Cooling Techniques: Characterizing Escherichia coli Population Changes in Low-Sodium Marinara Sauce

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Abstract

Introduction: The United States Food and Drug Administration has identified improper (“slow”) cooling as a factor that contributes to foodborne illness outbreaks. School nutrition programs often cool leftover food products for reuse in future meals. Thus, research that characterizes the impact of a variety of cooling methods on foodborne pathogen populations is important for protecting public health.

Purpose: Characterizing Escherichia coli population changes in low-sodium marinara sauce subjected to cooling methods commonly used in school foodservice was the purpose of this research.

Methods: Canned, low-sodium marinara sauce was heated to 168°F, poured to 2 and 3 inch depths into commercial serving pans and then cooled to 135-140°F before inoculation with E. coli (target concentration of 10^4 CFU/g) as a surrogate for Shiga Toxin-producing E. coli. All pans were stored uncovered or covered, with or without an air gap, in a commercial walk-in freezer (-20°C), or placed in ice water baths in a commercial walk-in refrigerator (4°C). MacConkey agar was used to enumerate E. coli populations at 0, 4, 8, 12, and 24 hours.

Results: Product depth (p<0.0001) and time (p=0.0312) were statistically significant. A difference of 0.40 log_{10} CFU/g E. coli was observed between 2-inch (4.20 log_{10} CFU/g) and 3-inch (3.79 log_{10} CFU/g) product depths. In regards to time, the largest increase in E. coli populations occurred between the 0- and 8-hour time points, with a difference of 0.21 log_{10} CFU/g.

Significance: Although significant, a marginal increase of 0.21 log_{10} CFU/g was more likely due to natural variation caused by inoculating and sampling large quantities of food rather than cooling failure. This combined with the lack of additional significant variables (i.e. cover), suggests that all cooling method combinations were effective at controlling E. coli populations in low-sodium marinara sauce.

Methods

Experimental Design: This study was developed to test the efficacy of cooling techniques used by school nutrition programs on controlling microbial growth, such as Escherichia coli (E. coli). In this study, four ATCC strains of E. coli were combined in a cocktail to a target population of 10^5 CFU/g in order to accurately simulate survivability of the foodborne pathogen E. coli O157:H7 low sodium marinara sauce.

Sample Preparation: Canned low sodium marinara sauce was cooked to 74°C (165°F) in a commercial tilt skillet, and then prepared at two and three inch depths in steam table pans. The product was allowed to cool to 140°F and then inoculated with the E. coli surrogate cocktail.

Treatments: Six treatments were evaluated to determine if there was an effect on the rate of cooling and subsequent E. coli growth. Steam table pans (2- and 3-inch depth) were portioned and either left uncovered, covered with one layer of aluminum foil that allowed a gap for air exposure, or covered with two layers of aluminum foil without a gap for air exposure between the foil and food product.

These treatments were carried out in duplicate to evaluate the effects of walk-in freezer (-20°C) and walk-in refrigerator (4°C) storage scenarios. Pans in the walk-in refrigerator were situated in ice baths to model common cooling techniques.

Microbiological Analysis: A composite sample of sauce was collected from various locations in each pan at 0, 4, 8, 12, and 24 hours of chilling. Composite samples were mixed by hand, measured to 25 gram samples and stomached for one minute with 225 mL of buffered peptone water (BPW). Samples were then serially diluted in BPW and dilutions were spread-plated onto MacConkey agar. Plates were incubated for 18-24 hrs and pink colonies were counted and recorded.

Conclusion and Significance

Product depth (P<0.0001) and time (P=0.0312) were statistically significant for low sodium marinara sauce. The difference in E. coli populations between 2-inch (4.20 log_{10} CFU/g) and 3-inch (3.79 log_{10} CFU/g) product depths overall was 0.41 log_{10} CFU/g (Figure 6). In regards to time, 0.21 log_{10} CFU/g was the largest increase in populations, occurring between the 0- and 8-hour time points (Figure 7). No statistically significant difference (P>0.05) in populations was observed for cover (covered two layers, covered one layer, uncovered) or storage location (refrigerator vs. freezer) variables (data not shown), and no interaction combinations tested were significant. Overall, these results indicate all cooling method variables suppressed growth to the same degree, suggesting all cooling methods evaluated were effective at controlling E. coli populations in marinara sauce.

Young children are at-risk population for severe illness and life-threatening complications from foodborne pathogens. Therefore, it is necessary to conduct research to discover and evaluate cooling methods that are effective at controlling foodborne pathogens in school lunch programs and to translate these data into educational materials and trainings for both school nutrition program personnel and other commercial food service personnel.

Acknowledgements

This project has been funded, at least in part, with Federal funds from the U.S. Department of Agriculture. The contents of this publication do not necessarily reflect the views or policies of the U.S. Department of Agriculture nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government.

Introduction

School nutrition programs provide more than 31 million children with meals in over 100,000 schools across the United States (1). In school settings, certain foods may be cooked, cooled, and stored for later service making proper food preparation and handling practices critical to preventing outbreaks of foodborne illness, especially among young children who are at-risk population for severe illness and complications. The US Food and Drug Administration has consistently identified temperature control, specifically cold holding, as a major factor contributing to the incidence of foodborne illness (2, 3). Improper cooling can lead to temperature abuse, a parameter conducive for foodborne pathogen growth (2, 3). Schools in particular may struggle with this critical control point for several reasons including: limited access to coolers, limited refrigeration units, and limited refrigerator storage space, which may result in improper storage conditions conducive to foodborne pathogen growth. Improper cooling can lead to time and temperature abuse, which can allow for the growth of pathogens.

Purpose

This study was developed to test the efficacy of cooling techniques used by school nutrition programs on controlling microbial growth, such as Escherichia coli (E. coli). In this study, four ATCC strains of E. coli were combined in a cocktail to a target population of 10^5 CFU/g in order to accurately simulate survivability of the foodborne pathogen E. coli O157:H7 low sodium marinara sauce.

Methods

Experimental Design: This study was developed to test the efficacy of cooling techniques used by school nutrition programs on controlling microbial growth, such as Escherichia coli (E. coli). In this study, four ATCC strains of E. coli were combined in a cocktail to a target population of 10^5 CFU/g in order to accurately simulate survivability of the foodborne pathogen E. coli O157:H7 low sodium marinara sauce.

Sample Preparation: Canned low sodium marinara sauce was cooked to 74°C (165°F) in a commercial tilt skillet, and then prepared at two and three inch depths in steam table pans. The product was allowed to cool to 140°F and then inoculated with the E. coli surrogate cocktail.

Treatments: Six treatments were evaluated to determine if there was an effect on the rate of cooling and subsequent E. coli growth. Steam table pans (2- and 3-inch depth) were portioned and either left uncovered, covered with one layer of aluminum foil that allowed a gap for air exposure, or covered with two layers of aluminum foil without a gap for air exposure between the foil and food product.

These treatments were carried out in duplicate to evaluate the effects of walk-in freezer (-20°C) and walk-in refrigerator (4°C) storage scenarios. Pans in the walk-in refrigerator were situated in ice baths to model common cooling techniques.

Microbiological Analysis: A composite sample of sauce was collected from various locations in each pan at 0, 4, 8, 12, and 24 hours of chilling. Composite samples were mixed by hand, measured to 25 gram samples and stomached for one minute with 225 mL of buffered peptone water (BPW). Samples were then serially diluted in BPW and dilutions were spread-plated onto MacConkey agar. Plates were incubated for 18-24 hrs and pink colonies were counted and recorded.

Conclusion and Significance

Product depth (P<0.0001) and time (P=0.0312) were statistically significant for low sodium marinara sauce. The difference in E. coli populations between 2-inch (4.20 log_{10} CFU/g) and 3-inch (3.79 log_{10} CFU/g) product depths overall was 0.41 log_{10} CFU/g (Figure 6). In regards to time, 0.21 log_{10} CFU/g was the largest increase in populations, occurring between the 0- and 8-hour time points (Figure 7). No statistically significant difference (P>0.05) in populations was observed for cover (covered two layers, covered one layer, uncovered) or storage location (refrigerator vs. freezer) variables (data not shown), and no interaction combinations tested were significant. Overall, these results indicate all cooling method variables suppressed growth to the same degree, suggesting all cooling methods evaluated were effective at controlling E. coli populations in marinara sauce.

Young children are at-risk population for severe illness and life-threatening complications from foodborne pathogens. Therefore, it is necessary to conduct research to discover and evaluate cooling methods that are effective at controlling foodborne pathogens in school lunch programs and to translate these data into educational materials and trainings for both school nutrition program personnel and other commercial food service personnel.

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Evaluating the Impact of Cooling Techniques on Bacillus cereus Populations in Brown Rice

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Abstract

Introduction: In institutional settings, large quantities of food may be cooked, cooled, and stored for later service. Improper, or "slow," cooling has been identified as the United States Food and Drug Administration as a contributing factor in foodborne illness outbreaks. Therefore, validating cooling methods that are feasible and effective at preventing pathogen growth is critical for public health.

Purpose: This study was designed to test the efficacy of cooling technique combinations on controlling Bacillus cereus spore outgrowth within brown rice.

Methods: Brown rice was prepared according to product label instructions and then cooled to 135-140°F before inoculation with spores (10^6 spores/g) of B. cereus. All pans were stored in a commercial walk-in freezer (20°C) or placed in ice water baths stored inside a commercial walk-in refrigerator (4°C), either uncovered or covered with one or two layers of aluminum foil. Samples were obtained at 0, 4, 8, 12, and 24 hours, placed onto Mannitol Egg Yolk with Polymyxin B agar, and incubated for 24-48 hours to enumerate B. cereus populations.

Results: Treatment time (P=0.0.026) and product depth (P=0.0268) were statistically significant for B. cereus populations within the brown rice product during cooling. B. cereus populations decreased by 0.37 log_10 CFU/g between 0 and 24 hours when stored in the freezer, whereas populations decreased by 0.09 log_10 CFU/g between 0 and 24 hours when stored in the refrigerator. B. cereus populations decreased in both 2 and 3-inch product depths between 0 and 24 hours by 0.21 log_10 CFU/g and 0.25 log_10 CFU/g, respectively.

Significance: The slight decrease in B. cereus populations observed over the 24-hour cooling period, combined with no significant difference (P=0.05) in B. cereus population observed for the cover (two layers, one layer, uncovered) variable, indicate that all cooling techniques were effective at controlling B. cereus population outgrowth from spores in prepared rice.

Introduction

School nutrition programs provide more than 31 million children with meals in over 100,000 schools across the United States (1). In school settings, certain foods may be cooked, cooled, and stored for later service making food preparation practices critical to preventing outbreaks of foodborne illnesses, especially among young children who are a high-risk population for severe illness and complications. The US Food and Drug Administration has consistently identified time/temperature control, specifically cold holding, as a major factor contributing to the incidence of foodborne illnesses (2). Improper cooling can lead to time and temperature parameters conducive for foodborne pathogen growth (2-3). Schools in particular may struggle with this critical control point for several reasons including: limited cooling capacity in freezers or refrigerators, a lack of funding for more effective cooling equipment, or the limitations that come with a short workday for school lunch program employees (4, 5). Fried rice, a dish commonly served in schools and daycares, has been implicated in several outbreaks of emetic-type B. cereus food poisoning in United States schools due to improper cooling practices after preparation (6, 7). This study was conducted to investigate outgrowth potential of B. cereus spores in brown rice during 24 hours of cooling utilizing different cover methods, depths, and storage temperatures.

Methods

Experimental Design: This study was designed to test the efficacy of cooling techniques which could be used by school nutrition programs on controlling microbial growth, such as B. cereus. Two strains of B. cereus (ATCC 11778 and 14579) were combined in a cocktail, heat-shocked (80°C for 10 min) and inoculated into rice to provide a target population of 10^6 spores/g.

Sample Preparation: Water was added to uncooked brown rice according to product label instructions and cooked in 2- and 3-inch steam table pans using commercial-grade convection ovens. The product was allowed to cool to 135-140°F and then inoculated into rice for validation.

Sample Collection: Treatments were evaluated to determine if there was an effect on the rate of cooling and subsequent B. cereus outgrowth/growth. Steam table pans (2- and 3-inch depth) were portioned and either left uncovered and exposed to air, covered with one layer of aluminum foil that allowed a gap for air exposure, or covered with two layers of aluminum foil without a gap for air exposure between the foil and food product. These treatments were carried out in duplicate to evaluate the effects of walk-in freezer (20°C) and walk-in refrigerator (4°C) storage scenarios. Pans in the walk-in refrigerator were situated in ice baths to model common food cooling techniques.

Microbiological Analysis: A composite sample of brown rice was collected from various locations in each pan at 0, 4, 8, 12, and 24 hours of chilling. Composite samples were mixed by hand, measured to 25 gram samples and stomached for one minute with 225 mL of buffered peptone water (BPW). Samples were then serially diluted in BPW and dilutions were spread-plated onto Mannitol Egg Yolk with Polymyxin B agar. Plates were incubated for 18-24 hrs and flat, pink colonies with an opaque zone were counted and recorded.

Data Analysis: Data were analyzed using the mixed procedure with repeated measures modeling in SAS.

Conclusion and Significance

A storage location/time interaction was observed. Between 0 and 24 hours of cooling, brown rice stored in the freezer demonstrated a B. cereus population decrease of 0.37 log_10 CFU/g. Between time points 0 through 24 hours, the ice bath stored in the refrigerator was responsible for a B. cereus population decrease of 0.09 log_10 CFU/g. A product depth/time interaction was also observed. Bacillus cereus populations did decrease overall in both 2- and 3-inch product depths between time points 0 and 24 hours (0.21 log_10 CFU/g and 0.25 log_10 CFU/g, respectively). The small but statistically significant decreases in B. cereus populations from the two significant variable interactions demonstrate that all twelve cooling techniques investigated were effective at controlling B. cereus populations.

Young children are an at-risk population for severe illness and life-threatening complications from foodborne pathogens. Therefore, it is necessary to conduct research to discover and evaluate cooling methods that are effective at controlling foodborne pathogens in school lunch programs and to translate these data into food products and training programs for school nutrition program personnel and other commercial food service personnel.

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Selected References


Figure 1: Bacillus cereus populations (log_10 CFU/g) in brown rice when analyzed by product depth and chilling time. abc Different superscripts indicate statistically significant differences. Error bars represent the standard error of the mean.

Figure 2: Bacillus cereus populations (log_10 CFU/g) in brown rice when analyzed by storage location and time. abc Different superscripts indicate statistically significant differences. Error bars represent the standard error of the mean.
Evaluating the Impact of School Foodservice Cooling Techniques on *Escherichia coli* Populations in Recipe Prepared Chili Con Carne with Beans

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Abstract

**Introduction & Purpose:** In preventing foodborne illness outbreaks, proper food preparation practices are especially critical in institutional settings where food products are prepared in large quantities. The third leading factor in outbreaks of school associated foodborne illness is improper or “slow” cooling. Therefore, conducting research regarding cooling methods that are both effective and feasible for preventing pathogen growth is critical to public health. The purpose of this study was to evaluate combinations of cooling techniques and their impact on *Escherichia coli* populations in a recipe prepared chili con carne with beans.

**Methods:** Chili was prepared according to a school nutrition program recipe and heated to 165°F, poured into steam table pans to 2 and 3 inch depths, then cooled to 135-145°F before inoculation with *E. coli* target concentration (10⁴ CFU/g). Pans were stored in a commercial walk-in freezer (–20°C) or placed in ice water baths in a commercial walk-in refrigerator (4°C). All pans were stored uncovered or covered with one or two layers of aluminum foil. Samples were plated onto MacConkey agar at 0, 4, 8, 12, and 24 hours, and incubated for 18-24 hours to enumerate *E. coli* populations.

**Results & Conclusions:** No statistically significant difference (P>0.05) in *E. coli* population was observed for cover (two layers, one layer, uncovered), treatment (refrigerator vs. freezer), or depth variables. However, time (P<0.0015) and a two way interaction, depth by time (P=0.0197), were significant for this product. Although time was statistically significant, the largest recorded change in *E. coli* population (–0.1534 log10 CFU/g) between time points 4 and 12 may not be considered microbiologically significant. Depth by time was also statistically significant, with the largest population change (–0.2777 log10 CFU/g) recorded for three inch food depths between time point 0 and time point 4. For two inch depths, the largest change in *E. coli* population (–0.1534 log10 CFU/g) occurred between time point 0 and 12. This data indicates that most cooling treatments evaluated were effective at controlling *E. coli* populations in commercially prepared chili product.

**Conclusion and Significance**

Time was statistically significant for this food product (P<0.0015). The slight decrease in *E. coli* population over time indicates an effective control for the cooling methods evaluated. The time by depth interaction was significant for this food product as well (P=0.0197). The decrease in *E. coli* population over time for the two and three inch food depths also demonstrates an effective control for the cooling methods evaluated. Although these effects were statistically significant, it should be noted that the variation observed in population was well under 0.5 Log₁₀ CFU/g. It is possible that this small degree of difference is the result of natural variation in populations throughout the food. These results, along with the lack of statistical differences among cover and treatment variables, indicate that a majority of foodservice cooling methods evaluated were effective at controlling *E. coli* populations in chili con carne with beans.

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Evaluating the Effectiveness of Cooling Techniques in Chili Con Carne with Beans

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Abstract

Introduction & Purpose: Large quantity recipes are commonly used in child nutrition programs. Improper cooling of food is a major contributing factor to foodborne illnesses. Requirements in the FDA’s Food Code 2013 state food should cool from 135°F to 70°F (57.2°C to 21.1°C) within two hours and from 135°F to 41°F (57.2°C to 5°C) within a total of six hours. Cooling foods within these time and temperature parameters is essential to prevent foodborne illness outbreaks, especially for vulnerable populations like children. Identifying cooling methods that are effective and feasible is an important component to reduce public health risks. This research is a continuation of previous studies to determine the effectiveness of cooling methods used in school nutrition programs by identifying which procedures best meet cooling requirements in the Food Code.

Methods: Chili was cooked to 165°F, portioned to 5.1 cm (2-inch) or 7.6 cm (3-inch) depths in stainless steel steam table pans, and cooled to 140-135°F. Pans were covered with a single layer of foil, two layers of foil, or left uncovered, and cooled in a walk-in freezer (4°F, -20°C) or on an ice bath placed in a walk-in refrigerator (39°F, 4°C). Temperatures were monitored every 60 seconds for 8 hours.

Results: At 2 hours, a significant difference was found between the freezer and ice bath temperatures (p<0.0001); the depth of the pan (p=0.0082), and the pan covering method (p=0.0001). Three cooling methods reached the 70°F (21.1°C) as recommended by FDA. By 6 hours, a significant difference was found between the depths of the pans (p=0.0038) and the pan covering method (p=0.0020). Five cooling methods reached 41°F (5°C).

Conclusions: Three cooling methods met Food Code requirements: uncovered 2-inch and 3-inch pans in the ice bath and uncovered 2-inch pan in the freezer. This study provides information about best practices for cooling large quantities of food following the Food Code 2013 guidelines using commercial kitchen equipment. Using the most effective practices to cool food can strengthen food safety practices in schools by preventing the growth of potential pathogens and, therefore, protecting students from foodborne illnesses.

Statement of Purpose

The purpose of this study was to determine if common cooling methods used in child nutrition programs for met the Food Code 2013 cooling guidelines.

Methods examined included:
• Ice bath in walk-in cooler
• Walk-in freezer
• Pan coverings
• Product depth

Methods

• Chili recipe met nutritional standards for the National School Lunch Program
• Chili was cooked to 165°F, cooled to 140-135°F before temperature monitoring
• Twelve treatments (n=3) tested all combinations of three factors:
  • Cooling method: walk in freezer (10% capacity) and ice bath in walk-in cooler (10% capacity)
  • Chili depth: 2 and 3-inch depth (commercial full-size stainless steel steam table pans)
  • Pan coverings: uncovered, single foil layer, double foil layer (standard weight food service aluminum foil)
• Chili temperatures were monitored every 60s for 8h

Results

• Main effect means for cooling method, chili depth and pan cover at 2h and 6h

Results, Continued

• Figure 2. Factor combinations meeting Food Code 2013 cooling factors in green meet standards when combined. Factors in yellow meet a part, but not all, of the standard. Factors in red did not meet standards.

Implications

• Many cooling methods commonly used in child nutrition programs do not meet Food Code 2013 cooling standards.

• None of the cooling methods with covered pans met standards.
Evaluating the Impact of School Foodservice Cooling Techniques on Escherichia coli Populations in a Commercially Available Marinara Sauce Product

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Abstract

Introduction: Proper commercial food preparation practices are critical for preventing outbreaks of foodborne illness. Improper or “slow” cooling is the third leading factor in school associated foodborne illness outbreaks. Thus, research to scientifically characterize and validate cooling methods that are both effective and feasible for preventing pathogen growth in meals prepared in school nutrition program settings is critical to public health.

Methods: Marisana sauce was purchased from a local foodservice distributor and heated to 165°F in a commercial tilt skillet, measured to 2 and 3 inch depths in steam table pans and allowed to cool to 135-140°F before inoculation with Escherichia coli (E. coli); target population of 10^6 CFU/g. Pans were placed in a commercial walk-in freezer (-20°C) or situated in ice water baths in a commercial walk-in refrigerator (4°C). All pans were either uncovered or covered, with one or two layers of aluminum foil to allow for air exposure. At 0, 4, 8, 12, and 24 hours, samples were serially diluted and plated onto MacConkey agar. Plates were then incubated for 18-24 hours to quantify E. coli populations.

Results: No statistically significant difference (P>0.05) in E. coli populations were observed for cover (covered two layers, covered one layer, uncovered) or treatment (refrigerator vs. freezer) and no variable combinations tested were significant. However, product depth (P<0.0001) and time (P<0.012) were statistically significant for this product. The difference in E. coli populations between 2 inch (4.20 log10 CFU/g) and 3 inch (3.79 log10 CFU/g) food depths were 0.40 log10 CFU/g. Though time was statistically significant, 20 log10 CFU/g was the largest difference in populations over time which may or may not be microbiologically significant.

Significance: Depth and time were statistically significant for this product. However, the lack of statistical differences among covered and uncovered treatments and variable interactions indicates that a majority of foodservice cooling methods evaluated were effective at controlling E. coli populations in Marisana sauce.

Introduction

A 2013 Morbidity and Mortality Weekly Report by the CDC analyzed foodborne illness outbreak data gathered from 1998-2008 and attributed illnesses to food preparation locations. Results revealed that schools were associated with the largest number of outbreaks (286) and illnesses (17,266) when compared with other institutions like daycares, workplace cafeterias, and prisons or jails (1). The National School Lunch Program serves over 31 million children each day (2). A significant risk for schools and other institutional settings is improper or “slow” cooling, which has been identified as the third leading factor for school associated foodborne illness (3). The risk to public health lies in the preparation of large quantities of food that are cooked, cooled, and stored until service. For this reason, the Food and Drug Administration issued a food code in 2009 requiring food products be cooled to 70°F within two hours of cooking and down to 41°F within a total of six hours. Studies have been carried out to evaluate effective cooling techniques for several food products (4,5) and have produced very few techniques that meet the 2009 FDA code standards. This study was conducted to evaluate pathogen survival and activity during cooling as a follow up to these studies.

Methods

Experimental Design: This study was developed to test the efficacy of school nutrition program cooling techniques on controlling microbial growth, such as Escherichia coli (E. coli). Four ATCC strains of E. coli were combined in a cocktail to a target population of 10^6 CFU/g in order to simulate survivability of the foodborne pathogen E. coli O157:H7 in marisana sauce product.

Sample Preparation: Marisana sauce was heated in commercial tilt skillet to 165°F and prepared at two and three inch depths in commercial pans. The product was allowed to cool to 140°F and then inoculated with the E. coli surrogate cocktail.

Treatments: Six different treatments were utilized to determine if there was an effect on the rate of cooling and subsequent microbial growth. Two and three inch steam table pans were portioned and either left uncovered and exposed to air, covered with one layer of aluminum foil and allowed a gap for air exposure, or covered with two layers of aluminum foil without a gap for air exposure between the foil and food product. These treatments were duplicated in a walk-in freezer and walk-in refrigerator. Pans in the walk-in refrigerator were situated in ice baths to represent a common food cooling technique.

Microbiological Analysis: A composite sample of the marisana sauce product was collected from various locations in each pan at sampling time points of 0, 4, 8, 12, and 24 hours. Composite samples were mixed by hand, measured to 25 gram samples and stomached for one minute with 225 mL of buffered peptone water (BPW). Following homogenization, samples were serially diluted in BPW and appropriate dilutions were spread-plate onto MacConkey agar (MAC). MAC plates were incubated for 18-24hrs and lactose fermenting colonies were enumerated and recorded.

Data Analysis: Data were analyzed as using a mixed procedure, repeated measures model in SAS.

Results and Conclusion

Depth was statistically significant for this food product (P<0.0001). It is possible that 3 inch pans facilitated the retention of pockets of high temperature within the food product that reduced some of the bacterial population at inoculation. The increased depth resulted in slower cooling, perhaps allowing pockets of high temperature to persist. Time was also significant for this product. The largest population fluctuations occurred between 0 and 8 hour time points, perhaps pointing to a time point risk where there is loss in pathogen population control for cooling methods tested. However, the lack of statistical differences among coverage and treatment variables and variable interactions indicates that a majority of foodservice cooling methods evaluated were effective at controlling E. coli populations in marisana sauce.

Scientific validation of cooling methods that are effective at controlling foodborne pathogens will continue to be a significant research area that directly benefits public health by reducing the risk of foodborne illness and allowing a degree of necessary flexibility for foodservice operations. This data could also be translated into educational materials and trainings that can be used to inform cooling protocols used in institutional or commercial foodservice settings.

Acknowledgements

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Evaluating the Impact of School Foodservice Cooling Techniques on Escherichia coli Populations in a Commercially Available Pre-Cooked Taco Meat Product

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Abstract

Introduction & Purpose: Proper commercial food preparation practices are critical for preventing outbreaks of foodborne illness. Improper or “slow” cooling is the third leading factor in school associated foodborne illness outbreaks. Thus, research to scientifically characterize and validate cooling methods that are both effective and feasible for preventing pathogen growth during school foodservice preparation is critical to public health.

Methods: Commercially available pre-cooked taco meat was re-heated to 165°F, measured to 2 and 3 inch depths in commercial serving pans and allowed to cool to 135-140°F before inoculation with Escherichia coli (target population of 10⁴ CFU/g). Pans were placed in a commercial walk-in freezer (-20°C) or situated in ice water baths in a commercial walk-in refrigerator (4°C). All pans were either uncovered or covered with or without a gap to allow for air exposure. At 0, 4, 8, 12, and 24 hours, samples were plated onto MacConkey agar and incubated for 18-24 hours to quantify E. coli populations.

Results: No statistically significant difference (P=0.9335) in E. coli population level was observed for the cooling technique combinations evaluated in this study. However, sampling time was significant (P<0.0001). A time by cooling treatment interaction was not observed (P=0.1462); thus, data were evaluated by time alone. E. coli populations declined slightly from 4.5 log₈ CFU/g at 0 hours to 4.2 log₈ CFU/g at 24 hours.

Conclusion: The lack of a cooling treatment effect combined with a small but statistically significant decline in target microbial population indicates that all foodservice cooling treatments evaluated were effective at controlling E. coli populations in cooked taco meat.

Introduction

Between 1998 and 2008, the CDC received 13,405 reports of foodborne illness outbreaks (1). In fact, the number of reported illnesses related to school food preparation were second only to those reported for prisons or jails (1). Good food preparation practices are critical for preventing outbreaks of foodborne illness and improper or “slow” cooling poses a significant public health risk. It has been identified as the third leading factor in school associated foodborne illness outbreaks (2). Schools provide, on average, 32 million meals daily (3), which means focusing research on proper cooling techniques and microbiological consequences is crucial. As of 2009, the Food and Drug Administration issued a food code requiring food products be cooled to 70 degrees Fahrenheit within two hours and down to 41 degrees Fahrenheit within a total of six hours. Variability related to food preparation facilities and chilling capacity, as well as variability in specific chilling protocols, exist in school foodservice operations across the state. Researching and evaluating cooling methods that are both effective and feasible for school foodservice preparation environments is essential.

Materials and Methods

Experimental Design: This study was designed to test the efficacy of school foodservice cooling techniques on controlling microbial growth, such as Escherichia coli (E. coli). In this study, four ATCC strains of E. coli were utilized at a target population of 10⁴ CFU/g as surrogates to simulate survivability and growth of the foodborne pathogen E. coli O157:H7 in taco.

Sample Preparation: Taco meat was re-heated in commercial steamers to 165°F and prepared at two and three inch depths in commercial pans. The product was allowed to cool to 140°F and then inoculated with the E. coli surrogate cocktail.

Treatments: Six different treatments were utilized to determine if there was an effect on the rate of cooling and subsequent microbial growth. Two and three inch commercial pans were prepared and either left uncovered and exposed to air, covered with tin foil and allowed a gap for air exposure, or covered and without a gap for air exposure. These treatments were duplicated in a walk-in freezer and walk-in refrigerator. Pans in the walk-in refrigerator were situated in ice baths to represent a common food cooling technique.

Microbiological Analysis: A composite sample of the taco meat product was collected from various locations in each pan at sampling time points of 0, 4, 8, 12, and 24 hours. Composite samples were mixed by hand, measured to 25 grams and stomached for one minute with 225 mL of buffered peptone water (BPW). Following homogenization, samples were serially diluted in BPW and appropriate dilutions were spread-plated onto MacConkey agar (MAC). MAC plates were incubated for 18-24hrs and lactose fermenting colonies were enumerated and recorded.

Data Analysis: Data were analyzed as a two-way ANOVA with repeated measures modeling using GraphPad Prism 6 software.

Results and Conclusion

No significant difference was observed in E. coli populations (P=0.9335) for the cooling techniques evaluated in this study. However, sampling time alone was found to be significant (P<0.0001); therefore, data were analyzed on time alone. Escherichia coli populations declined slightly from 4.5 log₈ CFU/g at 0 hours to 4.2 log₈ CFU/g at 24 hours. The lack of a cooling treatment effect combined with a small, but statistically significant, decline in target microbial population indicates that all foodservice cooling treatments evaluated were effective at controlling E. coli populations in cooked taco meat.

Research into cooling methods that are effective at controlling foodborne pathogens in school lunch programs will continue to grow in significance, as it directly benefits public health by reducing the risk of foodborne illness and allowing a degree of necessary flexibility for foodservice operations. While this study is targeted specifically for school foodservice, translating these data into educational materials and trainings that can be used to inform cooling protocols used in other commercial foodservice settings is a benefit as well.

Selected References


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