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High Hydrostatic Pressure Processing for Improving the Control of *Listeria monocytogenes* on Ready-to-Eat (RTE) Sliced Ham with Variable Nitrite Concentrations

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Summary and Implications

High pressure processing at 600 MPa, as used commercially, was confirmed as highly effective for control of *Listeria monocytogenes* on sliced ham manufactured with various nitrite concentrations and nitrite sources. Growth of *L. monocytogenes* was slowed but not prevented by addition of nitrite, as expected. Reducing the HPP treatment to 400 MPa with addition of nitrite, regardless of the concentration or source of the nitrite, was not as effective as 600 MPa for inhibiting *L. monocytogenes*, indicating that the addition of nitrite did not reduce the amount of pressure needed for effective HPP, counter to our hypothesis. These results indicate that processors of RTE meat products, especially those processed as natural or organic products with nitrite concentrations that are less than conventional nitrite-cured products, should continue to use the conventional HPP process at 600 MPa for best control of *L. monocytogenes* on RTE meat products.

Introduction

Listeria monocytogenes continues to be a bacterial pathogen of major concern to the processed meat industry because this pathogen is ubiquitous and will grow under refrigerated conditions in the presence of salt and nitrite. While conventional heat processing will eliminate *L. monocytogenes* contamination on processed meats, the organism is capable of surviving in the processing plant environment causing potential contamination by slicers and other surface contacts that can result in *L. monocytogenes* food-borne illness. Because many processed meat products such as sliced ham are ready-to-eat (RTE) and consumed without reheating, insuring control of any post-processing contamination that might occur is critically important for these products. In conventional RTE processed meats, nitrite, lactate, diacetate and other preservatives provide that insurance. However, cured, processed meats such as ham that are manufactured to meet qualifications of “natural” or “organic” are not permitted to use preservatives, and research has shown that these products will permit growth

of *L. monocytogenes* more easily and more quickly than conventionally processed products. Recent development of natural curing processes that utilize vegetable powder as a natural source of nitrite have become popular for natural and organic processed meats because this form of nitrite is acceptable by the regulatory agencies for these products. While the vegetable powder provides some nitrite, the concentration of nitrite is typically less than in conventionally cured products because of flavor limitations of the vegetable-based ingredient. While nitrite slows growth of *L. monocytogenes*, it is not adequate by itself to control this organism. Because high hydrostatic pressure (HHP) has been documented as an effective antimicrobial treatment for several foods including processed meats, this study was initiated to assess the combinations of HHP pressure levels with varying concentrations of nitrite to evaluate these combinations for achieving control of *L. monocytogenes* on natural and organic RTE processed meat products. The hypothesis was that the addition of nitrite would increase effectiveness of HHP and permit use of reduced pressure during HHP to accomplish inactivation of *L. monocytogenes* on sliced ham.

Materials and Methods

Boneless hams were manufactured as conventionally cured hams with an uncured control (0 parts per million (ppm)), 100 ppm or 200 ppm of formulated nitrite, or as naturally cured hams with 50 ppm or 100 ppm nitrite from celery powder. After injection of brine, tumbling, stuffing, cooking and chilling, hams were sliced, placed into vacuum packages and inoculated with a 5-strain mixture of *L. monocytogenes* before the packages were sealed. The inoculated packages were then assigned to either 1) no HPP treatment, 2) 400 MPa HHP or 3) 600 MPa HHP. All samples were stored at 4.4 °C. Surviving *L. monocytogenes* were plated and counted periodically for up to 182 days following preparation of the packages. Measurements of residual nitrite, ham composition and ham color were also conducted during the storage period.

Results and Discussion

The use of HHP at 600 MPa, which is the standard pressure level used in commercial applications, reduced *L. monocytogenes* on sliced ham by more than 3 log CFU/g and the organism did not increase in numbers during subsequent storage (Figure 1). However, use of 400 MPa achieved a reduction of only about 1 log CFU/g and the organism was able to recover and grow after 14 days of storage (Figure 1). Nitrite at 200 ppm slowed the growth of

L. monocytogenes as expected with no HHP or with 400 MPa HHP but at 600 MPa there was no difference in growth of *L. monocytogenes* due to nitrite concentration or nitrite source (Table 1). Consequently, there appears to be relatively little interaction between nitrite concentration and pressure level used in HHP for impact on control of *L. monocytogenes* growth on sliced ham, produced either by conventional curing or by natural curing with vegetable powders. While HHP at 600 MPa is very effective, nitrite concentration does not have sufficient effect to permit reduced pressure in HHP processing to achieve a similar degree of *L. monocytogenes* control to that achieved by 600MPa. On the other hand, complete absence of nitrite resulted in greater numbers of *L. monocytogenes* at the end of the storage period for the treatment with 600 MPa so it is clear that nitrite contributes to the suppression of growth of this organism.

Acknowledgements

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Figure 1. Means of *L. monocytogenes* counts by HHP treatment after inoculation of ham slices with a 5-strain cocktail of *L. monocytogenes* at 10^3 CFU/g followed by no HHP, 400 MPa HHP treatment for 3 min, and 600 MPa HHP treatment for 3 min (detection limit = $1.0 \log_{10}$ CFU/g).

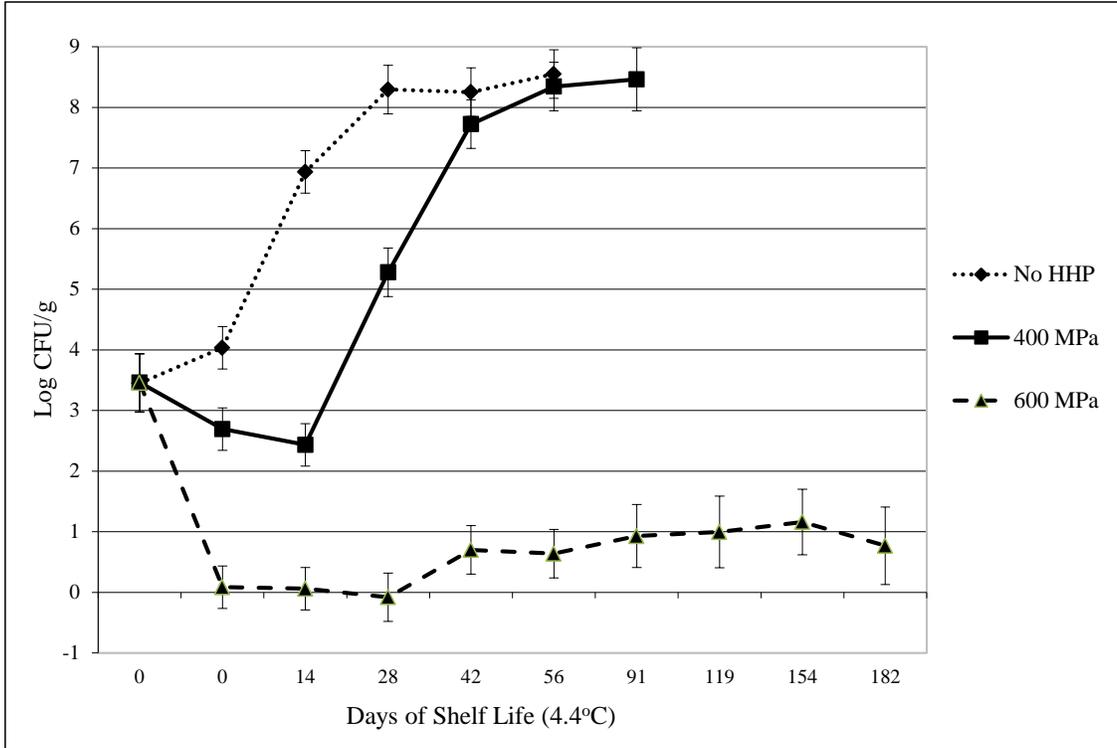


Table 1. Means for *L. monocytogenes* counts by treatment after inoculation of ham slices with a 5-strain cocktail of *L. monocytogenes* at 10^3 CFU/g followed by HHP treatment at 600 MPa for 3 min.

Treatments	Pre-HP	Day 0	Day 28	Day 56	Day 91	Day 119	Day 154	Day 182
No Nitrite Control	3.14 ^a	0.24 ^a	-0.11 ^a	3.29 ^b	2.51 ^b	3.94 ^b	3.66 ^c	3.15 ^b
Unconverted VJP*	3.04 ^a	-0.41 ^a	0.18 ^a	-0.22 ^a	0.32 ^{ab}	0.00 ^a	1.58 ^{abc}	-0.23 ^a
Na NO ₂ 100	3.46 ^a	0.38 ^a	-0.01 ^a	0.08 ^a	0.66 ^{ab}	0.16 ^a	2.02 ^{bc}	1.40 ^{ab}
Na NO ₂ 200	3.18 ^a	0.01 ^a	-0.69 ^a	-0.69 ^a	0.80 ^{ab}	0.00 ^a	0.31 ^{ab}	-0.69 ^a
50ppm Natural NO ₂	3.57 ^a	-0.08 ^a	-0.39 ^a	0.41 ^a	0.23 ^a	0.03 ^a	-0.39 ^a	-0.39 ^a
100 ppm Natural NO ₂	3.54 ^a	0.38 ^a	0.33 ^a	0.97 ^a	1.06 ^{ab}	1.84 ^{ab}	-0.23 ^a	1.37 ^{ab}
Std. Error	0.11	0.33	0.33	0.33	0.33	0.33	0.33	0.33

*Vegetable juice powder

a,b,c Means with different superscripts within a column are significantly different ($p > 0.05$)