Reduction of *Listeria monocytogenes* on Beef Franks utilizing Targeted Directional Microwave Technology

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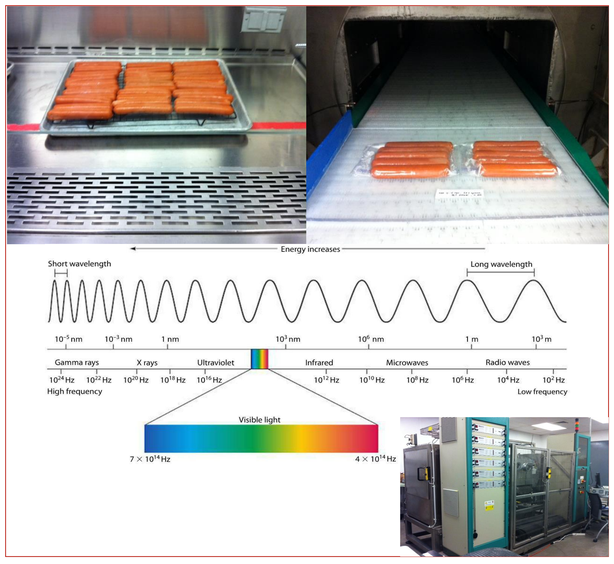
Abstract

The objective of this research is to determine the ability of targeted directional microwave (TDM) using a prototype industrial microwave unit to reduce *L. monocytogenes* on inoculated beef franks in package. Conventional beef franks were surface-inoculated with 10^6 CFU/ml of four-strain *L. monocytogenes* cocktail and cooled down in cold temperature storage (4°C). In duplicate, the samples in packages were subjected to seven treatments using the TDM to vary amounts of microwave energy, magnetron exposure time and temperature change. After treatment, serial dilutions were performed and plated on modified oxford agar (MOX) followed by incubation at 37°C for 24 hours. Experiment was performed in two replications. When compared to the control sample, there were significant reductions ($P<0.05$) of *L. monocytogenes* on beef franks in packages after treatments with varying TDM parameters controlling energy, exposure time and temperature. Four out of seven treatments had reductions of 1.35 to 3.86 $\log_{10}$ CFU/g. Only samples from one of the treatments had an internal temperature above the thermal kill temperature (71.1°C) of *L. monocytogenes*. The data from this experiment suggest that TDM technology is an effective intervention against *L. monocytogenes* on beef franks in packages providing 0.45 to just less than 4 $\log_{10}$ CFU/g reduction.



Introduction

- *Listeria monocytogenes* is one of the leading causes of death in the U.S. among food-borne bacterial pathogens with infections linked to consumption of contaminated food, raw and even post-packaged meat products.
- Post-contamination may occur even after ready-to-eat meats, such as hot dogs, have already been subjected to a pathogen-killing step in the plant before packing (Tauxe, 2001).
- Several research studies were conducted on the use of microwave frequencies which showed evidence of success in killing microorganisms in a short amount of time such as molds on sliced white bread (Lakins et. al, 2008a), *Salmonella* in shell eggs (Lakins et. al, 2008b), *Salmonella* and *Escherichia coli* O157:H7 in drinking water (Banegas et. al, 2014) and even Methicillin-resistant *Staphylococcus aureus* (MRSA) on towels (Laury et. al, 2011).

Results

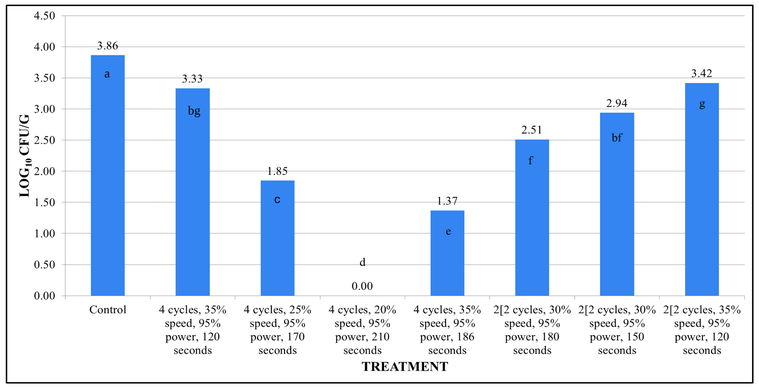


Figure 1. Average amount of *L. monocytogenes* on inoculated beef franks after treatment with TDM.

Treatment	Energy, kWs	Exposure Time, sec	Product Internal Temperature, °C	Amount of Reduction, Log_{10} CFU/G
1	282.6	120	46.4	0.53
2	396.6	170	60.6	2.02
3	498.8	210	79.0	3.86
4	429.9	186	65.9	2.49
5	420.4	180	46.3	1.35
6	360.5	150	40.0	0.93
7	285.0	120	29.2	0.45

Table 1. Average amount of *L. monocytogenes* reduction on beef franks after treatment with TDM of varying energy and exposure time with product temperature.

- There was significant reduction in the amount of *L. monocytogenes* recovered ($P<0.05$) from the samples when all the treatments were compared to the control that received no TDM treatment.
- Four out of seven treatments specifically T2, T3, T4 and T5 had reductions ranging from 1.35 to 3.86 $\log_{10}$ CFU/g (90% to almost 99.99%). The rest of the microwave treatments had a bacterial reduction of <1.00 $\log_{10}$ CFU/g.
- No differences were found when comparing the reductions in T1 and T6 or T1 and T7.
- Among the group of samples that received continuous TDM (T1-T4), reductions were higher on beef franks from T3 and T4 with higher energy input levels and longer exposure times. Among the group of samples treated by TDM with cooling in-between (T5-T7), similar result was observed on beef franks from T5 with the highest energy input and longer exposure.

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Methods

1. Beef frankfurters ("franks") were inoculated with 10^6 CFU/ml of the 4-strain *L. monocytogenes* inoculum.
2. Franks were placed on a sterile rack in the biosafety hood to allow excess inoculum to drip.
3. Five links of franks were immediately packed in quart double zipper bags.
4. Inoculated samples were cooled down prior to TDM treatment.
5. The samples in packages were subjected to the following treatments:

a) Control, no treatment **b)**Treatment 1 – 4 cycles, 35% speed, 95% power, 120 seconds **c)**Treatment 2 – 4 cycles, 25% speed, 95% power, 170 seconds **d)**Treatment 3 – 4 cycles, 20% speed, 95% power, 210 seconds **e)**Treatment 4 – 4 cycles, 35% speed, 95% power, 186 seconds **f)**Treatment 5* – 2[2 cycles, 30% speed, 95% power], 180 seconds **g)** Treatment 6* – 2[2 cycles, 30% speed, 95% power], 150 seconds **h)** Treatment 7* – 2[2 cycles, 35% speed, 95% power], 120 seconds

**With cooling in-between the treatment*

6. After treatment, samples were hand-stomached, serially diluted and plated onto MOX agar.
7. Plates were then incubated at 37˚C and colonies were counted after 24 hours.
8. Two replications were performed and results were analyzed via a one-way ANOVA on the Statistical Analysis Systems (SAS version 9.3, Cary, NC).

Conclusion

Based upon the results of this experiment, TDM is an effective intervention against *L. monocytogenes* on packaged beef franks as it can significantly reduce the pathogen from ~0.45 to as much as 3.86 $\log_{10}$ CFU/g ($P<0.05$). Only samples from one out of the seven treatments had an internal temperature above the thermal kill temperature (71.1°C/160°F) of *L. monocytogenes* (USDA, 2013).

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