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Summary of Alternative Cooling Procedures for Large Bone-In Hams[1]

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Introduction

Almost all hams sold within the U.S. are further processed with some hams being sold bone-in, rather than boneless. Commercial market hogs are leaner, faster growing, heavier muscled, and are marketed at heavier weights than 20 years ago, resulting in weight of hams increasing 19% from 1992 to 2003 (Stetzer and McKeith 2003). These heavier hams will have to be cooked longer at a higher temperature to reach desired endpoint temperatures. Likewise, it is more challenging to chill heavier weight hams with a greater surface area.

Clostridium perfringens is a bacteria commonly found in soil, water, and air that cross-contaminates the external surface of carcasses during processing (McClung 1945; Dische and Elek 1957). The inside of a whole-muscle product is essentially sterile, but bacteria can be introduced from the outside surface during needle injection. Cooking meat products to a proper endpoint temperature (≥148°F) kills the vegetative bacterial cells. During the cooling process, germinated *C. perfringens* spores will grow in the absence of oxygen, and growth is maximized at temperatures from 60 to 130°F (Kalinowski et al. 2003). Therefore, *C. perfringens* is the primary pathogen of concern during cooling of red meat products. A person must consume approximately 10^6–10^7 or 1,000,000 to 10,000,000 *C. perfringens* spores to result in food-borne illness (McClung 1945; Dische and Elek 1957; Kalinowski et al. 2003).

In 1999, the Food Safety Inspection Service (FSIS) branch of the U.S. Department of Agriculture (USDA) published a performance standard known as *Appendix B Guidelines for Cooling Heat-Treated Meat and Poultry Products (Stabilization)*. The guidelines require that cooked meat and poultry products must have less than a 1 log growth of spore-forming bacteria, such as *C. perfringens*, during cooling or stabilization (USDA 1999b). USDA enforces the compliance of these guidelines, or a scientifically valid alternative, to be followed to prevent bacterial growth and ultimately food-borne illness. *Appendix B* recommends cured meat should be chilled from 130°F to 80°F within five hours and then from 80°F to 45°F in an additional ten hours for a total chilling time of fifteen hours.

Many processors of large bone-in hams find it challenging to meet the *Appendix B* requirement.

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Researchers at Texas A & M University recently conducted a project to determine if cooling times slower than those defined in *Appendix B* would meet the FSIS microbiological performance standards for safety (Haneklaus et al. 2009). All of the following data and results are paraphrased from the final report submitted to the American Meat Institute.

Methods and Materials

Hams (n = 110) at an average trimmed weight of 23.4 lbs were pumped at a 20% injection level with a brine solution containing 2% sodium chloride, 2% sucrose, 200 ppm sodium nitrite, 0.054% (or 540 ppm) sodium erythorbate, and 0.5% (or 5000 ppm) of sodium tripolyphosphate.

To inoculate the hams with *C. perfringens,* a sterilized corer extracted four 1.3" long x 1" diameter muscle cores from each ham, and a 1" portion from the internal end of each core was cut from the remainder of the core. One uninoculated core from each ham was placed in a sterile bag as the negative control. All other cores were inoculated by injecting 0.1 ml of suspension containing 10^7 *C. perfringens* spores into the center of each core. Each inoculated core was wrapped in cheesecloth, placed back into the original ham, and covered with the remaining core portion to remain anaerobic. One extra core portion per evaluation was inoculated and immediately placed in a sterile bag as a positive control. The sterile bags containing the positive and negative controls were placed in an ice chest with refrigerant packs. Two cores per ham were removed after being chilled to 130°F and two more after reaching 45°F. Cores were replaced with uninoculated cores for the remainder of chilling.

Following processing and inoculation, the hams were cooked to an internal temperature of 148°F for a minimum of 107 seconds as suggested by *Appendix A* (USDA 1999a). After cooking, the products were subjected to one of the assigned cooling treatments described in Table 1. Treatment 1 met *Appendix B* requirements, and the remaining treatments extended the times taken to reduce internal product temperature from 130°F to 80°F and from 80°F to 45°F, independently. Treatment 11 represented a "worst case scenario" where products never reached 45°F as the hams were simply placed at room temperature (approximately 73°F) instead of normal cooling procedures in a chilling cooler.

Spores were counted by serial dilutions onto tryptose-sulfite-cycloserine (TSC) agar plates. Plates were placed in an anaerobic chamber and incubated at 98.6°F for 24 h. Typical *C. perfringens* colonies were counted after incubation and reported as number of *C. perfringens*/g of sample tested.

Results

Results after chilling failed to show significant growth (> 1 log growth) of *C. perfringens* for any treatment (Table 2). All treatments displayed means showing a numerical decrease in *C. perfringens*, and hams from the "worst case scenario," treatment 11, actually displayed a greater decrease ($P < 0.05$) in *C. perfringens* than hams from Treatments 1, 4, 5, 6, or 9 (Table 2).

The *C. perfringens* cocktail utilized in this research certainly appears viable due to the companion study conducted by these researchers that evaluated the chilling times for uncured roast beef. In this study, the researchers reported a 1.9 $\log_{10}$ growth of *C. perfringens* for roast beef from the worst case scenario, compared to the other nine treatments, which did not show significant growth (> 1 log growth) of *C. perfringens* (Haneklaus et al. 2009).

Implications

The findings in the report to the American Meat Institute by researchers at Texas A & M University suggest that large bone-in hams can be chilled slower than specified by FSIS in *Appendix B* and be safe for consumption. The findings of the Texas A & M results can be used as a processor's scientific validation after the results have been published in a peer-reviewed journal. However, USDA-FSIS will require that the processor's formulation—including sodium chloride, sodium nitrite, and sodium erythorbate—mimic the formulation in the peer-reviewed article in order to be scientifically valid. Most processors of both fully cooked and heat-treated, not fully cooked meat and poultry products use *Appendix B* as the scientific validation of their cooling process. It is not known what the

USDA-FSIS will require of processors of large bone-in hams to validate the safety of their cooling process.

These findings are being made public at a time when USDA-FSIS has issued Draft Guidance for the Hazard Analysis & Critical Control Points Systems Validation. This draft is not final; however, the focus of the program will be to ensure the in-plant Critical Control Points and Critical Limits used by a processor replicate the scientific documentation the processor uses as validation. If the actual in-plant actions and the scientific documentation do not match, then processors could be required to have in-plant validation of their process, which could include third-party microbiological testing.

Literature Cited

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Table 1. Hours taken to reach given internal ham temperature, modified from Haneklaus et al. 2009.

	Treatment number										
	1	2	3	4	5	6	7	8	9	10	11
130°F to 80°F	5	6	7	8	9	5	5	5	5	9	*
80°F to 45°F	10	10	10	10	10	11	12	13	14	14	Never reached
Total Time	15	16	17	18	19	16	17	18	19	23	*
*Represents an unknown period of time due to being placed at room temperature (approximately 73°F).											

Table 2. Effect of chilling treatments on the growth of *C. perfringens* spores, modified from Haneklaus et al. 2009.

	Treatment number										
	1	2	3	4	5	6	7	8	9	10	11
Log_{10} (CFU/g)	-0.3^{a}	-0.5^{ab}	-0.3^{ab}	-0.2^{a}	-0.2^{a}	-0.2^{a}	-0.3^{ab}	-0.6^{ab}	-0.3^{a}	-0.1^{ab}	-0.9^{b}
Means with a different letter differ ($P < 0.05$)											