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Microbial Growth in Ground Beef During Different Methods of Thawing

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Abstract

Consumer safety has now become a pressing issue with recent illnesses and food recalls due to elevated microbiological contamination of a variety of different foods. Although there are many different steps in the handling and processing continuum that expose the food supply to potential microbial exposure and contamination, consumers can limit their risk for food-borne illness by practicing safe food handling practices in their homes. In this study, we examined several commonly used thawing methods and their impact on microbial growth.

The purpose of this study was to evaluate the influence of different thawing methods on microbial growth in ground beef. Microbial growth was evaluated during a six-hour thaw period using three different thawing methods: refrigerator, room temperature, and standing water bath. Beef maintained in the freezer was used as a control. Bacterial counts per gram of beef were determined at one-hour intervals using a viable count method.

The least amount of bacterial growth occurred when beef was thawed in the refrigerator while bacterial growth occurred more rapidly in beef thawed at room temperature or in a standing water bath. After six hours, beef thawed in a standing water bath had the greatest bacterial count, 1.5 x 104 bacteria per gram of beef. This was 1.75 and 3.89 times greater than the microbial counts in beef samples thawed at room temperature or the refrigerator, respectively.

Introduction

Food safety is a top priority for food service organizations because mishandling and food spoilage can result in serious illnesses for consumers, in addition to obvious other business-related losses. Recently, many different food items have been recalled from the market due to wide outbreak of illness caused by bacterial growth. Ground beef was among the food items recalled (Sotos, 2008). Consumer safety has been brought to the forefront with these recent outbreaks.

An understanding of microbiology and microbiological models are important for implementing safe food processing and handling procedures. Models can be used to predict growth, survival, or inactivation of microbes as a function of influencing factors (Marks, 2008). Temperature and pH are among the factors that can affect microbial spoilage of ground beef. (Koutsoumanis, Nychas, Skandamis, & Stamatiou, 2006). Glucose and sodium chloride concentrations are other factors that influence microbial growth (Koutsoumanis et al.; Marks).

Microbial growth has been studied under various conditions to formulate mathematical models that may be utilized to predict microbial growth. These models and predications can then be used in food processing. However, utilization may be limited by uncertainty and variability of preparation conditions and accuracy of models (Marks, 2008). Different models have been designed and

validated using isothermal temperature conditions, non-isothermal conditions, and cooling period temperatures after preparation of food (Corradini, Normand, Peleg, Schaffner, & Smith Simpson, 2007; Koutsoumanis et al., 2006; Marks).

Although these microbiological models have been designed for utilization by food service organizations, many studies use specific and controlled temperature conditions to design models. Additionally, ground beef samples were inoculated with bacterial strains cultivated in the lab rather than using bacterial samples naturally grown in the ground beef (Corradini et al., 2007). I found no studies incorporating the general guideline that high-risk foods should not be out of storage temperatures for more than four hours.

The potential for microbial growth or contamination can occur in many of the different areas of the 'handling continuum from "farm to table"' (Black & Davidson, 2008, p. 163). At the consumer preparation level, there are also risk factors that can influence microbial exposure and growth. Temperature abuse in the domestic environment is a likely source of microbial growth and studies have shown that the refrigerator alone can be a source of great temperature variation. Black and Davidson also cited cross-contamination and inadequate cooking of ground beef as major risk factors of microbial exposure. Although they did acknowledge temperature variations in the refrigerator, there was no literature on different thawing methods and their influence on microbial growth in raw meat products.

Thus, the objective of this study was to quantify the bacterial growth in ground beef during four commonly used methods of thawing. Growth was standardized per gram of ground beef and compared. The question was which method of thawing would have the greatest amount of microbial growth during the six-hour thawing period. The different thawing methods provide different temperature and moisture environments, two factors that influence the growth of microbes (Koutsoumanis et. al, 2006; Marks, 2008). Based on the literature regarding factors of microbial growth, we hypothesized that the ground beef sample thawed in a room temperature water bath would have the greatest amount of microbial growth while the sample thawed in the refrigerator would have the least amount microbial growth.

Method

Sample

Four (4) one-pound packages of fresh ground beef were bought from a national chain grocery vendor and frozen for 3 days prior to experimentation. Each of the four packages was subjected to only one of the four conditions (freezer, water bath, room temperature, or refrigerator). All packages of ground beef were purchased within two days of their "sell by" dates.

Procedures

During experimental thawing, packages were held in the freezer (control), refrigerator, room temperature water bath, and room temperature. Thaw temperatures were taken to verify temperature constancy for each thaw method. Additionally, the outsides of the beef packages were sterilized with a 70 percent ethanol solution to eliminate contamination of the ground beef contained within the packages. One-inch incisions were made in the packaging to access the ground beef. The incisions were covered with sterile plastic wrap to prevent environmental contamination. Approximately one-gram samples were taken from each package at one-hour intervals and samples were diluted in nine milliliters of sterilized de-ionized water prior to being plated on Nutrient Agar plates. Plates were incubated at 30° C for 48 hours.

Measures
After 48 hours in the incubator, the number of bacterial colonies on each agar plate were counted and used to calculate bacterial cells per gram of beef for each sample.

Data Analysis
The calculated number of bacterial cells was plotted in an excel graph against time in hours (x-axis) for each of the thawing methods. Using excel, a best fit trendline was then added to the graph for each of respective sets of data for the thawing methods. These best fit lines represented the growth of bacteria in each of the samples over the six-hour testing period.

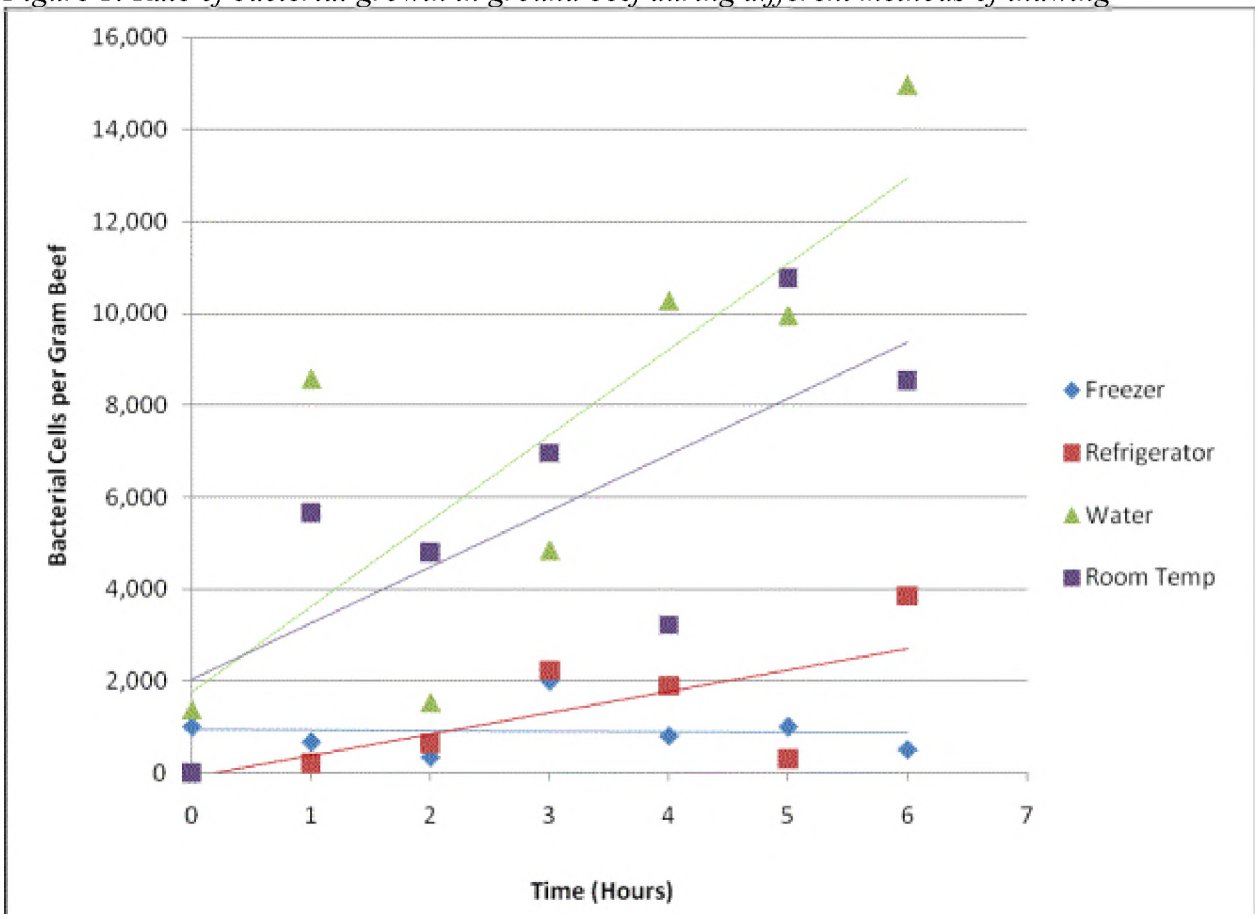
Results

The least amount of bacterial growth occurred when beef was thawed in the refrigerator while bacterial growth occurred more rapidly in beef thawed at room temperature or in a standing water bath. (These data are presented in Table 1.) After six hours, beef thawed in a standing water bath had the greatest bacterial count, 1.5 x 104 bacteria per gram of beef. This was 1.75 and 3.89 times greater than the microbial counts in beef samples thawed at room temperature or the refrigerator, respectively. Figure 1 shows that the sample thawed in the water bath had greatest rate of growth. Ground beef held in the freezer (the control) had no measurable increase in bacterial cell number.

Table 1:
Bacterial cells per gram beef during different thawing methods at one-hour intervals

	0 hours	1 hours	2 hours	3 hours	4 hours	5 hours	6 hours
Freezer (control)	1,000	667	333	2,000	800	1,000	500
Refrigerator	0	200	636	2,231	1,889	307	3,846
Water	1,383	8,571	1,545	4,848	10,270	9,949	14,963
Room Temp	0	5,667	4,800	6,957	3,226	10,769	8,533

Figure 1: Rate of bacterial growth in ground beef during different methods of thawing



Discussion

Results confirmed the hypothesis that a room temperature water bath used to thaw ground beef caused the greatest amount of microbial growth during the six-hour thawing period. The *rate* of growth was also greatest in this sample. The sample thawed in the refrigerator had the least amount of microbial growth.

There are no comparative data for this study that examined the rate and amount of microbial growth in ground beef during different methods of thawing. Bacterial numbers and growth rates were compared among the thawing methods (refrigerator, room temperature water bath, and at room temperature) and to the control (freezer). The initial number of bacteria per gram of beef was relatively low; however growth increased with time under all methods of thawing (relative to control). Data indicate that rates of bacterial growth in ground beef increased with both increased thaw temperature and time. Although published studies related to bacterial growth have been conducted under dynamic temperature conditions (Corradini et. al, 2007; Koutsoumanis et. al, 2006), no studies have focused on specific time periods of growth.

Interestingly, two of the four samples of ground beef had greater than zero bacterial cells per gram before thawing. However, a recent study conducted by Bosilevac, Guernini, Kalchayanand, & Kochmaraie (2009) found that commercial ground beef samples can contain strains of *Salmonellae,*

but the prevalence is low. This may account for the initial presence of microbial cells in the ground beef. In this study, the microbes were not identified.

Although the sample thawed in the room temperature water bath had the greatest number of microbial cells per gram of ground beef at the end of the six-hour thawing period, the data set had some outlier points, which affected the overall trend line and misrepresented the rate of microbial growth. Additionally, the data collected from the sample thawed at room temperature contained a significant outlier data points, which also affected its trend line. The rate of growth may actually have been greater than represented by the line, and this would have been represented had the outlier been thrown out. However, it must be noted that at the end of the six-hour thaw method, the number of microbes in the sample thawed in the room temperature water bath was still significantly greater than the number of microbes in the sample thawed at room temperature. The outlier was most likely the result of experimental error. One possible source of error may have been that the scalpel was too hot after being sterilized when it was used to obtain the one-gram of ground beef from the sample. The higher temperature may actually have killed some of the microbes in the ground beef that the sterilized scalpel contacted. This is an error that could have affected all measurements. Furthermore, it should be noted that while it has been stated that moisture influences growth, the humidity of the room and level of moisture in the refrigerator were not measured or necessarily controlled.

Although this study provided information under variable conditions of temperature and time, we conducted only one trial because of limited time and resources. This is a major limitation of the study. Future studies should conduct multiple trials to replicate our results and demonstrate reliability of experimental procedures and implementation. This study was also limited because no literature was found regarding "acceptable" or safe levels of microbial contamination so it is difficult to put the results into perspective. Beef samples used in this study had 80/20 composition (20 percent fat). Future research could explore the effect of fat percent on the microbial growth during different thaw methods. Another area that could be explored is the relationship between different types of packaging (i.e., plastic tube vs. Styrofoam plate and plastic wrap) and the rate or amount of microbial growth during thawing. An interesting application of this study may be its pairing with studies that examine how much of a microbial population is "cooked out" during preparation. The degree of doneness (i.e., rare, medium, well done) and the number of microbial cells remaining in the ground beef could be an area of future study. Although this study had its limitations, it provides valuable information about microbial growth in a "real-life" environment. The results of this study add to the knowledge base of consumer safety and the literature of consumer food safety practices.

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