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IMPACT OF SMOKE APPLICATION ON *SALMONELLA* SURVIVAL ON THE LEAN SURFACE OF PORK PRODUCTS DURING AN EXTENDED, LOW-HUMIDITY COOKING PROCESS

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I. INTRODUCTION

The study's primary objective was to assess *Salmonella* sp.'s survival on the surface of smoked pork loins during extended cooking, with a wet bulb (WB) temperature ≤ 48.9°C maintained throughout the process. We hypothesized that smoke absorption on the lean surface of the pork loin would lead to a decrease in pH and an increase in titratable acidity, resulting in a reduction in the thermal resistance of *Salmonella* and, thus, a decrease in pathogen survival. This study addresses the challenge of achieving microbial lethality in low-humidity thermal environments and focuses on the role of smoke application as a potential intervention for food safety assurance.

II. MATERIALS AND METHODS

The two isolated factors were the inclusion or exclusion of sodium tripolyphosphate (STPP) from the brine and the presence or absence of natural smoke during cooking. Experiments with each factorial combination were repeated three times. For each replication, fresh pork *Longissimus dorsi* muscles were closely trimmed to expose lean surfaces and vacuum-tumbled with a marinade solution (9.33% water, 1.42% salt, 0.85% sugar, ± 0.40% STPP, on a meat weight basis (w/w)) for one h. After tumbling, the loins were laid flat on the oven rack. 6-8 sections (4 cm2 per section) of each pork loin were then surface inoculated to approximately 9.0 log CFU/g with an 8-strain mixture of *Salmonella*. Before cooking, the inoculated loins were held at ≤4°C for one hour, and triplicate raw samples were collected for proximate analysis. The inoculated loins were then transferred to an oven (dry bulb = 82.2°C) and cooked for 6 hours with or without smoke. Triplicate surface samples from inoculated and non-inoculated loins were excised immediately before cooking, every 30 min for the first three hours, and every hour for the final three hours. The excised, inoculated surface samples were placed into Whirl-Pak bags and diluted 1:1 with BPW. The cooled samples were then stomached for 4 minutes and serially diluted to the desired concentration. The concentration was then plated onto XLD plates with a thin overlay of TSA and incubated at 37°C for 36-48h before enumeration. Non-inoculated samples were gathered for pH and titratable acidity. MadgeTech HiTemp140 data loggers programmed at 5-minute intervals recorded the process dry bulbs, wet bulbs, and product surface temperatures. Smoke density in the oven was quantified by measuring the pH and titratable acidity of 26 mm cellulose casings filled with DI water. Water-filled casings were replaced at one-hour intervals. Integrated lethality profiles for each factorial combination were created by plotting the average temperature data, microbial populations, and product surface pH versus time.

III. RESULTS AND DISCUSSION

As an example of the environmental conditions, we have aimed to recreate these conditions for these experiments. Figure 1 shows the thermal profile and surface pH data for pork loins cooked in a gravity oven at 82.2°C with no wet bulb temperature control and smoke added for the duration of the process. In this process, the surface remains hydrated at non-lethal temperatures for approximately six hours, and the surface pH declines from 6.24 to 5.33. Figure 2 illustrates the desiccated *Salmonella* population on the surface, resulting in heat tolerance without smoke applied to the surface. Cooking the pork loins in an oven set to 82.2 °C and maintaining the product surface fully hydrated during the first two hours and exposed to natural smoke led to a surface pH reduction from 5.85 to 5.01, as shown in Figure 3. *Salmonella* lethality varied due to exposure to smoke. Acidification of the product surface resulted in greater lethality of *Salmonella* on the surface, even when the product surface was not fully hydrated for a lethal time-temperature combination. The inclusion of STPP in the marinade led to a higher pH on the surface of the loins before and after smoking.

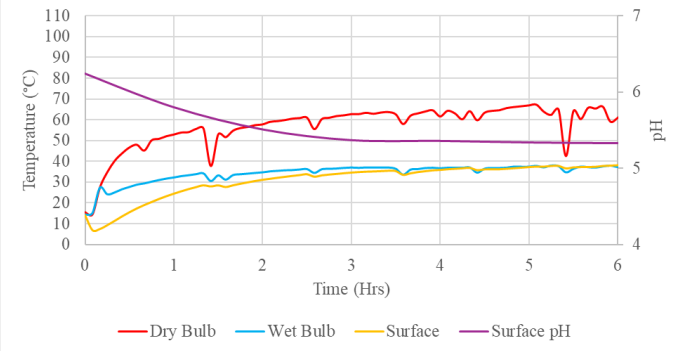


Figure 1. Thermal Profile and pork loin surface pH reduction in an industrial gravity oven set at 82.2 °C with smoke generation

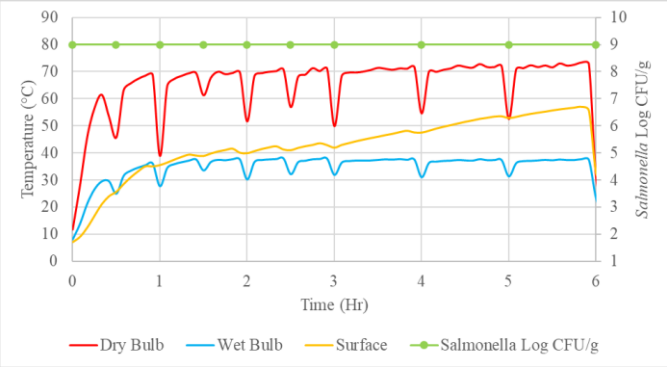


Figure 2: Thermal Profile and *Salmonella sp*. population in oven set at 82.2 °C without smoke generation

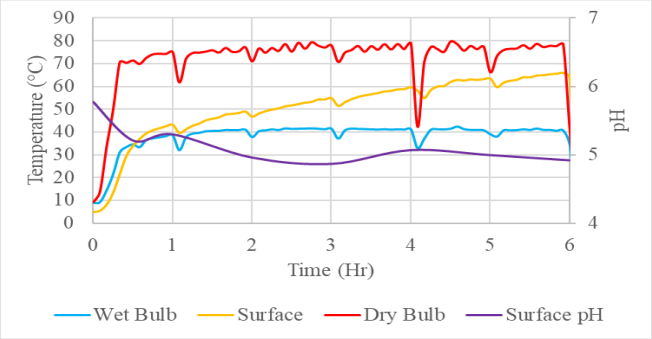


Figure 3. Thermal Profile and pork loin surface pH reduction in an industrial gravity oven set at 82.2 °C with smoke generation

IV. CONCLUSION

Without smoke added to the thermal process, desiccation of the product surface prevented a significant reduction of *Salmonella*. Adding smoke to the thermal process resulted in greater lethality of *Salmonella* while maintaining the wet bulb at sub-lethal temperatures (WB ≤ 48.9°C). Ongoing research focuses on the potential buffering capacity of STPP added to the brine marinade solution as a secondary treatment related to the buffering of acid components of smoke absorbed onto the product surface. Processes that lack the mechanism to control relative humidity and are therefore incapable of implementing a hydrated surface lethality step, including smoking during cooking, may be critical to achieving the lethality of *Salmonella* on the product surface. Further research in this area must investigate how other factors, such as animal species, additional functional ingredients in marinades, reduced smoke density, or smoke components, may impact the survival of *Salmonella* on the surface to ensure food safety on these ready-to-eat products.

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