Examining the Safety of Duck Breast Prepared the Sous Vide Method

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ABSTRACT

Objectives: There is an increasing desire in the culinary industry to use sous vide to prepare meals at low internal temperatures to enhance flavour, texture, and quality. The sous vide method uses specific time and temperature combinations to allow for sufficient microbial destruction. The BCCDC's *Guidelines for Restaurant Sous Vide Cooking Safety in British Columbia* suggests time and temperature combinations to help ensure that the required $\log_{10}$ reductions of pathogens are achieved. Concerns for public safety arise when chefs deviate from the guidelines, and therefore may not achieve the appropriate $\log_{10}$ reductions. This study looked at a commonly used sous vide duck breast recipe and determine whether appropriate the appropriate $\log_{10}$ reductions were met. It also examine the efficacy of the sear step and resting period in achieving the $\log_{10}$ reductions.

Methods: After calibration, two batches of 15 duck breasts were prepared using the sous vide method for 80 minutes at 58ºC, the breasts were then seared on a 200°C frying pan for 2 minutes each side, and then subjected to a 4 minute rest period at room temperature. The internal temperature of the breasts was continuously measured using SmartButton thermometers. This data was entered into the *AMI Process Lethality Determination Spreadsheet* to calculate the $\log_{10}$ reductions. The $\log_{10}$ reductions were analyzed using a one-sample t-test to assess whether the recipe achieved the required 7.0 $\log_{10}$ reductions.

Results: The results showed 14% of the 29 duck breasts achieved a 7.0 $\log_{10}$ reduction after the sous vide step of 80 minutes at 58 ºC. The null hypothesis (H_o: measured $\log_{10}$ reductions of duck breasts = 7.0 $\log_{10}$ reductions) was rejected with 100% power and a p-value of 0.00. The mean was 5.13, therefore it seems as though the $\log_{10}$ reductions were significantly lower than 7.0 $\log_{10}$ reductions. After the sear and the resting period, 52% of 27 duck breasts achieved a 7.0 $\log_{10}$ reduction. Statistical analyses showed that the null hypothesis could not be rejected. The p-value was 0.97 and the power was 0.413. Disregarding cumulative effects, the median $\log_{10}$ reductions achieved only by the sear step was 0.43, and the median $\log_{10}$ reductions achieved solely by the resting period was 0.35.

Conclusion: Due to lack of normality one cannot confidently say this recipe will achieve 7.0 $\log_{10}$ reductions. However, due to the high $\log_{10}$ reductions achieved, it seems plausible for another recipe to provide adequate $\log_{10}$ reductions while maintaining acceptable quality. The sous vide step should be used for the majority of the $\log_{10}$ reductions. Due to a wide variability in the results, the sear and resting period should only be used for small increases in $\log_{10}$ reductions.

Keywords: Sous vide, duck breast, temperature, SmartButton, public health, sear, foodborne illness

INTRODUCTION

Concerns have been raised by the British Columbia Center for Disease Control (BCCDC) regarding the safety of sous vide duck breast served with the center still pink (1). In 2015, the BCCDC received one reported case of Salmonella illness that was potentially linked to sous vide duck breast, and another incident of Salmonella illness that arose from grilled duck breast prepared at 58°C (1). After these two illnesses were reported, Lorraine McIntyre from the BCCDC determined that more research

needed regarding the safety of sous vide duck breast.

The public health concern is that many chefs believe that duck breast can be cooked at lower times and temperatures than recommended to achieve a desired pink colour in the meat. According to several blog sites, many chefs believe that the hot paraffin wax used to defeather the ducks kills the bacteria *Salmonella*, and therefore makes the duck meat safe to eat served pink (1). The chefs also claim that unlike chicken, duck breasts are not injected for moisture; therefore *Salmonella* will not be forced into the meat from the exterior (1). However, a meat safety specialist interviewed by the BCCDC stated that the wax does not get hot enough to kill the bacteria; the wax only reaches between 57°C to 71°C, and lower temperatures may also be used (1,2). These temperatures do not meet the necessary temperatures for microbial destruction. For adequate microbial destruction Health Canada recommends that all poultry must be cooked to an internal temperature of 82°C, and the Food Retail and Food Service Code recommends a temperatures of 85°C (3,4). The minimum temperature requirement for poultry is 74°C; this temperature is recommended by the Canadian Government, the BCCDC, and the Food and Drug Administration (FDA) (1,5,6). The purpose of this report is to examine if a common sous vide duck recipe with a final sear and rest achieves adequate microbial destruction.

LITERATURE REVIEW

Pathogens Associated with Duck Meat

Along with *Salmonella* there are other common pathogens associated with duck meat including *Listeria, Yersina, Campylobacter* and the Avian Flu (1,7,8). In fact, studies have shown that *Campylobacter* has a 32% prevalence in the meat, and *Salmonella* has a 28% prevalence in duck meat and parts (1). There is also current evidence that suggests that *Campylobacter* infections in humans are related to duck meat. A study of campylobacteriosis outbreaks in the United Kingdom found that duck meat was the source of 2% of the outbreaks (8). Considering the prevalence of *Campylobacter* in the meat, and the documented outbreaks in the United Kingdom, it is reasonable to assume that duck meat may be an underestimated contributor to camplyobateriosis cases (8). Due to these potential pathogens it is necessary to ensure microbial destruction.

Sous Vide

To eliminate these pathogens and retain the pink colour in meat, chefs have begun using the sous vide method. Sous vide is "defined as the cooking of raw materials under controlled conditions of temperature and time, inside heat-stable vacuumized pouches or containers followed by rapid cooling" (9, p572). It is a type of low-temperature long-time method of cooking that has existed in restaurants since the 1970s and has become increasingly popular since the early-2000s (10,11). The sous vide method often uses low temperatures below 70°C to cook fish and meat (12). These low temperatures can be used safely if coupled with a long enough cook time to adequately destroy pathogens; the cook times used may range from minutes to days depending on the temperature (13). It is essential for safety to ensure that proper time and temperature combinations are used.

Safety of Sous Vide

To ensure the safety of poultry the Canadian Food Inspection Agency (CFIA) requires 7.0 $\log_{10}$ reductions in *Salmonella spp.* (14). A $\log_{10}$ reductions, or logarithm, means to reduce the pathogens "by a factor of ten" (11, p2). If the adequate $\log_{10}$ reductions are achieved then the process is referred to as "sous vide pasteurization (SVP)" and the food is considered safe for consumption (11,

p3). If 7.0 $\log_{10}$ reductions are not achieved for poultry, the food is considered raw and must be processed longer to achieve the proper $\log_{10}$ reductions, or cooked to an internal temperature of 74°C (11).

Globally there are criteria for sous vide in the U.S. Food and Drug Administration's *Food Code,* as well as guidelines available in Australia (11). In Canada, the only guidelines for sous vide are the BCCDC's *Guidelines for Restaurant Sous Vide Cooking Safety in British Columbia* (11). These guidelines are consistent with the other guidelines and supported by microbiological studies done by the University of Wisconsin-Madison and HansonTech (15, 16, 17, 11, 18). Chefs are recommended to follow these guidelines to ensure proper microbial destruction.

Unfortunately, sous vide might not destroy spore forming bacteria, such as *Clostridium botulinum;* this pathogen can survive in the oxygen free environment provided by vacuum packaging (19). To limit the growth of *C.botulinum* sous vide products should be stored at ≤ 3.3°C for ≤ 7 days (11). Proper storage is therefore also essential for safety.

Potentially Problematic Recipes

Issues regarding safety may arrive when chefs deviate from the guidelines. For example, a study done by Nova Do examined a sous vide chicken recipe and found did not match the guidelines nor did it achieve sous vide pasteurization (20). In addition, Rebecca Li examined the safety of sous vide salmon and also showed that the recipe also did not meet the guidelines nor did it achieve sous vide pasteurization (21). Both of these studies suggested that recipes that do not meet the guidelines may not achieve appropriate internal temperatures.

Alternatives to the Guidelines

Recipes that do not meet guidelines may still be acceptable if they can prove that they met the acceptable $\log_{10}$ reductions.

This can be done by first determining the D-Value, T-ref, and z-value for the pathogen of concern, and then measuring the internal temperature of the dish. Calculations to determine the $\log_{10}$ reductions can be easily done by using the *AMI Process Lethality Determination Spreadsheet* provided by the North American Meat Institute (22).

Searing

If sous vide pasteurization is not achieved, many chefs claim that a sear step at 200°C to 250°C for short periods of time will help achieve adequate internal temperatures (10). However, more research is needed to assess the searing step as a critical control.

PURPOSE

Recent outbreaks, and studies regarding the microbial composition of duck meat have prompted concerns with the efficacy of common sous vide duck breast recipes (1). In addition, there are current questions regarding the efficacy of the sear step. Previous studies by Do, and Li examined the efficacy of the sear step. Do's study only examined the sear of one sous vide chicken breast and concluded that the sear did help it achieve sous vide pasteurization (20). Li's study examined 30 sous vides salmon samples that were seared and concluded that the sear step did not help it achieve sous vide pasteurization. Therefore, this experiment was designed to examine whether sous vide duck recipes that do not meet BCCDC's guidelines can achieve adequate $\log_{10}$ reductions. In addition this experiment examined if there are significant increases in $\log_{10}$ reductions during the sear step and resting period. Lastly, this experiment used a rough qualitative analysis to assess the recipe's practicality.

METHODS

The following describes the methods used to conduct the experiment.

ACR SmartButton Data Loggers: The SmartButtons (SmartButton, ACR, Surrey, British Columbia) were prepared by installing the TrendReader® software onto a PC computer and then individually programming each button to 1 minute data collection intervals and the memory usage to stop when full. The start time was programmed to begin immediately.

Immersion Circulators: Immersion Circulators (Sous Vide Professional, PolyScience, Torrance, California) were set to 58°C and calibrated using a calibrated lollipop thermometer (Waterproof Lollipop Min/Max Thermometer, DeltaTrak, Pleasanton, California). No adjustments were needed; the immersion circulation was accurate within ±0.05°C.

Duck Breast Preparation: Each breast was weighed and trimmed to approximately 188g. Next the fat on each breast was scored and the breasts were formed to ensure uniform thickness and shape using cellophane; each breast was roughly 32mm thick. Next, an ACR SmartButton thermometer was inserted into in the thickest part of each breast. The breasts were placed in separate food grade bags and vacuum packaged using a Vacuum Sealer (Komet PlusVac 25, Plochingen, Germany), labeled, and then placed into a cooler.

Sous Vide: Once the immersion circulators reached 58°C, 7 to 8 sealed breasts were placed in each bath to make a total batch of 15, as seen in Figure 1. The breasts were completely immersed in the 58°C water and a timer was set for 80 minutes. Once the 80 minutes was complete, all of the breasts were removed from the water bath at once, their vacuum packages were opened, and the time was recorded.

Figure 1: Sous Vide Water Bath

Searing and Resting Step: A frying pan was heated to approximately 200°C, the temperature was measured using an infrared thermometer (Infrared and Contact Thermometers, Fluke, Mississauga, Ontario). Three student chefs helped sear six breasts at a time. The other breasts remained at room temperature while waiting to be seared. The duck breasts were placed on the 200°C pan for 2 minutes on each side while being basted with a spoon. Once finished the breasts were then removed and rested for 4 minutes. After resting, the SmartButton thermometers were removed and connected to a PC using a USB interface cable to retrieve the data. The temperature readings were converted into $\log_{10}$ reductions and statistically analyzed. In addition, Chef Laura rated each breast based on taste and texture, a picture of the finished breast can be seen in Figure 2.

Figure 2: Sous Vide Duck Breast after Sear and Rest

Batch Two: The next batch of 15 was completed following the same procedure. The variance was that an ice bath was used for cooling. In addition, only four breasts were seared at once, as opposed to six.

STATISTICAL ANALYSIS & RESULTS

Although 30 samples were used, only 29 thermometers successfully recorded the data. In addition, two thermometers contacted the pan during the sear step and were ruled out as outliers.

Descriptive Statistics

Below are the descriptive statistics results:

Table 1: Sous Vide Process

Mean	5.13 $\log_{10}$ reductions
Median	4.99 $\log_{10}$ reductions
Standard Deviation	0.28 $\log_{10}$ reductions
Mode	4.77 $\log_{10}$ reductions

Table 2: Sear Step

Mean	8.13 $\log_{10}$ reductions
Median	6.77 $\log_{10}$ reductions
Standard Deviation	0.92 $\log_{10}$ reductions
Mode	6.13 $\log_{10}$ reductions

Table 3: Rest Period

Mean	15.53 $\log_{10}$ reductions
Median	7.08 $\log_{10}$ reductions
Standard Deviation	4.42 $\log_{10}$ reductions
Mode	N/A $\log_{10}$ reductions

Tables 1,2,3 show the cumulative $\log_{10}$ reductions achieved after each step. However, the steps were also individually assessed to give a better indication of the efficacy of the sear and rest step.

As seen in Figure 3, the sear and rest step achieved a wide variety of $\log_{10}$ reductions. In general, they only achieved small $\log_{10}$ reductions. The median $\log_{10}$ reductions caused by the sear step was 0.43, and the median $\log_{10}$ reductions caused by the rest period was 0.35 (24).

Qualitative Analysis

To assess the general practicality of the recipe, Chef Laura Dawe rated the texture and taste of each duck breast on a scale of 1-5, where 1 was the lowest quality and 5 was the highest (24). The mean rating for colour was 4.3, and the mean rating for texture was 4.4 (24).

Statistics

The Null and Alternative Hypotheses examined are as follows:

Sous Vide Process

H_0: μ $\log_{10}$ reductions of *Salmonella spp.* in the duck breasts cooked at 58°C for 80 min = 7.0 $\log_{10}$ reductions in *Salmonella spp.*

H_a: μ $\log_{10}$ reductions of *Salmonella spp.* in the duck breasts cooked at 58°C for 80 min $\neq$ 7.0 $\log_{10}$ reductions in *Salmonella spp.*

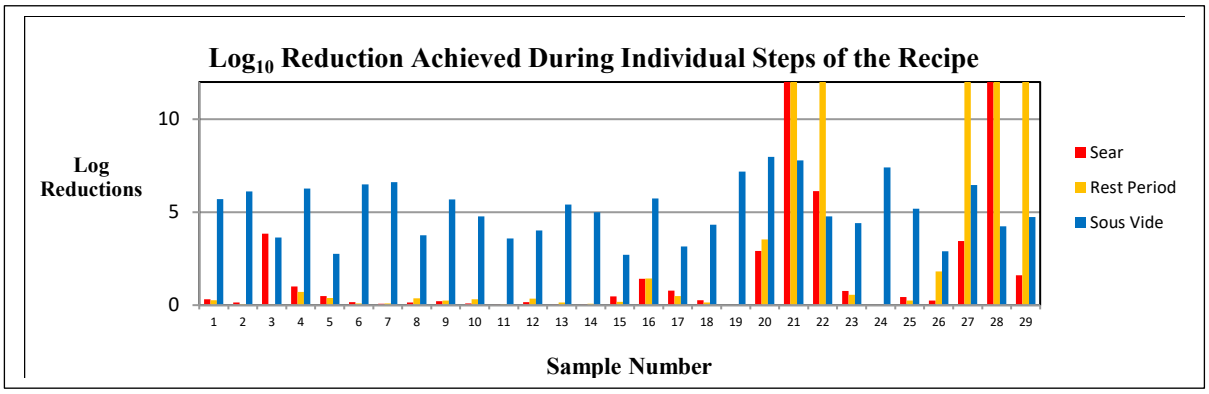

Figure 3: Log_{10} Reductions Achieved During Individual Steps of the Recipe

Sear Step

H_0: μ $\log_{10}$ reductions of *Salmonella spp.* in the duck breasts cooked at 58°C for 80 min

with a sear of 200ºC for 4 min = 7.0 $\log_{10}$ reductions in *Salmonella spp.*
H_a: μ $\log_{10}$ reductions of *Salmonella spp.* in the duck breasts cooked at 58°C for 80 min with a sear of 200ºC for 4 min ≠ 7.0 $\log_{10}$ reductions in *Salmonella spp.*

Rest Period
H_0: μ $\log_{10}$ reductions of *Salmonella spp.* in the duck breasts cooked at 58°C for 80 min with a sear of 200ºC for 4 min with a 4 min rest = 7.0 $\log_{10}$ reductions in *Salmonella spp.*
H_a: μ $\log_{10}$ reductions of *Salmonella spp.* in the duck breasts cooked at 58°C for 80 min with a sear of 200ºC for 4 min with a 4 min rest ≠ 7.0 $\log_{10}$ reductions in *Salmonella spp.*

Interpretation of the Data
A one tailed t-test was used to compare the samples in each step to the 7.0 $\log_{10}$ reductions required by the CFIA for sous vide poultry using NCSS 9 and Microsoft Excel 2010(23).

Sous Vide Process: The data was normally distributed; hence, a parametric one-sample t-test was used (23). The p-value was 0.00 which is significantly less than 0.05; therefore, the null hypothesis was rejected and it was concluded that the mean $\log_{10}$ reductions achieved for the duck breasts was statistically significantly different than the required 7.0 $\log_{10}$ reductions (23). Based on the fact that the mean was 5.13 $\log_{10}$ reductions, it seems that the $\log_{10}$ reductions were significantly lower than 7.0 $\log_{10}$ reductions. The power for the parametric test was 1.00 showing that there is a high probability of correctly concluding to reject the null hypothesis (23).

Sear Step: The data was not normally distributed; hence, the Wilcoxon Signed Rank Test was used (23). The p-value was 0.96. Therefore, the null hypothesis was not rejected and it was concluded that the mean $\log_{10}$ reductions achieved was not statistically significantly different than 7.0 $\log_{10}$ reductions (23). The power for the parametric test was 0.22.

Rest Period: The data was not normally distributed and the Wilcoxon Signed Rank Test was used (23). The p-value was 0.40. Therefore the null hypothesis was not rejected and it was concluded that the mean $\log_{10}$ reductions was not statistically significantly different than 7.0 $\log_{10}$ reductions (23). The power for the parametric test was 0.41.

LIMITATIONS
Sample Size: Due to time constraints, only 30 duck breasts were tested. One of the thermometers failed, leaving only 29 duck breasts. In addition, two samples were removed as outliers because the thermometers became exposed to the frying pan.

Difference in Sample 1: The first breast was tested with different parameters. The recipe was changed to be more practical. Sample 1 had a 57°C sous vide step for 80 minutes, a 2 minute sear, and a 5 minute rest.

Difference in Time from Sous Vide to Sear: Due to a lack of chefs and frying pans, the breasts had to wait to be seared. The wait times varied between 5 minutes to 30 minutes. Although these wait times were not a part of the recipe, a mean 1.22 $\log_{10}$ reductions was achieved during this time.

Positioning in the Water Bath: The $\log_{10}$ reductions achieved during the sous vide step ranged from 2.71 to 7.98, with a median of 4.99 $\log_{10}$ reductions. This variance was most likely due to improper positioning in the water bath, which prevented proper circulation. This occurred with a only 7 bags

in the water bath, which is considerably less than what is commonly used.

Start Temperature Variation: Although the breasts were all cooled in the same manner, their internal temperatures varied. However, during the sous vide step a low start temperature did not always suggest a low $\log_{10}$ reduction, or vice versa. For example, sample 17 started at 8°C, and achieved a 3.15 $\log_{10}$ reduction, whereas sample 2 started at 1°C and achieved a 6.12 $\log_{10}$ reduction. Therefore, it did not seem to significantly impact the results, but should be considered.

Variances in Searing: Variances occurred in the searing step were most likely due to wait times before the sear.

DISCUSSION

Safety of Sous Vide Recipes: There are many pathogens associated with duck breast, including *Salmonella*, *Listeria, Yersina, Campylobacter* and the Avian Flu (1,7,8); therefore, it is important to achieve the required 7.0 $\log_{10}$ reduction that the CFIA recommends for poultry (14).

A process that achieves adequate $\log_{10}$ reductions is referred to as "sous vide pasteurization (SVP)" (11, p3). If the required $\log_{10}$ reductions are not achieved the food must be processed to either reach the proper reduction or an internal temperature of 74°C (11). To ensure adequate processing, it is recommended to adhere to the BCCDC's *Guidelines for Restaurant Sous Vide Cooking Safety in British Columbia,* which are consistent with other guidelines and supported by microbiological studies (15, 16, 17, 11, 18).

Studies on the safety of common sous vide recipes are limited. Studies done by Li and Do demonstrated that sous vide recipes for chicken and salmon did not meet the guidelines nor did they achieve sous vide pasteurization (20, 21). These studies did not assess the $\log_{10}$ reductions achieved. To better assess the recipe's safety, this study considered the $\log_{10}$ reductions achieved.

The results of this experiment concluded that the sous vide step did not achieve a 7.0 $\log_{10}$ reduction. However, once the duck breast was subjected to a final sear and rest period, the $\log_{10}$ reductions achieved were not significantly different from 7.0 $\log_{10}$ reductions. Yet, due to a lack of normality, one cannot confidently say that the 7.0 $\log_{10}$ reduction was achieved. However, the 7.0 $\log_{10}$ reduction is only a guideline, and many chefs fail to meet this guideline. Therefore, a recipe that achieves $\log_{10}$ reductions close to the guidelines may be considered an improvement. This recipe had a median $\log_{10}$ reduction of 7.08, and only 3 samples achieved less than a 5.0 $\log_{10}$ reductions.

In terms of quality, the mean rating for colour was 4.3 out of 5, and the mean texture rating was 4.4 out of 5. High ratings were still achieved with a 7.0 $\log_{10}$ reductions or higher. This suggests that sous vide can be both safe and of high quality.

Significance of the Sear and Rest Step: Chefs often claim that the searing helps achieve sous vide pasteurization or an internal temperature of 74°C (11). This was examined by Li and Do. Do examined one sous vide chicken breast, and noted that searing did achieve sous vide pasteurization (20). In contrast, Li examined 30 sous vide salmon and found that searing did not achieve sous vide pasteurization (21).

This experiment showed a wide variability in $\log_{10}$ reductions achieved by the sear and resting period. Therefore, the majority of $\log_{10}$ reductions must be achieved during the sous vide step. The sear and resting period may be used for small improvements.

RECOMMENDATIONS

Based on the fact that the data lacked normally, one cannot confidently say that this recipe will consistently achieve 7.0 $\log_{10}$ reductions. Therefore, it is not recommended from a public health point of view.

It is important that Environmental Health Officers (EHOs) familiarize themselves with the BCCDC's guidelines for sous vide (11). In order to prove a recipe is safe, one must show it matches the guidelines, reaches an internal temperature of 74°C, or achieve the required $\log_{10}$ reductions. This may require the expertise of a Process Authority.

EHOs should also ensure Food Safety Plans are readily accessible with clearly outlined critical control points. They should also ensure operators are maintaining adequate temperature and calibration logbooks (21). In addition, Sanitation Plans should be in place to avoid contamination. EHO's should also ensure vacuum packed bags are fully submerged and arranged to allow proper circulation; properly sealed bags should not float (11). EHOs should also ensure that sous vide is stored at 3.3°C for no longer than 7 days to prevent the growth of *Clostridium botulinum* (11, 23).

Resources the EHOs can use include the BCCDC's guidelines, and the tools provided by the North American Meat Institute to calculate $\log_{10}$ reductions (11, 22).

FUTURE RESEARCH SUGGESTIONS

It is recommended to repeated this study with a larger sample size, and address any of the limitations discussed in this article. Future studies may also examine the $\log_{10}$ reductions achieved for duck breast prepared using the sear method, without sous vide. This is also a recipe of concern addressed by the BCCDC (1).

CONCLUSION

The data showed that duck breasts prepared for 80 minutes at 58°C sous vide step did not achieve 7.0 $\log_{10}$ reductions. When the breasts were subjected to a 4 minute 200°C sear, as well as a 4 minute rest there was no statistical difference between the $\log_{10}$ reductions reached and 7.0 $\log_{10}$ reductions. However, due to a wide variability in results, lack of normality one cannot confidently claim that the breasts achieved 7.0 $\log_{10}$ reductions. The median $\log_{10}$ reductions provided by the sear step alone were 0.43 and the resting period provided 0.35; these results were highly variable (24). Therefore, it is recommended to use the sous vide step to achieve the majority of the $\log_{10}$ reductions, and only use the sear and rest for small increases. The breasts that achieved 7.0 $\log_{10}$ reductions or higher generally had a rating of at least 4 out of 5 for colour and texture; this suggests that sous vide can be safe and of high quality.

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COMPETING INTERESTS

The authors declare that there are no competing interests.

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