Development of appropriate intervention methods to reduce the occurrence of pathogenic bacteria on Country-cured hams

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Abstract

The purpose of this research was to evaluate the characteristics of market-ready country-cured ham products related to product safety and to identify potential intervention methods for use against possible food borne pathogens, specifically *Listeria monocytogenes*. To accomplish these objectives, a market basket survey was conducted of country-cured products available at retail followed by inoculation of country ham center slices with *L. monocytogenes* subjected to various chemical and mechanical intervention methods. Market basket results provides the following characterization of country-cured ham products; water activity averaged .88, salt content 6.5%, pH 6.1, and moisture/protein ratio was 0.96. Preliminary data indicated that two chemical methods (Nisin and Liquid Smoke) and one mechanical methods (steam) were most promising and had the greatest potential synergism. The second experiment focused on reduction of *L. monocytogenes* on inoculated center cut slices. Samples treated with Nisin had the greatest population reductions versus both types of liquid smoke application. In addition, the application of steam in conjunction with chemical methods decreased populations by last least two-fold. The most effective combination in reducing *L. monocytogenes* populations was the use of steam and nisin at a level of 10 times the minimum inhibitory concentration. These data indicate that steam and nisin when used in combination can act as an effective intervention method for country-cured ham center slices.

Introduction

The production of country-cured hams has taken place for centuries and is located predominately in the southeast region of the United States. Currently, over 10 million hams are commercially country cured each year accounting for over five percent of the 180 million hams produced from market hogs. The viability of this profitable niche market is an essential aspect of value-added pork products. The United States Department of Agriculture (USDA) has standards of production, including salt level, shrinkage and processing times/temperatures, which have been used to assure the safe production of this product. The product may be smoked but is generally not cooked. The product is also considered shelf-stable and generally displayed at ambient temperatures in retail markets. However, certain ethnic groups consider country-cured hams a Ready-To-Eat (RTE) product and therefore do not cook the product. Although no food borne illnesses have been directly related to country hams there have been outbreaks in similar products such as dried sausages. In addition, earlier work in our lab (as early as 1970 until 1997) at UK has suggested that certain pathogens can survive on packaged country ham products under refrigeration. This combined with an increase concern over the safety of the meat supply has lead to the need to validate the safety of this unique product. However, to date, no work has validated the efficacy of processing methods reducing pathogens to safe levels in country-cured hams. The implementation of the recent pathogen reduction act (Mega-Reg) has placed a greater amount of responsibility for validating the safety of the meat supply on individual companies. The United States Department of Agriculture (USDA) has mandated that Ready-To-Eat (RTE) products be produced by a process, which will achieve over a 5-log reduction in *Salmonella*. In addition, the prevalence of *Listeria* in many RTE pork products as well as consumer concern related to recent illnesses due to *E. coli* O157:H7 leads these researchers to believe that these organisms are of equal importance. Recent research conducted in our laboratory (unpublished data) and a similar project funded by

the National Country Ham Producers Association indicated that the safety of country-cured hams was at question if minimum USDA guidelines were not adhered to stringently. The need to strictly follow total time in cure, equalization and aging, as well as weight reductions to achieve the desired level of water activity is crucial. This is especially true as USDA considers country-cured hams to be a "ready-to-eat" product with no need of heat treatment prior to consumption. In addition, most products are displayed as shelf-stable products without refrigeration. Our previous data indicate that the minimum required time of drying might vary from USDA regulations for larger hams as the industry slaughter weights continue to increase. These data indicate that water activity is a much better source of information for determining the safety of the product. In addition, preliminary research also indicates that if sufficient numbers of Staph sp. are found on the fresh incoming hams, toxin production might be a serious possibility, which needs to be addressed through multiple hurdles or additional intervention steps.

Objectives:

1) Conduct a market basket survey of country-cured ham products to assess criteria including pH, a_w, MPR, and *Staph. Sp* and *Listeria* to determine the current state of products supplied to the retail grocer.

2) Examine various methods of pathogen intervention for potential bacterial pathogens, which might occur due to lack of cutting edge processing and merchandising.

Procedures

This research was conducted in two phases. Phase one included a market basket survey of various country-cured products presently produced evaluate the safety of products currently in the marketplace. In addition, previous research has led to questions of the safety of hams produced, which are processed only following the minimum guidelines set forth by the United States Department of Agriculture. The two most opportunistic bacteria, *Staph. Sp* and *Listeria*, which has shown possible emergence in country-cured hams will be focused on. Hams produced under minimum processing steps with added intervention strategies were evaluated for microbial reductions to safe levels. The goal of the proposed research is to identify the state of the products presently in the marketplace and to evaluate various intervention methods such as hot washes or organic acid sprays either pre- or post-processing.

The first objective will be achieved by purchasing a variety of products (whole hams, slices, bits, etc.) from numerous retail markets, which carry a wide variety of producer products. Products will be examined for water activity (a_w), pH, salt, nitrite, moisture protein ratio (MPR), and for populations of *Staph sp. (As well as toxin)* and *Listeria*. Code dates from packages will be checked with processors to determine product age at the time of purchase.

The second objective will be accomplished by slicing hams processed under the minimum USDA requirements with or with out added intervention methods. Ham slices will be inoculated with six logs of *Listeria* monocytogenes and the following interventions applied separately or in conjunction with each other. These methods included the following treatments.

Treatment I: Control ham slices

Treatment II: Steamed ham slices

Treatment III: Ham slices with liquid smoke

Treatment IV: Ham slices with Nisin

Treatment V: Ham slices steamed with either liquid smoke or nisin added.

Cured ham slices will be obtained from a commercial processor and transported to the University of Kentucky Meat Science Laboratory. Ham slices will be surface inoculated with at least 10^6 CFU/cm^2 of *L. monocytogenes.* The inoculum level will permit evaluation that the cure treatment is capable of resulting in a 6 log

reduction in population of the test pathogen in the finished product. Six different ham slices per treatment group will be analyzed after inoculation on days 0, 3, and 7 in order to determine the population of the inoculated test species on the hams. The swab rinse procedure will be used to determine the populations of the inoculated hams. Two 25 cm^2 areas per ham slice will be swabbed and the swab rinse solution used for directing plating of the test species. Enrichment procedures will be used to determine the presence of test species on control hams and on inoculated hams after the storage procedure. Scrapings, less than 2 mm, will be aseptically obtained from each ham's surface. The scrapings will be composited and a 50-g sample from the composited sample will be added to the enrichment broth. Hams will be analyzed for water activity (a_w), pH, salt, nitrite, moisture protein ratio (MPR), and for populations of *Staph sp.* and *Listeria*.

Results

Market basket results were obtained from a wide range of country-cured ham products; center slices, bits and pieces, end pieces, biscuit slices, seasoning meats, hocks, etc. Water activity ranged from .74 to .93 with an average of .88) indicating various types of products had more available moisture for bacterial growth. Salt levels ranged from 4.0 (the minimum required level by USDA standards) to 9.7% (with an average of 6.5%). The moisture:protein ratio ranged from .54 to 1.56 (with an average of 0.96) again indicating a wide range in product characteristics. The evaluation of of both L*isteria monocytogenes* and *Salmonella spp.* indicated no positives were found in any of the products tested. *Staph* determinations found populations ranged from non-detectable to six log populations in the various products. However, no toxin production was determined. These data indicate that although ham slices produced from ham produced using the minimum USDA guidelines had characteristics which favored greater bacterial growth, the combination of salt content and the reduced water activity led to the production of a microbiologically safe product.

Preliminary evaluation of various intervention methods (water, steam, organic acids, nisin, liquid smoke, flame) indicated that two chemical methods (Nisin and Liquid Smoke) and one mechanical methods (steam) were most promising and had the greatest potential synergism. Therefore, the second experiment focused on reduction of *L. monocytogenes* on inoculated center cut slices through the use of steam, nisin, and/or liquid smoke. Steam application times were tested at both 5 and 10 seconds of exposure with the 10 second time chosen for its greater effectiveness. Both the nisin and liquid smoke interventions were first tested on inoculated broth to determine the minimum inhibitory concentrations. Then ham slices were treated with either the minimum concentration or 5 or 10 times that level. Samples treated with Nisin had the greatest population reductions versus both types of liquid smoke application in non-steamed samples (3.8 vs 4.8 log population). Slices had a one log greater reduction with nisin regardless of concentration used. In steamed slices, the minimum level of nisin had a 1.5 log greater reduction (2.6 vs 4.1 population) than liquid smoke treated samples, with the 10 X minimum concentration level having a 2.5 log greater reduction in populations (1.4 vs 4.1). In addition, the application of steam in conjunction with chemical methods decreased populations by last least two-fold. Furthermore, the application of steam and nisin at the highest level resulted in a six log reduction when evaluated at 7 days post treatment (0.5 log population vs innoculum level of approximately 6.3). These data indicate that steam and nisin when used in combination can act as an effective intervention method for country-cured ham center slices.

Table 1. Country Ham Market Basket Survey Results

Sample ID	Aw	pH	Salt %	Moisture %	Protein %	M/P ratio	Listeria	Salmonella	Staph. (Log CFU)
1	.911	5.73	5.8	64.35	66.31	0.97	-	-	10 X 2
2	.904	6.24	6.2	60.68	67.66	0.90	-	-	10 X 5
3	.929	6.56	5.9	60.35	55.66	1.08	-	-	10 X 5
4	.912	6.44	6.1	64.67	41.50	1.56	-	-	10 X 4
5	.839	6.22	6.3	30.81	33.41	0.92	-	-	10 X 4
6	.741	6.05	4.9	18.27	34.09	0.54	-	-	10 X 0
7	.900	6.23	7.4	60.73	58.53	1.04	-	-	10 X 2
8	.888	6.23	6.9	58.14	62.72	0.93	-	-	10 X 2
9	.882	6.15	5.6	43.06	26.94	1.60	-	-	10 X 0
10	.837	6.00	4.3	12.68	26.41	0.48	-	-	10 X 0
11	.884	6.42	5.4	50.34	55.41	0.91	-	-	10 X 4
12	.891	6.64	5.0	54.58	65.34	0.84	-	-	10 X 5
13	.889	6.42	5.4	57.48	49.41	1.16	-	-	10 X 3
14	.882	5.98	6.5	60.14	57.31	1.05	-	-	10 X 0
15	.833	5.73	9.0	44.66	52.63	0.85	-	-	10 X 3
16	.837	5.72	9.0	52.27	56.28	0.93	-	-	10 X 0
17	.877	6.33	7.4	46.42	65.63	0.71	-	-	10 X 6
18	.823	6.12	9.7	54.16	53.38	1.02	-	-	10 X 3
19	.754	6.17	8.0	26.77	40.25	0.67	-	-	10 X 3
20	.810	5.99	7.9	31.22	31.56	0.99	-	-	10 X 2
21	.880	6.14	6.1	51.74	63.13	0.82	-	-	10 X 5
22	.838	6.10	5.1	38.77	56.97	0.68	-	-	10 X 3
23	.902	5.88	5.2	57.99	65.13	0.89	-	-	10 X 4
24	.927	6.61	4.4	66.41	69.53	0.96	-	-	10 X 5
25	.841	5.61	6.5	57.33	51.06	1.12	-	-	10 X 4
26	.850	5.95	5.8	48.32	57.47	0.84	-	-	10 X 5
27	.909	6.02	4.5	62.04	66.41	0.93	-	-	10 X 5
28	.908	5.92	4.0	60.69	65.69	0.92	-	-	10 X 5
29	.902	5.73	4.5	55.24	63.63	0.87	-	-	10 X 4
30	.881	5.59	5.0	58.70	62.84	0.89	-	-	10 X 3
31	.913	6.51	5.5	53.95	66.41	0.81	-	-	10 X 5
32	.902	6.79	6.1	64.24	65.00	0.99	-	-	10 X 5
33	.888	6.01	8.1	61.82	62.13	1.00	-	-	10 X 0
34	.902	5.08	7.7	64.45	60.34	1.07	-	-	10 X 0
35	.879	5.92	9.6	58.69	56.06	1.05	-	-	10 X 2
36	.890	5.10	9.5	60.17	53.94	1.12	-	-	10 X 2
37	.897	6.08	7.8	51.56	43.38	1.19	-	-	10 X 2
38	.907	5.85	7.3	60.53	56.13	1.08	-	-	10 X 0
Average	.875	6.06	6.5	52.22	54.87	0.96	-	-	10 X 3