

# Fate of *Salmonella* in Beef Steaks during Sous Vide Cooking

Heather B. Hunt  
Samuel C. Watson  
Byron D. Chaves  
Gary A. Sullivan

## Summary with Implications

*Sous vide cooking meat products has become a popular in-home method of food preparation. Previous research from UNL Meat Science using generic E. coli demonstrated the potential risk of sous vide cooking at temperatures recommended by some popular press items. To increase the understanding of the safety concerns of cooking beef products to temperatures below USDA-Food Safety and Inspection Service (FSIS) guidance temperatures, the experiment was conducted with Salmonella. Steaks were internally inoculated with three serovars of Salmonella, and sous vide cooked to internal temperatures of 115, 125, and 130° F. At least a 5 log<sub>10</sub> reduction was achieved after various holding times for 125 and 130° F. Cooking at 115° F only achieved a 2.01 log<sub>10</sub> reduction after 420 minutes of holding. These results add to the understanding of the risks associated with sous vide cooking beef at temperatures below those recommended by USDA-FSIS.*

## Introduction

Sous vide is a popular cooking method that uses circulating water baths to heat foods sealed in bags or containers, resulting consistent internal doneness of the product. It is commonly used for cooking meat products to prevent over-cooking or to improve tenderness. Potentially hazardous time and temperature combinations for sous vide cooking meat have become common in popular cooking media; therefore, addressing the viability of low temperature and long-time sous vide cooking procedures is necessary. Previous research from

UNL Meat Science highlighted safety concerns with sous vide cooking beef steaks containing non-pathogenic *E. coli* at low temperatures (2021 *Nebraska Beef Cattle Report*, pp. 72–73). Since *Salmonella* is established by USDA-FSIS as the most relevant microorganism monitored in ready-to-eat products when validating an individual cooking process, an experiment was conducted using this pathogen in sous vide cooked steaks. The objective was to evaluate the safety of low temperature sous vide cooking using beef inoculated with *Salmonella*.

## Procedure

The experiment was replicated three times with two steaks sampled at each individual sampling time. One-inch steaks were cut from beef semitendinosus muscles (eye of round) and frozen under vacuum until the start of each replication. Steaks were thawed (48 hours, 39° F), exposed to UV light for 15 minutes on each side to reduce natural microflora, and submerged in liquid inoculum (1 liter each of *Salmonella* Typhimurium, Enteritidis, and Heidelberg overnight culture). Each steak was internally inoculated with a pin pad inserted three times into each side of each steak while submerged to achieve at least 7 log<sub>10</sub> cfu/g. Steaks were air-dried (15 min, 73° F) following inoculation to allow for bacterial attachment, individually vacuumed sealed, and immediately cooked in sous vide water baths. For cooked steaks, holding time started once the steak reached the target internal temperature. Within each replication, duplicate steak samples were taken from raw, inoculated steaks and at each of the following hold time/temperature combinations: 150 min/115° F, 420 min/ 115° F, 150 min/125° F, 193.5 min/125° F, 258 min/125° F, 322.5 min/125° F, 64.5 min/130° F, 86 min/130° F, and 107.5 min/130° F. The median sampling time for 130° F was taken from the USDA FSIS *Salmonella* Compliance Guidelines for Small and Very

Small Meat and Poultry Establishments that Produce Ready-to-Eat (RTE) Products and Revised Appendix A 5 log<sub>10</sub> reduction table, and the other times were +/- 25% of the median time. The 258 min sampling time for 125° F was extrapolated from the table in USDA Appendix A. The 115° F sampling times represented sous vide manufacturer's cooking guidance and an all-day cooking process. Core samples (25 g) were homogenized with buffered peptone water, serially diluted, and plated onto xylose lysine deoxycholate agar. *Salmonella* colonies were counted after incubation (24 hours, 95° F) and converted into log<sub>10</sub> cfu/g. Reductions were determined by subtracting concentrations at each sampling time from the raw sample. Data were analyzed using PROC GLM contrasts in SAS 9.4. Statistical comparisons between each temperature were not made.

## Results

Cooking at 130° F achieved a 5.72 log<sub>10</sub> reduction after 64.5 minutes holding time ( $P < 0.01$ ; Table 1) and increased to 6.74 log<sub>10</sub>/g reduction at 86 and 107.5 minutes holding times. A 6.26 log<sub>10</sub> reduction ( $P < 0.01$ ) was achieved after 150 minutes of holding at 125° F, and a final reduction of 7.28 log<sub>10</sub> ( $P < 0.01$ ) was achieved after 322.5 minutes of holding time. Cooking at 115° F only achieved a 2.01 log<sub>10</sub> reduction ( $P < 0.01$ ) after 420 minutes of holding time. Collectively, these data increase the support for the validity of time and temperature combination from USDA Appendix A for the reduction of *Salmonella* in beef at 130° F. Sous vide cooking at 125° F could potentially lead to safe products, but further validation of individual processes as a part of a food safety plan would be necessary. Sous vide cooking at 115° F does not result in adequate reductions of *Salmonella* concentrations and creates a potentially hazardous product. Further investigation is needed to determine if other heat tolerant pathogens could potentially grow at sous

**Table 1. Concentration of *Salmonella* (log<sub>10</sub> CFU/g) during sous vide cooking.**

Holding time (min)	log <sub>10</sub> CFU/g	Total Reduction
115° F holding temperature		
0	7.44 <sup>a</sup>	n/a
150	7.18 <sup>a</sup>	0.26
420	5.43 <sup>b</sup>	2.01
125° F holding temperature		
0	7.83 <sup>a</sup>	n/a
150.0	1.57 <sup>bc</sup>	6.26
193.5	0.95 <sup>bd</sup>	6.88
258.0	1.64 <sup>c</sup>	6.19
322.5	0.55 <sup>d</sup>	7.28
130° F holding temperature		
0	7.71 <sup>a</sup>	n/a
64.5	1.99 <sup>b</sup>	5.72
86.0	0.97 <sup>c</sup>	6.74
107.5	0.97 <sup>c</sup>	6.74

<sup>a-d</sup>Concentrations with different superscripts within each temperature treatment were different ( $P < 0.05$ ).

sous vide cooking temperatures below those recommended in USDA Appendix A. Data from this report should not be used as a part of food safety documentation for sous vide cooking meat without further validation studies, but this document does provide insight on thermal lethality and potential dangers associated with sous vide cooking methods with low temperatures.

Heather B. Hunt, undergraduate student  
 Samuel C. Watson, graduate student  
 Byron D. Chaves, assistant professor, Food Science and Technology, University of Nebraska–Lincoln

Gary A. Sullivan, associate professor, Animal Science, University of Nebraska–Lincoln