (RTE) foods is a concern for food regulatory agencies, food processors, and a potential threat to consumers. The U.S. Department of Agriculture, Food Safety and Inspection Service (FSIS), established a "zero tolerance" rule for *L. monocytogenes* in RTE meats because of its virulence and ability to grow at refrigeration temperatures. In addition, the agency requires food processors to control the pathogen in RTE foods using one out of three proposed alternatives *(FSIS, 2006)*. Alternative 1 requires use of a post-lethality treatment and antimicrobial agent or process that suppresses or limits the growth of *L. monocytogenes* after it has been exposed to the processing environment. Under alternative 2 processors must use either a post-lethality treatment or antimicrobial agent to control the pathogen. Processors that choose alternative 3 are required to control the pathogen in RTE foods or the processing environment by sanitation programs and are subject to frequent FSIS testing. The FSIS developed a compliance guideline to assist processors in meeting regulatory requirements of the FSIS final rule *(FSIS, 2006)*. The guideline suggests that the post-lethality treatment must reduce pathogen levels by at least 1 log-cycle; processing plants using treatments that cause a reduction of the pathogen by at least 2 log-cycles will be subject to less frequent FSIS microbial testing.

Lactic acid (LA) is a Generally Recognized as Safe chemical, which is commonly used for decontamination of beef carcasses, extension of shelf life and pathogen control in perishable foods. LA can also be used as a surface treatment of RTE meats for the control of *L. monocytogenes.* Sodium lauryl sulfate (SLS) is an acid anionic surfactant which is approved by the U.S. Food and Drug Administration as a whipping or wetting agent or as an emulsifier in a wide variety of foods such as egg whites, fruit juices, vegetable oils and other non-meat products (*FDA, 2006*). However, the chemical is not included in the current FSIS list of "Safe and Suitable Ingredients Used in the Production of Meat and Poultry Products". The antibacterial effect of SLS increases at a pH below 4, with the optimum range being 1.5 to 3.0.

The bactericidal effect of SLS in combination with organic acids has been documented against *Salmonella* Typhimurium *(Tamblyn and Conner, 1997; Hill et al, 1998)* and *Campylobacter jejuni* (*Zhao and Doyle, 2006)* on broiler skin. The chemical is also an effective ingredient of patented sanitizers for fresh produce *(Takeuchi and Frank, 2001)* and surfaces in contact with foods *(Restaino et al, 1994)*. To our knowledge there is no published research on the effect of SLS alone or as a mixture with LA against *L. monocytogenes* on frankfurters.

In the present study, we considered the possibility of product contamination after application of the post-lethality treatment. Under this scenario the processors may need to rely on the residual effect of the antimicrobials rather than decontamination of the product.

OBJECTIVES

The objective of the present study was to determine the effect of spraying with LA and SLS alone or as a mixture (LASLS) against *L. monocytogenes* on frankfurters, and to compare the effect of the LASLS mixture applied before and after inoculation.

MATERIALS AND METHODS

Frankfurters prepared with beef (40%) + pork (60%)

Sprayed with DW and LASLS (10 s, 20 bar, 23 ± 2°C) → Inoculated with *L. monocytogenes* (10-strain mixture, 4.8 log CFU/cm²)

Inoculated with *L. monocytogenes* (10-strain mixture, 4.8 log CFU/cm²) → Sprayed with DW, LA, SLS, and LASLS (10 s, 20 bar, 23 ± 2°C)

Vacuum-packaging and storage for 90 days at 4°C

Analyses: *L. monocytogenes* (PALCAM agar), total microbial counts (TSAYE), proximate analysis, pH and a_w

Spraying solutions

- Control, CONT
- Distilled water:
  - before inoculation, DB
  - after inoculation, DA
- 5% LA+0.5% SLS
  - before inoculation, LSB
  - after inoculation, LSA
- 5% LA after inoculation, LA
- 0.5% SLS after inoculation, SA

Statistical analysis

- Two replications
- Three samples per treatment at each sampling time
- Randomized complete block design
- Factorial arrangement of the treatments
- Analyzed with GLM procedure of SAS
- Curves fitted using Baranyi model *(Baranyi and Roberts, 1994)*
- Significance level ≤ 0.05

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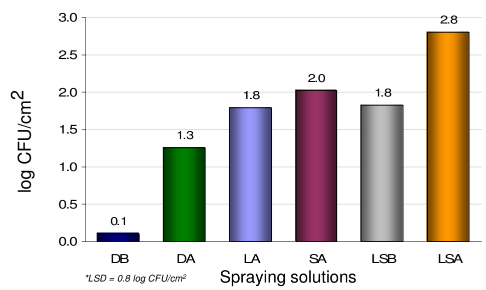
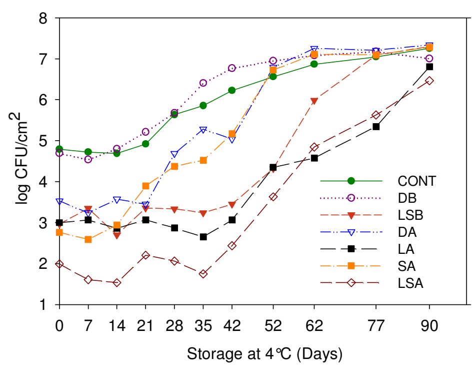
RESULTS

Reduction of *L. monocytogenes* on frankfurters*



Growth of *L. monocytogenes* on frankfurters during storage



Growth kinetics of *L. monocytogenes*

Treatment	Lag phase (days)	[a]GR (log CFU/day/cm²)	Y_0 (log CFU/cm²)[b]	Y_{end} (log CFU/cm²)[c]	R^2
Control	14-15	0.05-0.06	4.6	7.1	0.92
DB	13-16	0.07-0.09	4.6	7.1	0.95
LSB	33-48	0.09-0.17	3.1	–[d]	0.92
DA	17-25	0.10	3.4	7.3	0.90
LA	39-41	0.06-0.09	2.9	–	0.89
SA	10-16	0.08-0.10	2.7	7.3	0.94
LSA	39-40	0.09-0.17	1.8	–	0.92

[a]Growth rate of *L. monocytogenes* estimated by the Baranyi model *(Baranyi and Roberts, 1994)*
[b]Lower asymptote estimated by the Baranyi model *(Baranyi and Roberts, 1994)*
[c]Upper asymptote estimated by the Baranyi model *(Baranyi and Roberts, 1994)*
[d]Stationery phase was not reached

RESULTS

- The initial a_w and pH of the frankfurters was 0.974 ± 0.006 and 6.04 ± 0.10, respectively.
- When averaged over the storage time, total microbial counts (TSAYE) were not significantly ($P > 0.05$) different from counts of *L. monocytogenes* (PALCAM agar).
- All spraying solutions applied after inoculation significantly ($P < 0.05$) reduced initial levels of the pathogen.
- The SLS solution applied after inoculation reduced numbers of the pathogen by 2.0 log CFU/cm²; the reduction was not significantly ($P < 0.05$) different from that caused by DW or LA sprayed after inoculation.
- The SLS did not significantly ($P > 0.05$) enhance removal of *L. monocytogenes* from the surface of frankfurters.
- Spraying with LASLS solution after inoculation reduced numbers of the pathogen by 2.8 log CFU/cm²; the reduction was greater ($P < 0.05$) than that caused by DW or LA applied after inoculation, but not different ($P < 0.05$) from that caused by SLS.
- Spraying with DW before inoculation did not affect the initial numbers of the pathogen or the lag-phase duration. In contrast to DW, LASLS solution applied before inoculation exhibited strong residual effect reducing numbers of the pathogen by 1.8 log CFU/cm² and extending the lag phase to 33 to 48 days.
- The residual antimicrobial effect of the combination of LA and SLS may be of particular importance for control of *L. monocytogenes* in the processing environment where microbial contamination may take place after application of a post-lethality treatment.
- The lag phase duration of the pathogen on untreated (control) frankfurters was 14 to 15 days and it was similar to the lag phase on frankfurters treated with DW before or after inoculation or with SLS.
- All treatments that contained LA extended the lag phase duration of the pathogen even when applied before inoculation.
- The stationary phase of pathogen growth was not reached on frankfurters sprayed with solutions that contained LA.

IMPLICATIONS

Processing plants using the mixture of 5% lactic acid and 0.5% sodium lauryl sulfate for spraying frankfurters will be subject to less frequent FSIS verification testing, since a 2-log reduction can be achieved with the combination of these antimicrobials, regardless of time of possible contamination. Based on these results, spraying frankfurters with the mixture of lactic acid and sodium lauryl sulfate may be considered for use as a post-lethality treatment to reduce initial pathogen levels and to suppress growth during storage; thus complying with alternative 1 of the FSIS final rule.

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