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Cooling of Foods in Retail Foodservice Operations

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SUMMARY

The Food and Drug Administration's Model Food Code requires that food be cooled from 57.2°C to 21.1°C (135°F to 70°F) within two hours and from 57.2°C to 5°C (135°F to 41°F) within a total of six hours. The FDA defines cooling as a critical control point essential to preventing foodborne illness outbreaks. The purpose of this research was to determine if common cooling practices used in retail foodservice operations, such as those in schools, would meet the FDA Model Food Code standards. Two food products were tested, chili con carne with beans and tomato sauce (meatless). Products were cooled at 5.1 cm (2-inch) and 7.6 cm (3-inch) depths in stainless steel counter pans placed uncovered in a walk-in refrigerator, a walk-in freezer, and a walk-in refrigerator with an ice bath. An additional treatment utilizing three gallons of product was cooled in a stockpot placed in a walk-in refrigerator with the use of a chill stick. Cooling the product in a walk-in freezer, with a depth of 5.1 cm (2-inches), was the only method that met both FDA Model Food Code time and temperature standards. Cooling in a walk-in refrigerator with a chill stick required the longest cooling time.

INTRODUCTION

Improper cooling or "slow cooling," of food has been identified as a food safety problem in retail food service operations for many years *(1, 3, 10)*. Bryan *(1)* reported that improper cooling was the number one factor in 1,918 outbreaks of *C. perfringens* illnesses in the United States between 1961 and 1982. More recently, Pogostin et al. *(10)* identified "slow cooling" as the third leading contributing factor to school-associated foodborne outbreaks, contributing to 16 outbreaks between 1998 and 2006.

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TABLE 1. Cooling scenarios and methods for chili and tomato sauce

Pan size (W x L x D)	Product depth	Cooling methods
30.5 cm × 50.8 cm × 6.4 cm (12-inch × 20-inch × 2 ½-inch)	5.1 cm (2-inch)	Walk-in refrigerator Walk-in freezer Ice bath, in walk-in refrigerator[a]
30.5 cm × 50.8 cm × 10.2 cm (12-inch × 20-inch × 4-inch)	7.6 cm (3-inch)	Walk-in refrigerator Walk-in freezer Ice bath, in walk-in refrigerator[b]
19 L (5 gallon) Stockpot	11.4 L (3 gallon)	1.9 L (64 oz) Chill stick

[a] *The pans of product were placed into 30.5 cm × 50.8 cm × 10.2 cm (12-inch × 20-inch x 4-inch) insert pans holding ice water that contacted the bottom of the hot pan completely.*

[b] *The pans of product were placed into 30.5 cm × 50.8 cm × 15.3 cm (12-inch × 20-inch x 6-inch) insert pans holding ice water that contacted the bottom of the hot pan completely.*

The FDA Model Food Code requires that food be cooled from 57.2°C to 21.1°C (135°F to 70°F) within two hours and from 57.2°C to 5°C (135°F to 41°F) within a total of six hours. The FDA defines cooling as a critical control point essential in preventing foodborne illness outbreaks *(4).* Snyder and Labalestra *(11)* indicated that the FDA Model Food Code standard is difficult to achieve. Their data showed that any depth of food product greater than 2.5 cm (1 inch) or any volume of food product greater than 0.94 L (1 quart) will not cool adequately within the recommended time. The FDA Model Food Code outlines multiple methods to cool food quickly during food production: placing the food in shallow pans; dividing the food into smaller portions; using rapid cooling equipment; placing the food in an ice water bath and then stirring the food; using containers that facilitate heat transfer; and adding ice as an ingredient *(4).* While anecdotal evidence supports these guidelines, there is a paucity of published scientific data explaining which cooling methods can achieve the cooling standards required in foodservice.

Olds, Mendonca, Sneed, and Bisha *(8)* explored the cooling of turkey roasts. Four different treatments observed in school foodservice operations were investigated: roast quartered, uncovered, and placed in the walk-in refrigerator; whole roast, loosely wrapped in a blast chiller; whole roast, loosely wrapped, in a walk-in refrigerator; and whole roasts, three per sheet pan, wrapped, and placed in a walk-in refrigerator. No treatment in this study met the current FDA Model Food Code standards.

Olds and Sneed *(9)* explored cooling methods for chili in 6.4 cm (2 ½-inch) and 10.2 cm (4-inch) depth stainless steel pans (25.4 cm [10-inch] width × 30.5 cm [12-inch] length) in both a walk-in refrigerator and a blast chiller, a three-gallon stockpot in a walk-in refrigerator, and a chill stick in a walk-in refrigerator. A probe thermometer, programmed to record temperatures every 10 minutes, was placed in the geometric center of the chili. After the containers had been placed in the walk-in refrigerator and blast chiller, the doors remained closed during the entire cooling process. The only method that met the FDA Model Food Code standard was the blast chiller, which cooled chili in both the 6.4 cm (2 ½-inch) and 10.2 cm (4-inch) pans within the recommended time. While blast chillers are effective for cooling food, only about 8% of schools actually have them in their kitchens *(6).*

The 2004 Child Nutrition and WIC [Women, Infants, and Children] Reauthorization Act required that schools implement a food safety program based on a Hazard Analysis Critical Control Point (HACCP) system *(2).* Ensuring proper cooling is an important part of the school food safety program, especially when food is cooled and reheated for future service.

Krishnamurthy and Sneed *(6)* explored cooling practices in a national sample of schools. Of 411 usable responses, 78% of schools cooled food for reheating and service at a later date. The majority (76%) of school foodservice directors reported using 5.1 cm (2-inch) counter pans for cooling food. Other respondents reported using 10.2 cm (4-inch) counter pans (39%), 15.2 cm (6-inch) counter pans (9%), and stockpots (6%), all of which extend the time required for cooling at increased food product depths. Only 37% and 38% of respondents reported using ice baths and chill sticks, respectively.

Schools present a unique environment for food production. Once lunch service ends, the work day of most school foodservice staff and managers ends, and no one is available to monitor the cooling process. Therefore, data to support appropriate cooling methods for school foodservice operations are needed. The purpose of this research was to determine if common practices used in school foodservice would sufficiently cool common foods to the standards established by the FDA. Specific cooling methods explored included placing uncovered products in a walk-in refrigerator, a walk-in freezer, a walk-in refrigerator with the use of a chill stick, and a walk-in refrigerator with an ice bath.

TABLE 2. Mean time for chili and tomato sauce to meet FDA Food Code recommendations

Product	Product depth	Cooling methods	Mean time (Hours:Minutes) ± SD[a] 57.2°C to 21.1°C (135°F – 70°F)	57.2°C to 5°C (135°F – 41°F)
Chili	5.1 cm (2-inch)	Walk-in freezer	1:47 ± 0:10	3:10 ± 0:21
		Ice bath, walk-in refrigerator	1:04 ± 0:05	8:59 ± 1:38
		Walk-in refrigerator	3:09 ± 0:21	9:42 ± 1:22
	7.6 cm (3-inch)	Walk-in freezer	2:38 ± 0:13	4:50 ± 0:28
		Ice bath, walk-in refrigerator	2:59 ± 0:15	16:33 ± 1:59
		Walk-in refrigerator	5:31 ± 0:35	16:30 ± 1:41
	11.4 L (3 gallon)	Chill stick (1.89 L; 64 oz)	4:41 ± 0:30	22:38 ± 2:44
Tomato sauce	5.1 cm (2-inch)	Walk-in freezer	1:38 ± 0:13	2:58 ± 0:24
		Ice bath, walk-in refrigerator	1:03 ± 0:11	7:02 ± 1:26
		Walk-in refrigerator	3:08 ± 0:17	9:25 ± 0:52
	7.6 cm (3-inch)	Walk-in freezer	2:52 ± 0:16	4:58 ± 0:24
		Ice bath, walk-in refrigerator	2:33 ± 0:18	14:37 ± 1:59
		Walk-in refrigerator	4:46 ± 0:14	14:16 ± 1:16
	11.4 L (3 gallon)	Chill stick (1.89 L; 64 oz)	4:28 ± 0:40	20:28 ± 2:38
FDA MODEL FOOD CODE (2009) STANDARD			2:00	6:00

[a] *Standard Deviation*

MATERIALS AND METHODS

SAMPLE

Two food products, Chili con Carne with Beans (USDA Recipe #D-20) and Tomato Sauce, Meatless (USDA Recipe # G-07), were selected for the study because of their common use in schools *(6).* USDA recipes *(7)* available to school districts were used and prepared in a standard steam-jacketed kettle, a piece of equipment commonly found in school foodservice operations.

COOLING PROCEDURES

A convenience sample of 15 school foodservice operators were interviewed prior to the beginning of the study to determine the normal capacity of walk-in refrigerator and freezers most often used for cooling. An average walk-in refrigerator/freezer load of 80% capacity (20% free/open space) was found in these schools and replicated in this study. The walk-in refrigerator was maintained at an average temperature of 3.9 ± 0.6°C (39 ± 1°F); the walk-in freezer was maintained at -17.8 ± 2.8°C (0 ± 5°F).

Three replications established the average cooling curve for each product and cooling method. Based on previous research that suggested uncovered food products cool more rapidly than covered food products *(5, 8),* all pans remained uncovered during testing. Table 1 presents the cooling methods tested. Temperatures were recorded using the Comark RF500 temperature monitoring system (Comark USA, Beaverton, OR) and data were captured at 1-minute intervals during the testing period. A 3-cm (1 3/16") long Comark RFAX100D thermistor (Comark USA, Beaverton, OR)

FIGURE 1. Cooling curves for chili.

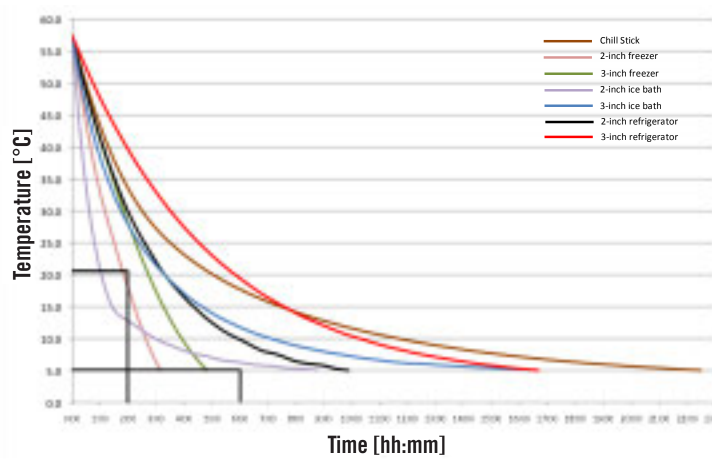
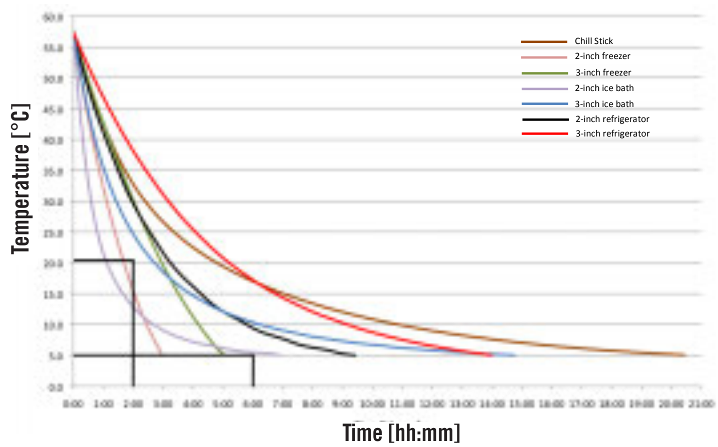


FIGURE 2. Cooling curves for tomato sauce.



was placed in the geometric center of 30.5 cm x 50.8 cm (12-inch × 20-inch) stainless steel pans and positioned at the midpoint of the product depth (i.e., the probe was placed at a 2.5 cm [1-inch] depth in products that were at 5.1 cm [2-inches] depth in the pan and at a 3.8 cm [1 ½-inch] depth in products that were at 7.6 cm [3-inches] depth in the pan).

The replicates using ice baths were prepared identically to those in the walk-in refrigerator/freezer methods. The pans of product were placed into insert pans (30.5 × 50.8 × 10.2 cm [12-inch × 20-inch × 4-inch] insert pans for 5.1 cm [2-inch] methods and 30.5 × 50.8 × 15.2 cm [12-inch × 20-inch × 6-inch] insert pans for 7.6 cm [3-inch] methods) holding an ice water bath (7.6 L [2 gallons] ice, 3.8 L [1 gallon] water) that contacted the bottom of the hot pan completely. The hot pan/ice bath insert pan replicates were then immediately placed in the walk-in refrigerator.

To test the effectiveness of the 1.9 L (64 oz.) chill stick/ice paddle (Rapi-Kool Plus, Ecolab, St. Paul, MN), it was filled with tap water and frozen for 48 h until it was solid. Three gallons of cooked food product were transferred to a stainless steel 18.9 L (5-gallon) stock pot. The chill stick was then completely immersed into the center of the stock pot, perpendicular to the bottom of the stockpot. Two probes were placed on each side of the chill stick, equidistant between the sides of the stockpot and the sides of the chill stick located in the center. The probes were also positioned half way into the product, equidistant from the bottom of the stockpot and the top of the product. The temperature readings from both probes were then averaged to determine the cooling time of the product in the stockpot.

In both the ice bath and chill stick replicates, neither coolant (ice) was replaced once the initial ice melted. This was done to mirror practices that would occur in school foodservice operations, where only breakfast and lunch meals are served and employees leave work shortly after the cooling process begins.

In each replicate, no more than four pans were placed in the walk-in refrigerator or freezer during testing. No other concurrent food production activity occurred during the cooling of the food products, and once pans were placed in the unit, doors to the walk-in refrigerator/freezer remained closed throughout the entire cooling process.

RESULTS AND DISCUSSION

Required cooling standards established in the 2009 FDA Model Food Code (4) for each of the products tested (chili and tomato sauce) are presented in Table 2. Figures 1 and 2 illustrate the cooling curves for each method of cooling for both chili and tomato sauce, respectively. The only method that met both standards (57.2°C to 21.1°C [135°F to 70°F] within two hours and 57.2°C to 5°C [135°F to 41°F] within a total of six hours) for chili and tomato sauce was when the product at a 5.1 cm (2-inch) depth was placed in a walk-in freezer.

Both chili and tomato sauce cooled using an ice water bath in the refrigerator and cooled in the freezer met the first standard of 57.2°C to 21.1°C (135°F to 70°F) within two hours, but failed to meet the standard of 57.2°C to 5°C (135°F to 41°F) within a total of six hours. Neither product cooled within the recommended standards when the 7.6 cm (3-inch) depth in an ice bath was used.

Although products stored at 5.1 cm (2-inch) depths in the refrigerator cooled more quickly than those stored at 7.6 cm (3-inch) depths, neither met FDA Model Food Code standards. Therefore, while the FDA's recommendation to reduce the volume of the product being cooled does help products cool more quickly, FDA standards were still not met. Because space is limited in the refrigeration units of most foodservice operations, it is unlikely that any product could be reduced to a small enough volume to be cooled successfully to FDA standards by use of a refrigerator.

The method with the longest total cooling time for both products was the use of the chill stick. Total cooling time for the chili was 16.5 h ± 1.7 h and for the tomato sauce was 20.5 h ± 2.6 h. Use of a chill stick did speed initial cooling from 57.2°C to 21.1°C [135°F to 70°F]; however, once the chill stick warmed up to the temperature of the product, the additional water (i.e., melted ice) in the chill stick added volume and caused the product to cool at an even slower rate than the product placed in the walk-in refrigerator without a chill stick. Chill sticks are designed to be used to reduce the temperature at the beginning of the cooling process and are not intended to be left in the product for extended periods of time with no movement. Because this study was designed to simulate operational practices in most school foodservices, the chill stick remained in the product throughout the cooling process.

CONCLUSIONS/RECOMMENDATIONS

Results indicate that cooling food effectively is difficult and may pose a risk in retail foodservice operations. Previous research utilizing blast chillers in school foodservice operations proved successful in cooling food to meet the FDA requirements stated in the 2009 Food Code *(9).* However, blast chillers cost a minimum of $5,500, posing a financial challenge to many foodservice operations. Therefore, foodservice operators and employees require low-cost solutions to cool food safely.

In this study, food products cooled in the freezer met the time requirements of the FDA Model Food Code. Therefore, foodservice operators with limited budgets who are not able to purchase specialized cooling equipment, such as blast chillers, can use the freezer to safely cool products if the products are kept at a maximum depth of 5.1 cm (2 inches). However, this method may not be practical if the food is to be served the following day, unless the food can be reheated from a frozen state. Also, many retail foodservice operations may be limited in freezer storage space.

Cooling foods in school foodservice operations is even more important as programs consider scratch cooling. If schools transition to using fewer preprocessed foods to promote better health among our nation's children, food safety issues such as cooling may take on greater importance.

School foodservice operators may perceive chill sticks as a safeguard in avoiding a foodborne illness outbreak. However, this research has shown that passive use of chill sticks actually increased the cooling time of both products tested. Therefore, active cooling should be promoted within foodservice environments. Employees need to monitor food products undergoing cooling, stirring the product with a chill stick and then replacing it with another chill stick once the ice has melted.

Future research should explore the cooling of other types of food products, such as semi-solid and solid foods. Research also should explore if the existing FDA Food Code standards are necessary or valid to ensure food safety. The results of this study show that it is extremely difficult to cool foods to the standards identified. Research is needed to assess whether these standards are crucial to prevent foodborne illness or if additional time could be allotted to the cooling process with little to no impact on bacterial growth.

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