Cooling Foods in School Foodservice Operations
Summary Report

The Center of Excellence for
FOOD SAFETY RESEARCH IN
CHILD NUTRITION PROGRAMS

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Cooling Foods in School Foodservice Operations
Summary Report

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Executive Summary

The Food and Drug Administration's (FDA) 2009 Food Code states that food shall be cooled from 135°F to 70°F within two hours and from 135°F to 41°F within a total of six hours. The FDA also states that cooling is a critical control point in preventing foodborne illness. This research identified practices commonly used to cool food produced in school foodservice operations and tested those practices to determine they meet established FDA Food Code standards. Four food products, Chili con Carne with Beans, Tomato Sauce (Meatless), Steamed Rice, and Beef Taco Meat, were tested. Products were cooled at 2-inch and 3-inch depths in stainless steel counter pans placed uncovered in a walk-in refrigerator, a walk-in freezer (rice excluded), and a walk-in refrigerator with an ice water bath. An additional treatment using a chill stick was tested for three-gallons of chili and tomato sauce cooled in a stockpot and placed in a walk-in refrigerator.

Conclusions

Based on this study, we reached the following conclusions:

1. Chili, tomato sauce, and beef taco meat cooled at 2-inch depths using an ice water bath in a walk-in refrigerator cooled from 135°F to 70°F within two hours but failed to cool, from 135°F to 41°F within a total of six hours.
2. None of the cooling treatments tested at 3-inch depths met both of the Food Code cooling standards.
3. Products cooled in a walk in freezer and rice cooled in an ice water bath (in a walk in refrigerator) at a depth of 2 inches were the only methods that met both Food Code time and temperature standards.

4. Ice water baths and chill sticks are supposed to speed the cooling process, but if not used properly, they can actually increase cooling time. If the coolant melts or if either process is used for a large amount of food, neither method will meet the standards.

Recommendations

We recommend the following:

1. Federal and state agencies should encourage the use of blast chillers in high volume school foodservice operations that cool foods.
2. Active cooling must be encouraged by both federal and state agencies for proper cooling of food.
3. The Standard Operating Procedure for cooling in the *Guidance for School Food Authorities: Developing a School Food Safety program Based on the Process Approach to HACCP Principles* should be updated to provide school foodservice operators with specific recommendations for proper cooling of food.
4. Educational materials and programs must provide research-based recommendations for cooling foods.
5. Section 3-501.15 of the 2009 Food Code should be revised to provide more specific recommendations on methods for cooling.

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Background

Safe cooling of food is a critical control point for preventing foodborne illness in school foodservice operations because foods not cooled rapidly allow exponential microbial growth (U.S. Department of Agriculture [USDA], Food Safety and Inspection Service [FSIS], 2012). Improper cooling could be a problem in school foodservice because so many children are served. During 2012 in the United States (U.S.), 31 million children were served lunch each school day under the federally funded National School Lunch Program (NSLP) (USDA Food and Nutrition Services [FNS], 2011).

Between 1961 and 1982, inadequate cooling of food contributed most heavily to 1,918 outbreaks of *C. perfringens* food intoxication in the U.S. (Bryan, 1988). The Centers for Disease Control and Prevention estimated that *C. perfringens* account for 10% of the 9.4 million cases of foodborne illness that occur annually in the U.S. (Scallan et al., 2011). The U.S. General Accounting Office (GAO) (2003) reported 447,483 cases of foodborne illness and 15,831 foodborne outbreaks between 1973 and 1999, which caused 20,119 hospitalizations and 457 fatalities. From 1973 to 1997, 604 foodborne disease outbreaks were reported in U.S. schools, a median of 25 per year (Daniels et al., 2002). From 1990 to 1999, improper cooling was identified as a cause in five of 19 outbreaks in school foodservice operations (GAO, 2003). Inadequate or slow cooling of food prepared on school premises was ranked third of the top ten reported contributing causes in 16 of 298 school-associated foodborne outbreaks from 1998-2006 (Pogostin et al., 2008).

Cooling standards in the 2009 U.S. Food and Drug Administration (FDA) Food Code (hereafter referred to as the Food Code), section 3-501.14, specify that potentially hazardous cooked food shall be cooled within two hours from 135°F to 70°F and to 41°F or less within a total of six hours (FDA, 2009). The FDA considers cooling a critical control point, “a point or procedure in a specific food system where loss of control may result in an unacceptable health risk” (FDA, 2009). Section 3-501.15 of the Food Code outlines acceptable cooling methods based upon the type of food: placing food in shallow pans, portioning food into thinner or smaller amounts, using specialized equipment to cool food rapidly, stirring food in a container placed in an ice water bath, using containers that allow heat transfer, adding ice to the food product instead of water, or using other methods that facilitate the cooling process (FDA, 2009). Although the Food Code identifies methods for cooling, it neither specifies procedures for monitoring cooling nor does it provide guidelines for foodservice operators or inspectors to verify if cooling standards are met. Snyder and Labalestra (2004) indicated the Food Code cooling standards are difficult to achieve and that health departments do not conduct cooling studies to verify if cooling standards are met in retail foodservice.

Although rapid cooling of food is linked to preventing outbreaks of foodborne illness, previous studies reveal difficulty in cooling bulk foods in retail foodservice within Food Code cooling limits (Olds, Mendonca, Sneed, & Bisha, 2006; Olds & Sneed 2005; Snyder & Labalestra, 2004). Moreover, only limited information addresses which cooling methods can meet the Food Code standards in school foodservice operations.

Olds et al. (2006) explored the cooling of turkey roasts. Four cooling methods used in school foodservice operations were investigated: roast quartered, uncovered, and placed in a 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 cooling method tested in this study met the current Food Code standards.

Olds and Sneed (2005) explored cooling methods for chili 2 ½ and 4 inches deep in 10 x 12 inch stainless steel pans in both a walk-in refrigerator and a blast chiller, a three-gallon stockpot in a walk-in refrigerator, and with 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 placing the containers in a walk-in refrigerator and blast chiller, the doors remained closed during the entire cooling process. The only method that met the Food Code standard was the blast chiller, which cooled chili in both the 2 ½-inch and 4-inch pans within the recommended time. While blast chillers are effective for cooling food, only about 8% of schools kitchens have blast chillers (Krishnamurthy & Sneed, 2011).

Krishnamurthy and Sneed (2011) explored cooling practices in a national sample of schools. Of 411 usable responses, 78% of schools cooled food for reheating and subsequent service. Most (76%) school foodservice directors indicated that 2-inch counter pans were used for cooling food. Other respondents reported using 4-inch counter pans (39%), 6-inch counter pans (9%), and stockpots (6%), all of which extend the rate of cooling as food product depths increase. Only 37% of respondents reported using ice water baths, and 38% reported using chill sticks. Henroid and Sneed (2004) conducted food safety observations in 40 Iowa school foodservice operations to assess whether school foodservice was ready to implement Hazard Analysis and Critical Control Point (HACCP) systems. Of the 40 operations studied, no cooling was observed in 30 schools, and adequate rapid cooling methods were used in only three of the 10 operations where cooling was observed.

Schools present a unique environment for food production. The workday often ends shortly after lunch service, so monitoring product temperatures throughout the cooling process is difficult. Therefore, research on appropriate cooling methods for school foodservice operations is needed. The purpose of this research was to determine if typical practices used in school foodservice would sufficiently cool common foods to meet the standards established by the FDA. The research focused on specific cooling methods: placing uncovered products in a walk-in refrigerator, in a walk-in freezer, in a walk-in refrigerator with a chill stick, and in a walk-in refrigerator with an ice water bath.

Objectives

This study had two specific objectives:

1. Compare the effectiveness of cooling methods commonly used in school foodservice to determine if they meet 2009 Food Code standards.
2. Develop recommendations for school foodservice operators on best practices for cooling.

Materials and Methods

This section outlines the materials and methods utilized in this study. This includes a description of the products tested, explanations of the cooling procedures, and an outline of treatments for each product.

Products Tested

USDA school recipes, available online from the National Food Service Management Institute (NFSMI), were used to prepare food products (NFSMI, 2012). Four food products, Beef Taco (USDA Recipe #D-13), Chili con Carne with Beans (USDA Recipe #D-20), Steamed Rice (USDA Recipe #B-03) and Tomato Sauce, Meatless (USDA Recipe # G-07), were selected for the study because they are commonly used in schools (NFSMI, 2012). Copies of the recipes are in Appendix A. The Beef Taco, Chili Con Carne with Beans, and Tomato Sauce, Meatless recipes were prepared in a standard steam-jacketed kettle. The Steamed Rice recipe was prepared in a standard convection steamer. Both pieces of equipment are commonly used in school foodservice operations.

Cooling Procedures

A convenience sample of 15 school foodservice operators provided the operating capacity of commercial walk-in refrigerators and freezers used for cooling food in their schools. Foodservice operators indicated that, on average, approximately 80% of the available storage capacity of walk-in refrigerators and walk-in freezers was dedicated to regular food production (thus, 20% of the space was available for cooling). Walk-in refrigerators were operated on average at 39°F ± 1°F, and walk-in freezers were operated on average at 0°F ± 5°F. This study replicated both the average loads and temperatures.

Three replications were conducted for each cooling method tested, and three identically prepared and portioned food product samples were used in each replication. Tables 1, 2, and 3 present the types of cooling methods used for each product in this study. The mean cooling curves for each method and product tested in this study were determined. Prior studies reported that covered food products cooled more slowly than uncovered products (Olds et al., 2006; Krishnamurthy, et al., 2011). Based on these findings, all food products tested were left uncovered during cooling. Cooling times and temperatures were logged at 1-minute intervals during testing using Comark RF512 wireless temperature transmitters with a Comark RF500A wireless monitoring gateway (Comark Instruments, Beaverton, Oregon, U.S.A.). A Comark RFAX100D thermistor (Comark Instruments, Beaverton, Oregon, U.S.A.) was fixed in the geometric center of food products

Table 1. Cooling Treatments for Chili and Tomato Sauce

Pan Size (W x L x D)	**Product Depth**	**Cooling Methods**
12-inch x 20-inch x 2 ½-inch	2-inch	Walk-in refrigerator
		Walk-in freezer
		Ice water bath, in walk-in refrigerator[a]
12-inch x 20-inch x 4-inch	3-inch	Walk-in refrigerator
		Walk-in freezer
		Ice water bath, in walk-in refrigerator[b]
5 gallon Stockpot	3 gallon	Chill stick (64 oz)

[a]Pans of product were placed into 12-inch x 20-inch x 4-inch insert pans holding ice water that contacted the bottom of the hot pan completely.
[b]Pans of product were placed into 12-inch x 20-inch x 6-inch insert pans holding ice water that contacted the bottom of the hot pan completely.

Table 2. Cooling Treatments for Beef Taco Meat

Pan Size (W x L x D)	Product Depth	Cooling Methods
12-inch x 20-inch x 2 ½-inch	2-inch	Walk-in refrigerator
		Walk-in freezer
		Ice water bath, in walk-in refrigerator[a]
12-inch x 20-inch x 4-inch	3-inch	Walk-in refrigerator
		Walk-in freezer
		Ice water bath, in walk-in refrigerator[b]

[a]Pans of product were placed into 12-inch x 20-inch x 4-inch insert pans holding ice water that contacted the bottom of the hot pan completely.
[b]Pans of product were placed into 12-inch x 20-inch x 6-inch insert pans holding ice water that contacted the bottom of the hot pan completely.

Table 3. Cooling Treatments for Steamed Rice

Pan Size (W x L x D)	Product Depth	Cooling Methods
12-inch x 20-inch x 2 ½-inch	2-inch	Walk-in refrigerator
		Ice water bath, in walk-in refrigerator[a]
12-inch x 20-inch x 4-inch	3-inch	Walk-in refrigerator
		Ice water bath, in walk-in refrigerator[b]

[a]Pans of product were placed into 12-inch x 20-inch x 4-inch insert pans holding ice water that contacted the bottom of the hot pan completely.
[b]Pans of product were placed into 12-inch x 20-inch x 6-inch insert pans holding ice water that contacted the bottom of the hot pan completely.

tested in 12-inch x 20-inch stainless steel pans (Figure 1). Probes were fixed at 1-inch depths for food products tested at 2-inch depths and at 1 ½-inch depths for food tested at 3-inch depths.

Figure 1. Temperature Probes in Prepared Food Products

An insert pan containing an ice water bath was added for replicates using the ice water bath method. For ice water bath replicates, pans of food product were lowered into insert pans (12-inch x 20-inch x 4-inch insert pans for 2-inch cooling methods and 12-inch x 20-inch x 6-inch insert pans for 3-inch cooling methods). The insert pans contained ice water (2:1 cubed ice to cold water ratio), which covered the outside bottom and sides of the hot pans completely (Figure 2). Immediately following ice water bath insertion, replicates (food product pans with ice water bath insert pans) were placed in a walk-in refrigerator for the remainder of the cooling process.

Figure 2. Ice Water Bath Preparation

A 64 oz. chill stick/ice paddle (San Jamar® Rapi-Kool® Plus – model #RCU64V2, St. Paul, MN) was filled with tap water and frozen for 48 hours to test the cooling effectiveness. Three gallons of cooked food product (chili and tomato sauce only) were transferred to a stainless steel 5-gallon stockpot. The chill stick was then completely immersed into the center of the stockpot, perpendicular to the bottom of the stockpot (Figure 3). Two probes were placed on each side of the chill stick, equidistant from the sides of the stockpot and the sides of the chill stick in the center. The probes were positioned half way down into the product, equidistant from the bottom of the stockpot and the top of the product. The temperature readings from both probes were averaged to determine the cooling time of the product in the stockpot.

Figure 3. Chill Stick Positioning in Stockpot

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

For each replication, no more than four pans were placed in the walk-in refrigerator or freezer during testing (Figure 4). No other food production occurred during cooling, which is consistent with practices in schools. Once food products were placed in the walk-in refrigerator/freezer, doors were securely locked and remained closed until the cooling process concluded.

Figure 4. Chili Cooling in Walk-in Refrigerator

Results and Discussion

Cooling standards in the Food Code, section 3-501.14, state that cooked potentially hazardous food shall be cooled within two hours from 135°F to 70°F and within a total of six hours from 135°F to 41°F or less (FDA, 2009). To comply with the Food Code, both standards must be met. Mean cooling times for all cooling treatments tested are shown in Table 4. Aggregated cooling curves for chili, tomato sauce, beef taco meat, and steamed rice cooling treatments are in Appendix B.

The only cooling treatments for chili, tomato sauce, and beef taco meat that met both Food Code standards (cooked, potentially hazardous food cooled within two hours from 135°F to 70°F and within a total of six hours from 135°F to 41°F or less) were products cooled in a walk-in freezer at 2-inch depths. Steamed rice was not tested in a walk-in freezer because this cooling method is not commonly used for this product.

Table 4. Mean Time for Chili and Tomato Sauce to Cool from 135°F to 70°F and from 135°F to 41°F

Product	Product Depth	Cooling Methods	Mean Time (Hours:Minutes) ± SD[a] 135°F - 70°F	135°F - 41°F
FDA MODEL FOOD CODE (2009) RECOMMENDATION			**2:00**	**6:00**
Chili	2-inch	Walk-in freezer	1:47 ± 0:10	3:10 ± 0:21
		Ice water bath, walk-in refrigerator	1:04 ± 0:05	8:59 ± 1:38
		Walk-in refrigerator	3:09 ± 0:21	9:42 ± 1:22
	3-inch	Walk-in freezer	2:38 ± 0:13	4:50 ± 0:28
		Ice water bath, walk-in refrigerator	2:59 ± 0:15	16:33 ± 1:59
		Walk-in refrigerator	5:31 ± 0:35	16:30 ± 1:41
	3 gallon	Chill stick (64 oz)	4:41 ± 0:30	22:38 ± 2:44
Tomato Sauce	2-inch	Walk-in freezer	1:38 ± 0:13	2:58 ± 0:24
		Ice water bath, walk-in refrigerator	1:03 ± 0:11	7:02 ± 1:26
		Walk-in refrigerator	3:08 ± 0:17	9:25 ± 0:52
	3-inch	Walk-in freezer	2:52 ± 0:16	4:58 ± 0:24
		Ice water bath, walk-in refrigerator	2:33 ± 0:18	14:37 ± 1:59
		Walk-in refrigerator	4:46 ± 0:14	14:16 ± 1:16
	3 gallon	Chill stick (64 oz)	4:28 ± 0:40	20:28 ± 2:38
Beef Taco Meat	2-inch	Walk-in freezer	1:47 ± 0:14	3:19 ± 0:24
		Ice water bath, walk-in refrigerator	1:05 ± 0:06	7:30 ± 1:34
		Walk-in refrigerator	3:01 ± 0:18	9:19 ± 1:01
	3-inch	Walk-in freezer	3:04 ± 0:19	5:22 ± 0:31
		Ice water bath, walk-in refrigerator	3:00 ± 0:17	15:48 ± 1:08
		Walk-in refrigerator	4:55 ± 0:14	15:24 ± 0:34
Steamed Rice	2-inch	Ice water bath, walk-in refrigerator	1:04 ± 0:05	3:04 ± 0:13
		Walk-in refrigerator	3:18 ± 0:17	9:55 ± 0:53
	3-inch	Ice water bath, walk-in refrigerator	2:02 ± 0:11	7:11 ± 1:15
		Walk-in refrigerator	4:32 ± 0:18	13:37 ± 0:40

[a]Standard Deviation

Please note: Those products highlighted in yellow achieved both of the FDA recommended cooling benchmarks.

Chili, tomato sauce, and beef taco meat cooled at 2-inch depths using an ice water bath in a walk-in refrigerator all cooled from 135°F to 70°F within two hours, but failed to cool further to 41°F within a total of six hours. However, steamed rice at a 2-inch depth met both Food Code cooling standards using an ice water bath in a walk-in refrigerator.

Chili, tomato sauce, and beef taco meat cooled in the walk-in freezer at a 3-inch depth failed to meet the first Food Code standard of 135°F to 70°F within two hours but did cool from 135°F to 41°F within the required six hours. None of the cooling treatments tested at 3-inch depths met both Food Code cooling standards.

Food products cooled at 2-inch depths in the walk-in refrigerator cooled more quickly than the same products cooled at 3-inch depths in the walk-in refrigerator. No cooling treatment tested in the walk-in refrigerator at either 2-inch or 3-inch depths met either Food Code cooling standard. The FDA recommends reducing the volume of the product being cooled to improve the cooling process, but even so, cooling even at 2-inch depths in the refrigerator did not meet the Food Code standards.

Chili cooled at 3-inch depth in an ice water bath in a walk-in refrigerator required the longest cooling time (16 hours and 33 minutes ± 1 hour and 59 minutes). This product required longer than the same 3-inch depth of chili in a walk-in refrigerator without the ice water bath. The use of an ice water bath increased the cooling rate of chili from 135°F to 70°F, but once the ice had melted, the additional volume of warmed water actually inhibited cooling; the same product tested in the walk-in refrigerator without an ice water bath at the same 3-inch depth cooled more quickly overall. An ice water bath should speed the cooling process, but if the ice water is not renewed, it can actually increase cooling time.

The treatment with the longest total cooling time involved using the chill stick in a walk-in refrigerator to cool 3 gallons of chili. Total cooling time for the chili was 22 hours and 30 minutes ± 1 hour and 41 minutes. Tomato sauce (3 gallons) cooled with a chill stick in a walk-in refrigerator took 20 hours and 28 minutes ± 2 hour and 38 minutes, which was the second-longest cooling time observed in this study. Olds and Sneed (2005) found chill sticks did significantly speed cooling of chili in 3-gallon stockpots. However, in that study, chill sticks were actively checked every 20 minutes throughout the cooling process, and when the ice in the chill stick had melted, it was replaced with a new chill stick. Chill sticks are designed to reduce the temperature at the beginning of the cooling process but should not be left in the product for extended periods with no movement. Because this study was designed to simulate operational practices that may be used in school foodservice operations, the chill stick remained in the product throughout the cooling process. Once the chill stick warmed up to the temperature of the product, it no longer cooled the product; moreover, the melted ice added volume to the product.

Conclusions and Recommendations

This section presents the conclusions drawn from this study and practical recommendations for school foodservice operators and regulators.

Section 3-501.15 of the Food Code recommends reducing the volume of the product being cooled to help products cool more quickly. However, these results indicate that even reducing the volume failed to help meet Food Code standards for food products cooled in the walk-in refrigerator. Refrigeration space is limited in most foodservice operations, so reducing food to an appropriate cooling volume is a serious challenge. Blast chillers can cool foods to Food Code standards (Olds & Sneed, 2005). However, Krishnamurthy and Sneed (2011) found that only 8% of schools had blast chillers available even though 78% of school foodservice operations cool leftovers, reheat them, and serve them at subsequent meals. We recommend that federal and state agency personnel encourage using blast chillers in high volume operations, which includes school foodservice, for cooling foods. Blast chillers cost a minimum of $5,500, however, posing a financial challenge to many school foodservice operations.

Based on our study, cooling foods in a 2-inch deep pan in a freezer may be a feasible alternative to a blast chiller, although freezer methods have their own practical limitations. Food may be needed for next day service, for instance, or the quality of rethermalized foods may be affected. Additionally, many retail foodservice operations have limited freezer storage space. Steamed rice, of course, can be cooled rapidly at 2-inch depths using an ice water bath in a walk-in refrigerator.

School foodservice operators may feel that chill sticks provide additional safeguards against foodborne illness outbreaks. However, our research suggests that passive chill stick use actually increases the cooling time of both products tested. Using a chill stick requires that employees monitor food products during cooling, stir the product with a chill stick, and replace the chill stick once the ice has melted.

Many schools are evaluating the nutritional quality of preprocessed food items as they consider a transition to scratch cooking, but preparing food in-house means that food safety issues like cooling may become more important. Because of this, Food Code cooling guidelines and recommendations should be updated to be more specific and clear.

One area requiring further research involves the common practice of tightly wrapping foods for storage in school foodservice operations. Future research could compare the effects of covering foods during the cooling process as well as explore the cooling of other food products.

Experimental evidence is needed to support the validity of FDA Food Code cooling standards and the overall effect on food safety. The results of this study show it is extremely difficult to cool foods to meet the standards. Food Code standards for time and temperature could be validated for microbiological growth of pathogens in environments that more closely simulate quantity food production in school foodservice operations. This research could determine if the FDA Food Code standards could add more time to the cooling process with little to no impact on bacterial growth and foodborne illness outbreaks.

Best Practice Recommendations

Based on the research literature and findings from this study, the following best practices are suggested for school foodservice:

- Recommend the purchase and use of blast chillers for any school that will be cooling high volumes of food.

- Cool products uncovered when possible, while ensuring that cross-contamination does not occur. If food must be covered, place it directly on the food product to eliminate the air layer between the food and the covering.
- Cool food products in the freezer when freezer space is available.
- Place food in counter pans 2 inches deep or less.
- Use active cooling methods such as ice water baths or chill sticks to speed cooling.
- Add or replace ice in ice water baths or chill sticks as it melts.
- Monitor and document temperatures during the cooling process.
- Take corrective actions if cooling does not meet the Food Code standards.

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APPENDIX A: USDA Recipes Tested

Beef or Pork Taco

Meat/Meat Alternate-Vegetable-Grains/Breads | Main Dishes | D-13

Ingredients	50 Servings		100 Servings		Directions
	Weight	Measure	Weight	Measure	
Raw ground beef (no more than 20% fat) OR Raw ground pork (no more than 20% fat)	6 lb 6 oz		12 lb 12 oz		1. Brown ground beef or pork. Drain. Continue immediately.
*Fresh onions, chopped OR Dehydrated onions	5 oz OR 1 oz	¾ cup 2 Tbsp OR ½ cup	10 oz OR 2 oz	1 ¾ cups OR 1 cup	2. Add onions, granulated garlic, pepper, tomato paste, water, and seasonings. Blend well. Bring to boil. Reduce heat and simmer for 25-30 minutes. Stir periodically. CCP: Heat to 155 ° F for at least 15 seconds.
					3. CCP: Hold for hot service at 135° F or higher.
Granulated garlic		1 Tbsp 1 ½ tsp		3 Tbsp	
Ground black or white pepper		2 tsp		1 Tbsp 1 tsp	
Canned tomato paste	14 oz	1 ½ cups 1 Tbsp (⅙ No. 10 can)	1 lb 12 oz	3 cups 2 Tbsp (¼ No. 10 can)	
Water		1 qt		2 qt	
†Seasonings Chili powder Ground cumin Paprika Onion powder		 2 Tbsp 1 Tbsp 1 ½ tsp 1 ½ tsp 1 ½ tsp		 ¼ cup 3 Tbsp 1 Tbsp 1 Tbsp	
Reduced fat Cheddar cheese, shredded	1 lb 10 oz	1 qt 2 ½ cups	3 lb 4 oz	3 qt 1 cup	4. For topping: Set cheese aside for step 5. Combine lettuce and tomatoes. Toss lightly. Set mixture aside for step 5.
*Fresh lettuce, shredded	2 lb 7 oz	1 gal 2 cups	4 lb 14 oz	2 gal 1 qt	
*Fresh tomatoes, chopped	1 lb 5 oz	2 ¾ cups 2 Tbsp	2 lb 10 oz	1 qt 1 ¾ cups	
Enriched taco shells (at least 0.45 oz each)		100 each		200 each	5. Serving suggestions (2 tacos per serving) A. Before serving or on serving line, fill each taco shell with a No. 30 scoop (2 Tbsp) meat mixture. On each student tray, serve 2 tacos, No. 10 scoop (⅜ cup) lettuce and tomato mixture, and ½ oz (2 Tbsp) shredded cheese. OR B.1. Preportion No. 10 scoop (⅜ cup) lettuce and tomato mixture and ½ oz (2 Tbsp) shredded cheese into individual soufflé cups. Refrigerate until

Beef or Pork Taco

Meat/Meat Alternate-Vegetable-Grains/Breads | Main Dishes | D-13

service.
B.2. Transfer meat mixture and taco shells to steamtable pans. On each student tray, serve 2 unfilled taco shells, 2 No. 30 scoops (¼ cup ½ tsp) meat mixture, with preportioned lettuce and tomato mixture and preportioned cheese. Instruct students to "build" their own tacos.

Comments:
*See Marketing Guide.

†Mexican Seasoning Mix (see G-01A, Sauces, Gravies, and Seasoning Mixes) may be used to replace these ingredients. For 50 servings, use ¼ cup 1 ½ tsp Mexican Seasoning Mix. For 100 servings, use ½ cup 1 Tbsp Mexican seasoning Mix.

Marketing Guide for Selected Items		
Food as Purchased for	50 Servings	100 Servings
Mature onions	6 oz	12 oz
Head lettuce	3 lb 4 oz	6 lb 8 oz
Tomatoes	1 lb 9 oz	3 lb 2 oz

SERVING:	YIELD:		VOLUME:	
2 tacos provide 2 oz equivalent meat/meat alternate, ½ cup of vegetable, and 1 serving of grains/breads.	**50 Servings:**	about 7 lb 4 oz (filling) about 15 lb 10 oz	**50 Servings:**	3 quarts 1 ⅓ cups (filling) 100 tacos
	100 Servings:	about 14 lb 8 oz (filing) about 31 lb 4 oz	**100 Servings:**	1 ½ gallons 2 ⅔ cups (filling) 200 tacos

Tested 2004

Beef or Pork Taco

Meat/Meat Alternate-Vegetable-Grains/Breads | Main Dishes | D-13

Nutrients Per Serving

Calories	299	**Saturated Fat**	5.80 g	**Iron**	2.43 mg
Protein	18.26 g	**Cholesterol**	46 mg	**Calcium**	200 mg
Carbohydrate	20.36 g	**Vitamin A**	600 IU	**Sodium**	253 mg
Total Fat	16.36 g	**Vitamin C**	8.2 mg	**Dietary Fiber**	3.0 g

Chili con Carne with Beans

Meat/Meat Alternate-Vegetable | Main Dishes | D-20

Ingredients	50 Servings		100 Servings		Directions
	Weight	Measure	Weight	Measure	
Raw ground beef (no more than 20% fat)	7 lb		14 lb		1. Brown ground beef. Drain. Continue immediately.
*Fresh onions, chopped OR Dehydrated onions	14 oz OR 2 ½ oz	2 ⅓ cups OR 1 ¼ cups	1 lb 12 oz OR 5 oz	1 qt ⅔ cup OR 2 ½ cups	2. Add onions, granulated garlic, green pepper (optional), pepper, chili powder, paprika, onion powder, and ground cumin. Cook for 5 minutes.
Granulated garlic		1 Tbsp 1 ½ tsp		3 Tbsp	
*Fresh green pepper, chopped (optional)	8 oz	1 ½ cups 2 Tbsp	1 lb	3 ¼ cups	
Ground black or white pepper		2 tsp		1 Tbsp 1 tsp	
Chili powder		3 Tbsp		¼ cup 2 Tbsp	
Paprika		1 Tbsp		2 Tbsp	
Onion powder		1 Tbsp		2 Tbsp	
Ground cumin	1 oz	¼ cup	2 oz	½ cup	
Canned diced tomatoes, with juice	3 lb 3 oz	1 qt 2 ¼ cups (½ No. 10 can)	6 lb 6 oz	3 qt ½ cup (1 No. 10 can)	3. Stir in tomatoes, water, and tomato paste; mix well. Bring to boil. Reduce heat. Cover. Simmer slowly, stirring occasionally until thickened, about 40 minutes.
Water		2 qt 1 cup		1 gal 2 cups	
Canned tomato paste	1 lb 12 oz	3 cups 2 Tbsp (¾ No. 10 can)	3 lb 8 oz	1 qt 2 ¼ cups (½ No. 10 can)	
Canned pinto or kidney beans, drained OR *Dry pinto or kidney beans, cooked (see Special Tip)	3 lb 6 oz OR 2 lb 4 oz	1 qt 3 ½ cups (½ No. 10 can) OR 1 qt 2 cups	6 lb 12 oz OR 4 lb 8 oz	3 qt 3 cups (1 No. 10 can) OR 3 qt	4. Stir in beans. Cover and simmer. Stir occasionally. CCP: Heat to 155° F or higher for 15 seconds. OR If using previously cooked and chilled beans: CCP: Heat to 165° F or higher for at least 15 seconds.
					5. Pour into serving pans.
					6. CCP: Hold for hot service at 135° F or higher. Portion with 4 oz ladle (½ cup).
Reduced fat Cheddar cheese, shredded (optional)	1 lb 8 oz	1 qt 2 cups	3 lb	3 qt	7. Garnish with cheese (optional).

Chili con Carne with Beans

Meat/Meat Alternate-Vegetable | Main Dishes | D-20

Comments:
*See Marketing Guide.

Marketing Guide for Selected Items		
Food as Purchased for	50 Servings	100 Servings
Mature onions	1 lb	2 lb
Green peppers	11 oz	1 lb 6 oz
Dry pinto beans, dry OR Dry kidney beans	1 lb OR 1 lb	2 lb OR 2 lb

SERVING:	YIELD:	VOLUME:
½ cup (4 oz ladle) provides 2 oz equivalent meat/meat alternate and ⅜ cup of vegetable.	**50 Servings:** about 16 lb 4 oz	**50 Servings:** about 1 gallons 2 ¼ quarts
	100 Servings: about 32 lb 8 oz	**100 Servings:** about 3 gallons 2 cups

Tested 2004

Special Tip:
SOAKING BEANS
Overnight method: Add 1 ¾ qt cold water to every 1 lb of dry beans. Cover and refrigerate overnight. Discard the water. Proceed with recipe.

Quick-soak method: Boil 1 ¾ qt of water for each 1 lb of dry beans. Add beans and boil for 2 minutes. Remove from heat and allow to soak for 1 hour. Discard the water. Proceed with recipe.

COOKING BEANS
Once the beans have been soaked, add ½ tsp salt for every lb of dry beans. Boil gently with lid tilted until tender, about 2 hours.

Use hot beans immediately.
CCP: Hold for hot service at 135° F.
OR
Or, chill for later use.
CCP: Cool to 70° F within 2 hours and to 41° F or lower within an additional 4 hours.

1 lb dry pinto beans = about 2 ⅜ cups dry or 5 ¼ cups cooked beans.

Variation:
A. Chili con Carne without Beans

50 servings: In step 1, use 8 lb 10 oz raw ground beef. Continue with steps 2 and 3. In step 4, omit pinto or kidney beans. Continue with steps 5 - 7.

100 servings: In step 1, use 17 lb 4 oz raw ground beef. Continue with steps 2 and 3. In step 4, omit pinto or kidney beans. Continue with steps 5 -7.

Chili con Carne with Beans

Meat/Meat Alternate-Vegetable | Main Dishes | D-20

1 lb dry kidney beans = about 2 ½ cups dry or 6 ¼ cups cooked beans.

Nutrients Per Serving

Calories	180	**Saturated Fat**	3.57 g	**Iron**	2.71 mg
Protein	15.44 g	**Cholesterol**	42 mg	**Calcium**	46 mg
Carbohydrate	10.68 g	**Vitamin A**	813 IU	**Sodium**	204 mg
Total Fat	8.58 g	**Vitamin C**	14.5 mg	**Dietary Fiber**	2.5 g

Cooking Rice (Oven or Steamer)

Grains/Breads Grains/Breads B-03

Ingredients	50 Servings		100 Servings		Directions
	Weight	Measure	Weight	Measure	
					1. Do not rinse enriched rice.
Enriched white rice, medium grain, regular OR Enriched white rice, long grain, regular OR Enriched white rice, long grain, parboiled	3 lb 12 oz OR 3 lb 6 oz OR 3 lb 10 oz	2 qt ½ cup OR 2 qt OR 2 qt 1 ¼ cups	7 lb 8 oz OR 6 lb 12 oz OR 7 lb 4 oz	1 gal 1 cup OR 1 gal OR 1 gal 2 ½ cups	2. Place 1 lb 14 oz medium grain, or 1 lb 11 oz long grain, or 1 lb 13 oz par boiled rice in each steamtable pan (12" x 20" x 2 ½"). For 50 servings, use 2 pans. For 100 servings, use 4 pans.
Water, boiling		3 qt		1 gal 2 qt	3. Add salt to boiling water. Pour water over rice. (1 qt 2 cups per steamtable pan).
Salt		2 tsp		1 Tbsp 1 tsp	
					4. Cover pans tightly.
					5. Bake: Conventional oven: 350° F for 30 minutes Convection oven: 325° F for 30 minutes Steamer: 5 lb pressure for 25 minutes
					6. Remove from oven or steamer.
					7. CCP: Hold for hot service at 135° F or higher. OR CCP: Cool to 70° F within 2 hours and from 70° F to 41° F or lower within an additional 4 hours. Portion with No. 8 scoop (½ cup).

SERVING:	YIELD:	VOLUME:
½ cup (No. 8 scoop) provides 1 serving of grains/breads.	**50 Servings:** 2 steamtable pans	**50 Servings:** about 1 gallons 2 ¼ quarts
	100 Servings: 4 steamtable pans	**100 Servings:** about 3 gallons 2 cups

Tested 2004, Tested 2007

Cooking Rice (Oven or Steamer)

Grains/Breads | Grains/Breads | B-03

Special Tip:
Cooking Brown Rice, long grain, regular

For 50 Servings, use 3 lb 2 oz brown rice and 1 gal 3 ½ cups boiling water and 2 tsp salt. Place 1 lb 9 oz of rice and 2 qt 1 ¾ cups of water in each steamtable pan (12" x 20" x 2 ½"). Use 2 pans. Cover and bake at 350° F or steam at 5 lb pressure for 50 minutes.

For 100 servings, use 6 lb 4 oz brown rice and 2 gal 1 ¾ qt boiling water and 1 Tbsp 1 tsp salt. Place 1 lb 9 oz of rice and 2 qt 1 ¾ cups of water in each steamtable pan (12" x 20" x 2 ½"). Use 4 pans. Cover and bake at 350° F or steam at 5 lb pressure for 50 minutes.

Tomato Sauce (Meatless)

Sauces, Gravies, and Seasoning Mixes G-07

Ingredients	1 Quart		1 Gallon		Directions
	Weight	Measure	Weight	Measure	
Vegetable oil		2 ¼ tsp		3 Tbsp	1. Heat oil. Add onions and cook approximately 5 minutes.
*Fresh onions, chopped OR Dehydrated onions	3 ½ oz	½ cup 1 Tbsp OR ¼ cup 1 Tbsp	13 ½ oz OR 2 ½ oz	2 ¼ cups OR 1 ¼ cups	
Canned tomato paste	9 ¼ oz	1 cup	2 lb 5 oz	1qt (½ No. 10 can)	2. Add tomato paste, canned tomatoes, water, pepper, parsley, granulated garlic, and seasonings. Mix well and bring to boil. Reduce heat and simmer, uncovered, 25-30 minutes. CCP: Heat to 140° F or higher.
Canned diced tomatoes, with juice	1 lb 9 ½ oz	3 cups 1 Tbsp (¾ No. 10 can)	6 lb 6 oz	3 qt ¼ cup (1 No. 10 can)	
Water		½ cup		2 cups	
Ground black or white pepper		⅛ tsp		½ tsp	
Dried parsley		1 Tbsp		¼ cup	
Granulated garlic		2 ¼ tsp		1 Tbsp	
†Seasonings Dried basil Dried oregano Dried marjoram Dried thyme		 ¼ tsp ¼ tsp ⅛ tsp pinch		 1 tsp 1 tsp ¾ tsp ¼ tsp	
					3. CCP: Hold for hot service at 135° F or higher. Serve over Meat Loaf (see D-27), Meat Balls (see D- 27A), or Salisbury Steak (see D-33).

Comments:
*See Marketing Guide.
†Italian Seasoning Mix (see G-01, Sauces, Gravies, and Seasoning Mixes) may be used to replace these ingredients. For 1 quart, use ¾ tsp Italian Seasoning Mix. For 1 gallon, use 1 Tbsp Italian Seasoning Mix.

Marketing Guide for Selected Items		
Food as Purchased for	1 Quart	1 Gallon
Mature onions	4 oz	1 lb

Tomato Sauce (Meatless)

Sauces, Gravies, and Seasoning Mixes G-07

SERVING:	YIELD:		VOLUME:	
2 Tbsp (1 oz ladle).	**1 Quart:**	32 2 Tbsp servings	**1 Quart:**	about 1 quart
	1 Gallon:	128 2 Tbsp servings	**1 Gallon:**	about 1 gallon

Tested 2004

Nutrients Per Serving					
Calories	16	**Saturated Fat**	0.05 g	**Iron**	0.36 mg
Protein	0.56 g	**Cholesterol**	0 mg	**Calcium**	11 mg
Carbohydrate	3.01 g	**Vitamin A**	347 IU	**Sodium**	37 mg
Total Fat	0.38 g	**Vitamin C**	8.1 mg	**Dietary Fiber**	0.7 g

APPENDIX B: Product Cooling Curves

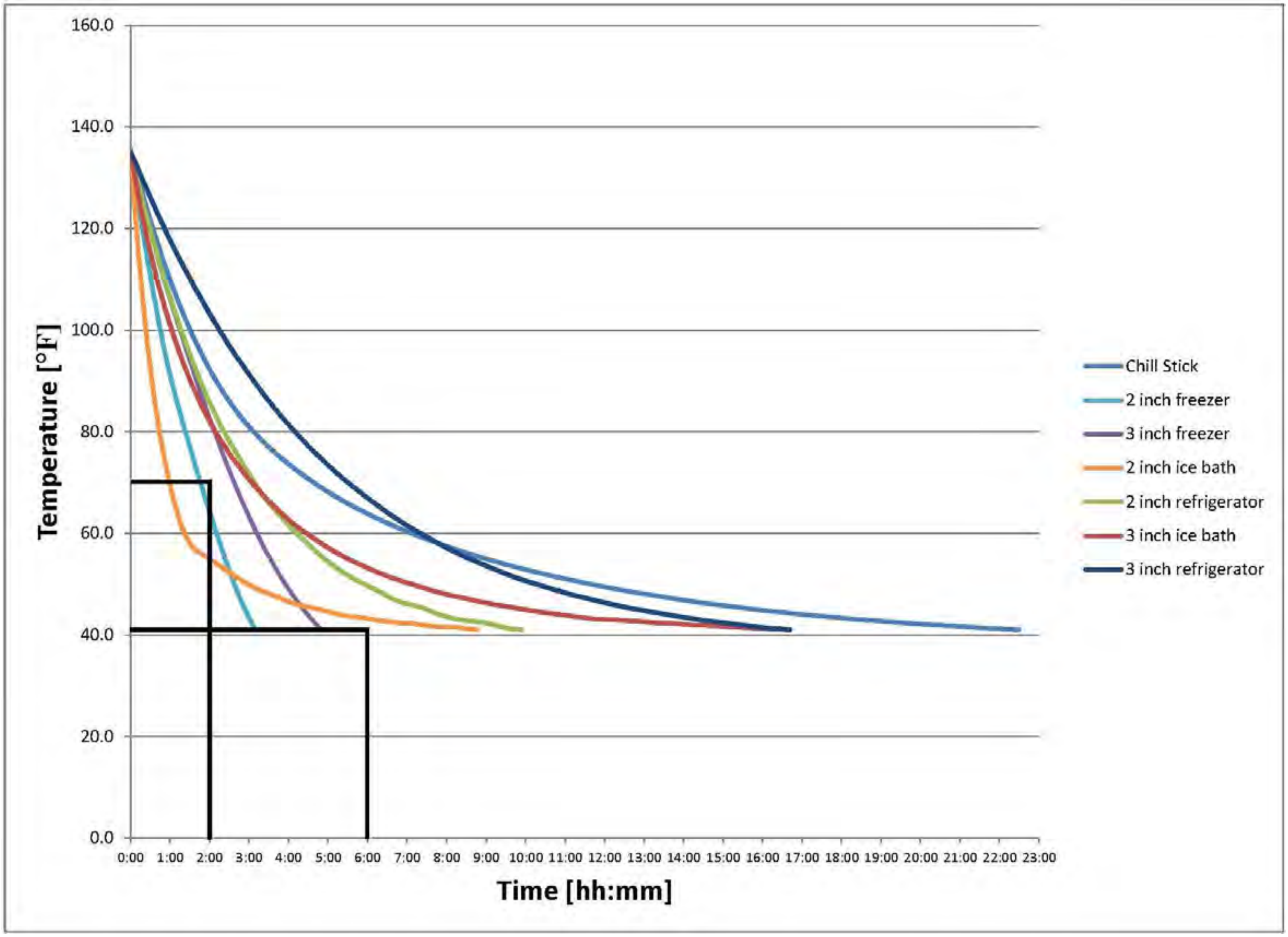

Figure 5. Cooling Curves for Chili

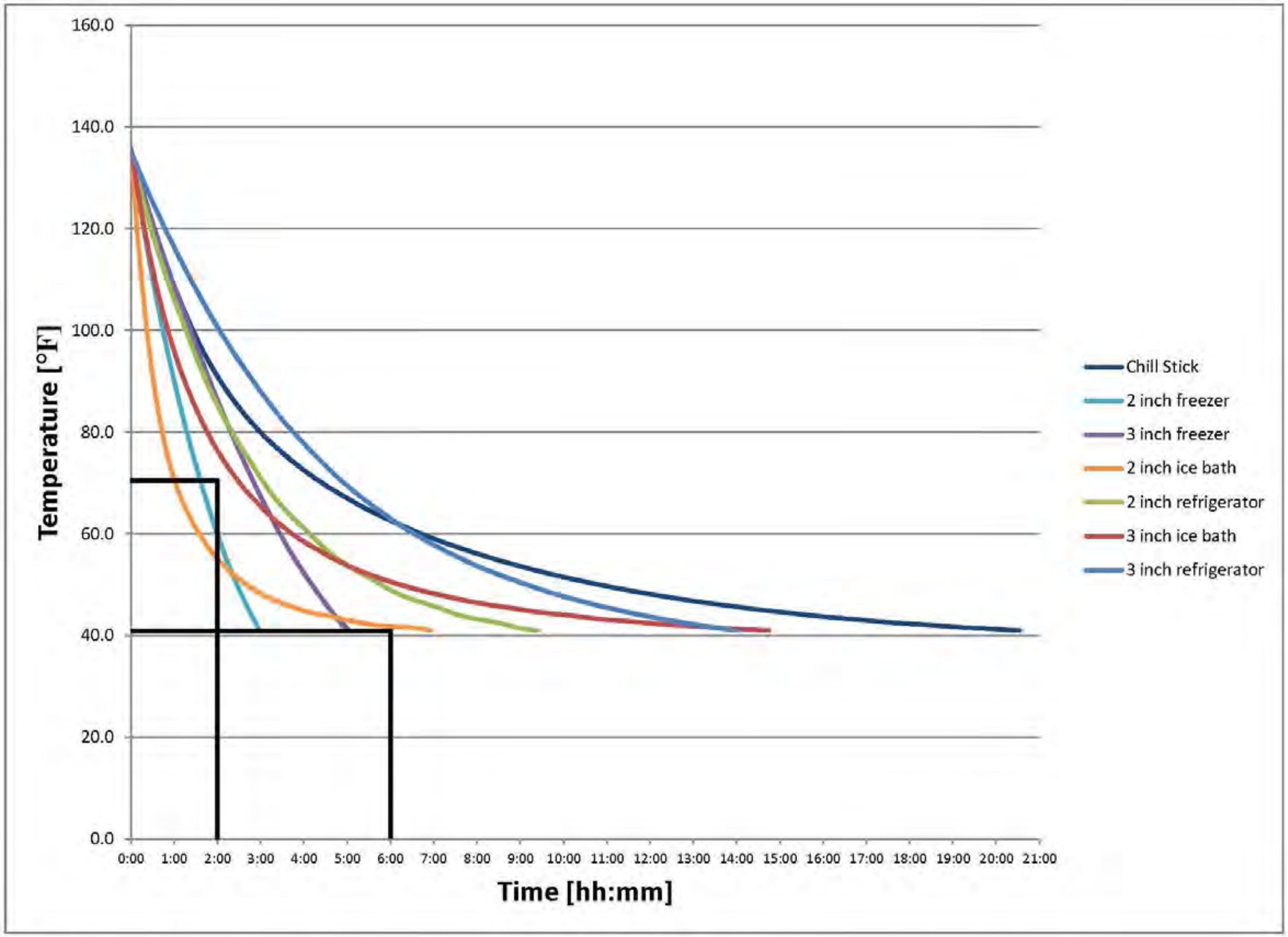

Figure 6. Cooling Curves for Tomato Sauce (Meatless)

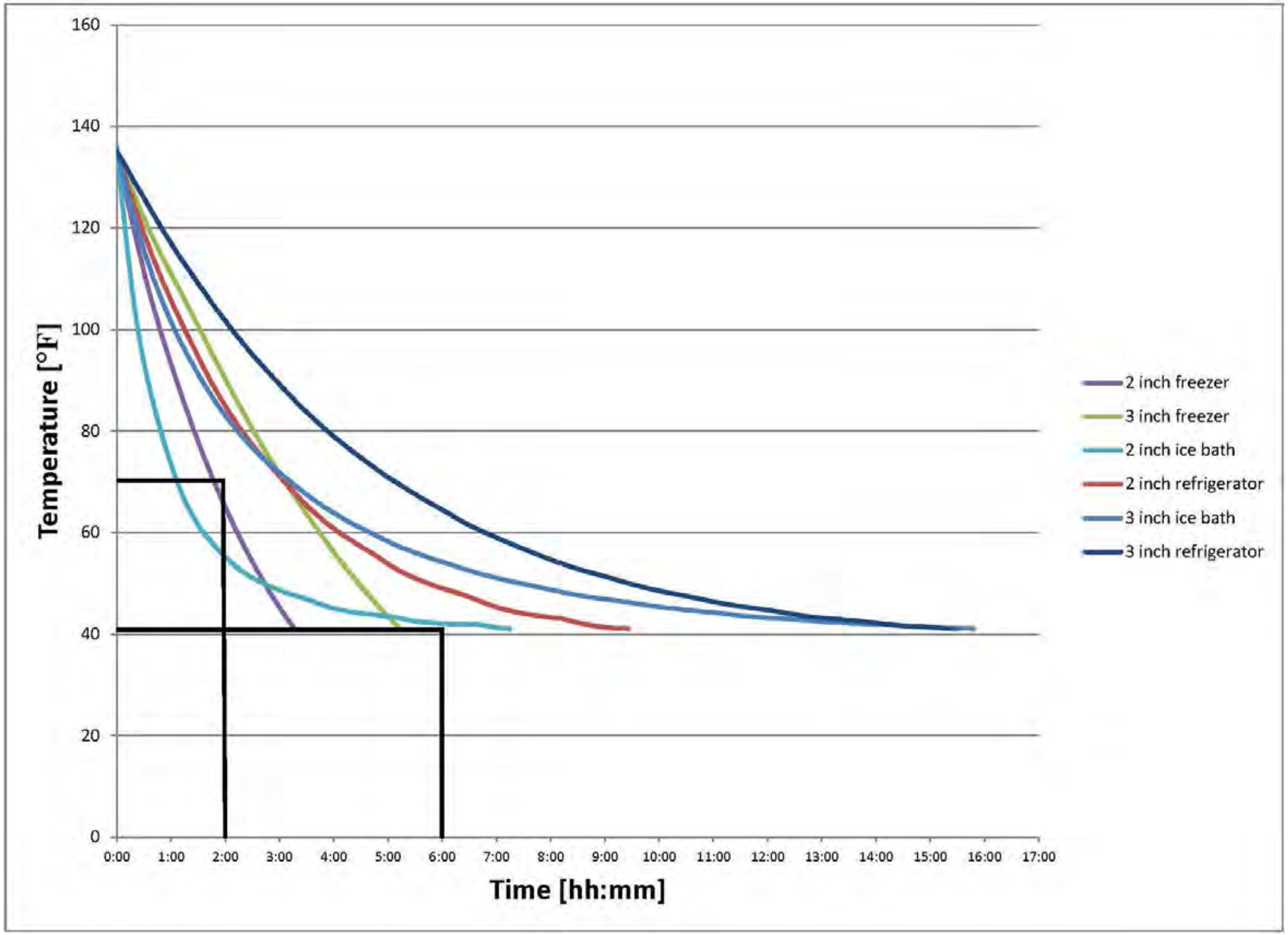

Figure 7. Cooling Curves for Beef Taco Meat

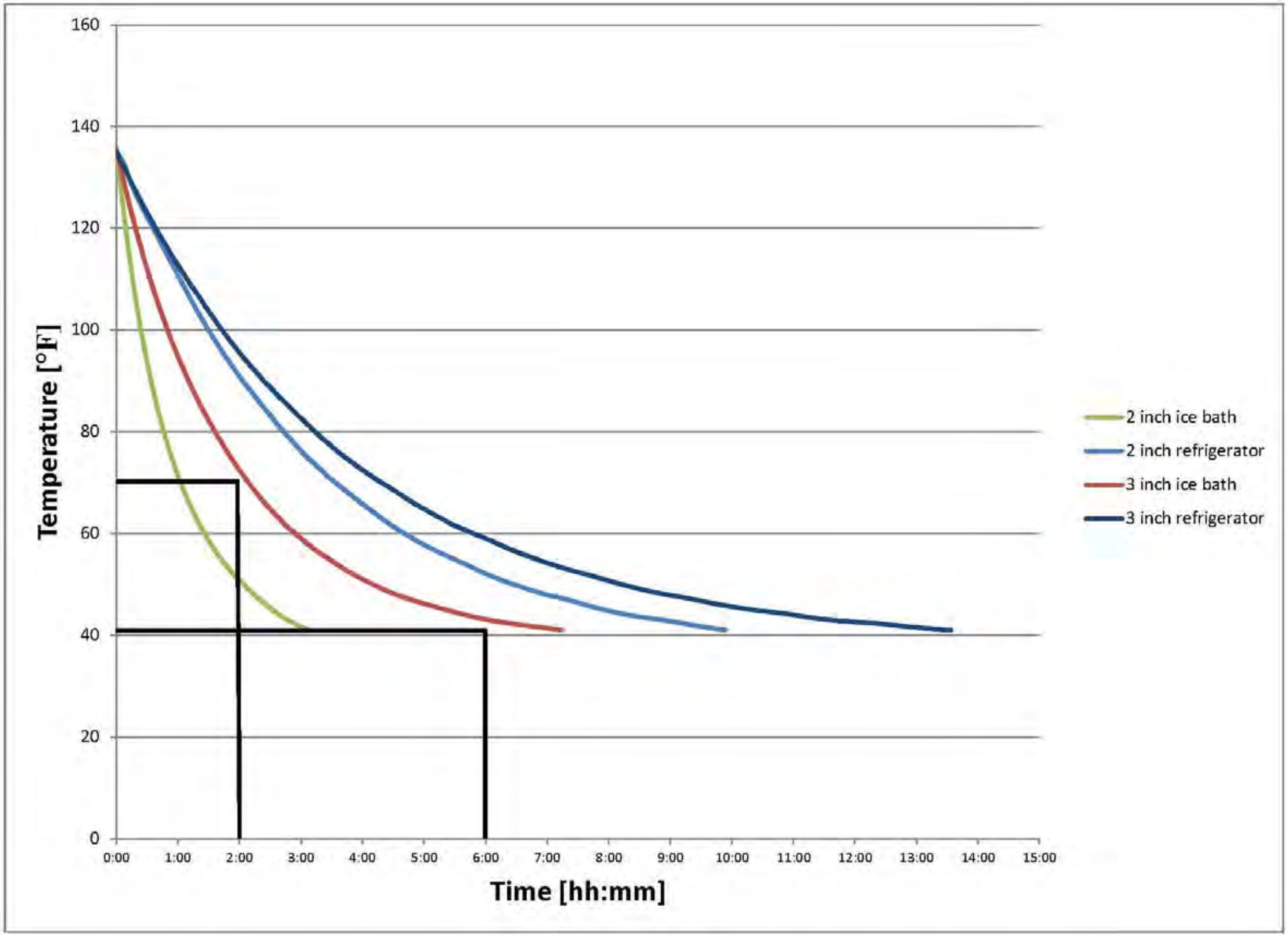

Figure 8. Cooling Curves for Steamed Rice

APPENDIX C: Detailed Descriptions of Cooling Methods/Treatments for Each Recipe

Beef or Pork Taco (USDA Recipe #D-13)

1. Recipe ingredients were procured from retail food suppliers, such as superstore chains and local grocery stores.

2. Beef taco meat was prepared per the USDA recipe in a 40-gallon Groen™ DLT-40 Tilting Steam Jacketed Kettle (Unified Brands, Jackson, Mississippi). Dehydrated onions (instead of fresh onions) and 80% ground beef were used in all beef taco meat prepared for testing. The additional toppings (cheese, lettuce, tomatoes) and taco shells included in the recipe were not prepared or used for testing.

3. Upon completion of cooking, taco meat was transferred quickly into 12-inch x 20-inch x 2 ½-inch stainless steel pans (for 2-inch product depths) or 12-inch x 20-inch x 4-inch stainless steel pans (for 3 inch product depths), depending on the selected cooling treatment. All taco meat tested was left uncovered during cooling. Cooling times and temperatures were logged at 1-minute intervals during testing using Comark RF512 wireless temperature transmitters with a Comark RF500A wireless monitoring gateway (Comark Instruments, Beaverton, Oregon, U.S.A.). A Comark RFAX100D thermistor probe (Comark Instruments, Beaverton, Oregon, U.S.A.) was fixed in the geometric center of food products tested in 12-inch x 20-inch stainless steel pans.

4. Probes were fixed at 1-inch depths for taco meat tested at 2-inch product depths and at 1 ½-inch depths for taco meat tested at 3-inch depths. Three replications were conducted for each cooling method tested and three identically prepared and portioned food product samples were used in each replication.

Chili con Carne with Beans (USDA Recipe #D-20)

1. Recipe ingredients were procured from retail food suppliers, such as superstore chains and local grocery stores.

2. Chili was prepared per the USDA recipe in a 40-gallon Groen™ DLT-40 Tilting Steam Jacketed Kettle (Unified Brands, Jackson, Mississippi).

3. Upon completion of cooking, chili was transferred quickly into 12-inch x 20-inch x 2 ½-inch stainless steel pans (for 2-inch product depths) or 12-inch x 20-inch x 4-inch stainless steel pans (for 3 inch product depths), or 5 gallon stockpots (with 3 gallons of product), depending on the selected cooling treatment. All chili tested was left uncovered during cooling. Cooling times and temperatures were logged at 1-minute intervals during testing using Comark RF512 wireless temperature transmitters with a Comark RF500A wireless monitoring gateway (Comark Instruments, Beaverton, Oregon, U.S.A.). A Comark RFAX100D thermistor probe (Comark Instruments, Beaverton, Oregon, U.S.A.) was fixed in the geometric center of chili tested in 12-inch x 20-inch stainless steel pans.

4. Probes were fixed at 1-inch depths for chili tested at 2-inch product depths and at 1 ½-inch depths for chili tested at 3-inch depths. Three replications were conducted for each cooling method tested and three identically prepared and portioned food product samples were used in each replication.

5. A 64 oz. chill stick/ice paddle (San Jamar® Rapi-Kool® Plus – model #RCU64V2, St. Paul, MN) was filled with tap water and frozen for 48 hours until it was solid. Three gallons of chili were transferred to a stainless steel 5-gallon stock pot. The chill stick was then completely immersed into the chili in 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 down into the chili, equidistant from the bottom of the stockpot and the top of the food product. The temperature readings from both probes were then averaged to determine the cooling time of the product in the stockpot.

Cooking Rice (USDA Recipe #B-03)

1. Recipe ingredients were procured from retail food suppliers, such as superstore chains and local grocery stores.

2. Rice was prepared in a Cleveland SteamCraft® Gemini™ Short Series Pressureless Steamer, Model 24CGA6.2S (Cleveland Range, LLC, Cleveland, Ohio).

3. Upon completion of cooking, rice was transferred quickly into 12-inch x 20-inch x 2 ½-inch stainless steel pans (for 2-inch product depths) or 12-inch x 20-inch x 4-inch stainless steel pans (for 3 inch product depths), depending on the selected cooling treatment. All rice tested was left uncovered during cooling. Cooling times and temperatures were logged at 1-minute intervals during testing using Comark RF512 wireless temperature transmitters with a Comark RF500A wireless monitoring gateway (Comark Instruments, Beaverton, Oregon, U.S.A.). A Comark RFAX100D thermistor probe (Comark Instruments, Beaverton, Oregon, U.S.A.) was fixed in the geometric center of rice tested in 12-inch x 20-inch stainless steel pans.

4. Probes were fixed at 1-inch depths for rice tested at 2-inch product depths and at 1 ½-inch depths for rice tested at 3-inch depths. Three replications were conducted for each cooling method tested and three identically prepared and portioned food product samples were used in each replication.

Tomato Sauce, Meatless (USDA Recipe # G-07)

1. Recipe ingredients were procured from retail food suppliers, such as superstore chains and local grocery stores.

2. Tomato sauce was prepared per the USDA recipe in a 40-gallon Groen™ DLT-40 Tilting Steam Jacketed Kettle (Unified Brands, Jackson, Mississippi).

3. Upon completion of cooking, tomato sauce was transferred quickly into 12-inch x 20-inch x 2 ½-inch stainless steel pans (for 2-inch product depths) or 12-inch x 20-inch x 4-inch stainless steel pans (for 3 inch product depths), or 5 gallon stockpots (with 3 gallons of product), depending on the selected cooling treatment. All tomato sauce tested was left uncovered during cooling. Cooling times and temperatures were logged at 1-minute intervals during testing using Comark RF512 wireless temperature transmitters with a Comark RF500A wireless monitoring gateway (Comark Instruments, Beaverton, Oregon, U.S.A.). A Comark RFAX100D thermistor probe (Comark Instruments, Beaverton, Oregon, U.S.A.) was fixed in the geometric center of tomato sauce tested in 12-inch x 20-inch stainless steel pans.

4. Probes were fixed at 1-inch depths for tomato sauce tested at 2-inch product depths and at 1 ½-inch depths for tomato sauce tested at 3-inch depths. Three replications were conducted for each cooling method tested and three identically prepared and portioned food product samples were used in each replication.

5. A 64 oz. chill stick/ice paddle (San Jamar® Rapi-Kool® Plus – model #RCU64V2, St. Paul, MN) was filled with tap water and frozen for 48 hours until it was solid. Three gallons of tomato sauce were transferred to a stainless steel 5-gallon stock pot. The chill stick was then completely immersed into the tomato sauce in 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 down into the tomato sauce, 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.