Pork cooking doneness and salmonellosis likelihood: A risk assessment

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Abstract

A retail-to-table risk assessment was developed to evaluate the probability of developing salmonellosis after eating consumer-cooked fresh retail pork. Exposure assessment estimated Salmonella levels and distributions on retail pork, then transport, storage and cooking changes. Risk characterization estimated risk per serving. No Salmonella survived at 71.1° C or at 62.8°C, except at the latter temperature, after extreme time/temperature abuse. There, predicted risk was 10-4 to 10-2 per serving for some cuts, at >99th percentiles. Thus, fresh pork may be cooked to 62.8°C for 15 seconds without increased risk, if good handling practices are employed.

Introduction

While salmonellosis is a major U.S. public health problem, (Voetsch *et al.*, 2004), pork contributed only approximately 2% of culture-confirmed cases annually (USDA, 2007b). The current USDA end-point temperature guideline for consumer cooking of fresh pork is ≥71.1°C, which may contribute to overall pork safety. To evaluate the public health impact of pork doneness, a retail-to-table risk assessment was developed to evaluate the probability of developing salmonellosis from consumer-cooked moisture enhanced and unenhanced pork chops (bone-in) and roasts (boneless) cooked to 71.1-62.8°C at the coldest gram of the product, without regard to cooking method.

Materials and methods

The model began with an estimation of *Salmonella* prevalence and levels on retail pork. A 4,000-sample, four-U.S. city survey was conducted to determine the range and distribution of *Salmonella* levels. The survey provided a convenience sample yielding 28 positives. Confirmed positives were in enhanced chops (n=18) and roasts (n=10). *Salmonella* levels were low, ranging from 0.3-1.40 MPN/g. *Salmonella* levels were combined with the negative results (<0.3 MPN/g) and assumed to follow a lognormal distribution. The model evaluated *Salmonella* growth during transport from retail stores to homes and additional growth during home storage/refrigeration. A model similar to the USDA-ARS growth model (USDA, 2006) was used to estimate *Salmonella* growth. Storage times and temperatures were developed for transport from stores to homes, and storage and refrigeration in homes prior to cooking. Meat was assumed to be spoiled if there was *Salmonella* growth above 7 log CFU/g. Subsequently, the exposure model considered the decline in *Salmonella* levels due to thermal inactivation. A Food and Drug Administration model was used to estimate cooking lethality (FDA, 2000). A D-value was derived from the USDA-FSIS recommendations for *Salmonella* heat lethality in beef. The estimated z-value of 10ºF was based on the same guidance. *Salmonella* levels inactivated at various cooking end-point temperatures were estimated at holding times of 15 seconds and 1, 3 and 4 minutes. It was estimated that *Salmonella* were eliminated or reduced at end-point temperatures of 71.1, 68.3, 65.6 and 62.8 ºC. The mean levels of the pathogen killed after a 15 second holding time were 13.9, 4.4, 1.4 and 0.4 log CFU/g at 71.1, 68.3, 65.6 and 62.8ºC, respectively. The exposure assessment model examined the cooking end-point temperature at the coldest gram, which was the serving size in the exposure simulation. Exposure simulation was carried out using Crystal Ball®. Latin Hypercube sampling and 10,000 iterations were used. The following sequence was conducted: (1) estimation of levels of *Salmonella* in pork meat at retail; (2) estimation of growth during transportation from retail stores to consumer homes; (3) estimation of growth during storage in homes (refrigeration); (4) estimation of surviving *Salmonella* levels (log CFU/g) after cooking; (5) estimation of *Salmonella* levels and risk of salmonellosis per serving. To estimate the risk of illness per serving, the model combined the exposure estimates of the post-cooking colony forming units per serving with the *Salmonella* dose-response model. The FAO/WHO dose-response model for *Salmonella* offers a reasonable estimate for the distribution of the probability of human illness upon ingestion of a corresponding dose of *Salmonella* (FAO/WHO, 2002).

Results

In the baseline (71.1°C/15 sec) scenario, there were no surviving *Salmonella* per serving and there was no risk per serving. In alternative scenarios, cooking time was 15 sec and end-point temperatures included 62.8, 65.6 and 68.3°C. In these cases, risk per serving was zero ≤97.5th percentiles. Simulated alternative cooking of 62.8ºC and holding time of 4 minutes showed no surviving levels of *Salmonella* and zero risk per serving, for all four pork cuts. When product was held at 62.8ºC for either 1 minute or for 15 seconds, surviving *Salmonella* per serving and associated risk per serving were only predicted at ≥99th percentiles. Sensitivity analyses were conducted for higher retail *Salmonella* levels and different *Salmonella* distributions; several time and temperature abuse scenarios; and consideration of the risk for a human subpopulation that is especially *Salmonella* sensitive. The sensitivity analysis showed that for the enhanced pork meats, the estimated levels of *Salmonella* were the highest when the input distribution of levels at retail was based on USDA carcass prevalence (4%). When retail survey data were combined and a Weibull distribution was used instead of the lognormal, the estimated levels at retail were the lowest ≤90th percentiles. For the unenhanced pork, when the input distribution of levels at retail was based on carcass prevalence data, the estimated levels of *Salmonella* in pork meats at retail were higher than estimates in the baseline in the upper percentiles. However, in the lower percentiles, the predicted levels were slightly higher in the baseline model. When alternative (higher) carcass contamination (4%) and model approaches were used to estimate *Salmonella* levels at retail and after simulated cooking to an end-point of 62.8°C for 15 seconds, the resulting predicted pathogen reduction and risk per serving for all cuts was essentially zero for ≤97.5th percentiles. In two temperature abuse scenarios, consumers were assumed to remove products from the refrigerator and leave them on the counter at room temperature for an extended time before cooking. In both abuse scenarios, there were no surviving *Salmonella* and no risk per serving in all four pork cuts ≤97.5th percentiles. The dose-response model used in the baseline risk assessment was derived by the Food and Agriculture Organization/World Health Organization of the United Nations (FAO/WHO, 2002), and is not specific to sensitive subpopulations. The probability of illness derived from the FAO/WHO model was adjusted for a sensitive subpopulation. There was no risk per serving for all four cuts ≤97.5th percentiles, when cooked to an end-point temperature of 62.8ºC for 15 seconds using the alternative dose-response model. Uncertainty in predicted retail *Salmonella* levels was assessed by redefining the distributions used to characterize these parameters and running alternate sets of simulations and comparing the resulting estimates to those derived using the base model. In addition, uncertainty of the fraction of unenhanced pork products likely to be contaminated with *Salmonella* was addressed by using a tolerance interval approach to estimate the highest percentile (P) of the distribution that could be estimated with 95% confidence, given the number of samples available, and assuming, conservatively, that P% of the distribution of unenhanced pork chops and roasts would have *Salmonella* levels < 0.3 CFU/g.

Discussion

Microbiological safety assurance is a cumulative process, reflected in the product pathway analysis used in current risk assessment. Refrigerated products, such as fresh pork, need to remain clean, cold, and must be cooked properly to prevent the respective contamination, growth, and survival of pathogens. Inadequacies in retail and consumer handling are recognized and may pose an unnecessary, but controllable, risk to consumers. This risk assessment predicted that for many such abuses, consumers' risk of developing salmonellosis remains low, even if foods are cooked to an endpoint of 62.8° C. This risk assessment also demonstrated that those risks could be controlled by adherence to good pre-cooking handling practices and by continued holding of pork chops and roasts at hot temperatures after removal from the heat source, but before serving.

Conclusions

The major conclusion of this risk assessment is that consumer cooking to 62.8°F provides adequate protection against developing salmonellosis from the consumption of pork chops and roasts, if good retail and consumer handling practices are employed. This suggests that the current FSIS consumer cooking end-point temperature guidance of at least 71.1° C (USDA, 2003b) yields a very conservative margin of protection. New science presented here supports a re-evaluation of the current USDA consumer recommendations, since results suggest that end-point temperature can be lowered without adversely affecting public health.

Additional public awareness education would help consumers ensure that they are using safe and consistent food handling and proper cooking practices.

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