COOLING FOOD IN 6 HOURS IN NSF REFRIGERATION UNITS

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Introduction

The FDA Food Code recommends that hot food be cooled from 140 to 70ºF within 2 hours, and from 70 to 41ºF within 4 hours or less. [See §3-501-14 of the 1999 FDA Food Code *(3)*].

In order to cool food in the recommended amount of time (within 6 hours), the 1999 FDA Food Code recommends the following cooling methods based on the type of food being cooled [See §3-501-14 (A)].

1) Placing food in shallow pans;
2) Separating the food into smaller thinner portions;
3) Using rapid cooling equipment;
4) Stirring the food in a container placed in an ice bath;
5) Using containers that facilitate heat transfer;
6) Adding ice as an ingredient; or
7) Other effective methods.

The Food Code [§3-501-14 (B)] also states that: "When placed in cooling or cold holding equipment, food containers in which food is being cooled shall be:

1) Arranged in the equipment to provide maximum heat transfer through the container walls; and
2) Loosely covered, or uncovered if protected from overhead contamination --- during the cooling period to facilitate heat transfer from the surface of the food."

To comply with any of these instructions, foodservice and restaurant operators must be able to actually measure the cooling process. This is, in fact, very complicated. To gather accurate data and judge if the cooling has been done in 6 hours requires the use of fine-gauge thermocouples, data loggers, and an understanding of the mathematics of cooling *(5)*.

A large number of foodservice facilities and restaurants do not have rapid cooling equipment. Instead, they rely on NSF-compliant, commercial refrigeration equipment to cool food. To be NSF compliant, commercial foodservice refrigerators are built to NSF Standard 7 *(1)*. This standard specifies criteria for refrigeration performance in an environment with maximum 90ºF ambient air blowing through the condenser coil and increasing 15ºF in temperature. It does not specify standards for the cooling capacity of refrigeration unit compressors, coils, etc. When reach-in refrigerators are tested in the factory, they are new, the units are empty, and the door is never opened. If the compressor is on 70% or less of the time, and the temperature within the refrigerator does not rise above 40ºF in a 4-hour test period, the NSF standard is met. NSF-compliant refrigerators have no capacity and are not tested to cool food to 41ºF within 6 hours. According to the FDA Food Code recommendations *(3)*, the food should be placed in shallow pans and loosely covered; however, no depth of food is defined. Published research *(6)* has shown that a covered pan of food, with a depth of 2 inches, requires 12 to 14 hours to cool in an NSF-compliant refrigerator with an air temperature of 38ºF and typical air flow of 40 to 50 feet per minute.

Purpose

The purpose of this experiment is to determine and compare the time required to cool Alfredo Cream Sauce in a commercial foodservice refrigeration unit—at a depth of 1 inch in a covered, shallow stainless steel pan, and in a 1-quart mayonnaise jar (4-inch diameter).

Experimental Method

Alfredo Cream Sauce was chosen as the food to cool, because the commercial restaurant in which this experiment was performed frequently prepares it and it was available for the study. The sauce is viscous and cools primarily by conduction, has a high specific heat, and represents a more difficult item to cool. The basic ingredients for the sauce were water, milk, cream, butter, Parmesan cheese blend, nonfat dry milk solids, egg yolk, modified starch, and seasonings. The finished sauce has a pH of 5.7 and water activity of 0.97.

After preparation, the Alfredo Cream Sauce was placed 1 inch deep in a 12"x 20"x 2 1/2" pan. The 1-inch depth was chosen as one point from which to develop a cooling prediction program. In order to measure the temperature decline in the sauce as it cooled in the pan, a 30-gauge chromal-aluminal thermocouple was fastened 1/2 inch from the bottom of a 1/8-inch-diameter polypropylene rod. The rod was then placed vertically into the pan with the tip resting on the bottom of the pan. (See Figures 1 and 3.) To measure the temperature decline of the Alfredo Cream Sauce cooling in a 1-quart mayonnaise jar, a 30-gauge chromal-aluminal thermocouple was fastened to a 1/8-inch-diameter polypropylene rod and centered in the middle of the jar. (See Figures 2 and 3.) With the arrangements described, the geometric center temperature in the middle of the Alfredo Cream Sauce could be accurately monitored as the sauce cooled in a walk-in refrigeration unit. A Model 50 Electronic Controls and Design 5-thermocouple-channel data logger (ECD, Beaverton, OR) were used to collect and record data.

The airflow around the containers of sauce was about 50 feet per minute. At the time the experiment was done, the refrigerator was loaded with food and actually operated at 41°F. Therefore, the study was stopped when the sauce temperature reached 42°F.

Results

The results of this study are shown in Tables 1 and 2 and are graphed in Figure 4 using calculations described by Pflug and Blaisdell *(5)*. The graphed data show that the Alfredo Cream Sauce, at a depth of 1 inch, cooled from 140 to 42°F in about 6 1/2 hours. The sauce in the 1-quart mayonnaise jar (4-inch diameter) required about 1 hour to get to 140°F from a filling temperature of 165°F. At the end of 6 hours, the center temperature of the sauce cooled in the mayonnaise jar was 49.2. The slope of the line on the graph indicates that an additional 4 1/2 hours would be required for it to reach 42°F. Thus, the total cooling time required for the Alfredo Cream Sauce in the mayonnaise jar to cool from 140 to 42°F would be about 10 hours.

Discussion

For over 25 years, retail food operators have been trying to comply with the FDA's cooling standards. One reason restaurants and foodservice units are not meeting FDA Food Code requirements is that sanitarians do not have the proper equipment – data loggers, thermocouples, and airflow meters to measure and verify cooling. Nor are they taught verification procedures such as that used in this study. Since they lack this capability, they cannot provide correct measurement methods to the industry.

This study shows that, if regulators allow cooling of food 2 inches deep in a 2-inch pan in an NSF refrigerator, they are not enforcing the food code. The food cannot be more than 1 inch deep. If an operator wants to comply with the 6-hour cooling recommendation / requirement and cool food with a depth of 2 inches, operators must have a blast cooler with high-capacity refrigeration and high-velocity airflow of 800 to 1,000 feet per minute. These rapid cooling refrigerator systems cost more than $15,000 for a single-door unit.

The FDA can provide no validation that the 6-hour cooling is necessary, or any scientific study as the source for the 6-hour standard. The only scientifically based safe cooling study, as found in the USDA 9 CFR 318.17 *(2)*, is that reported by Juneja et al *(4)*. This study showed that there was only about a 1 log multiplication of *Clostridium perfringens* when cooked hamburger was cooled continuously from 130 to 45°F during a 15-hour cooling period simulating cooling in a commercial retail food service refrigeration unit.

Conclusion

This study shows that food in a pan must be less than 1 inch deep to cool to 42°F in 6 hours in a standard NSF compliant refrigerator operating at 41°F. A cylindrical container of food must be less than 4 inches in diameter. Food inspectors have never enforced these critical limits, because they do not have the proper instruments or training to measure food cooling. The study by Juneja, et al. *(4)*, has shown that continuous cooling of food within 15 hours from 130 to 45°F in a 38°F refrigeration system is safe. Either the Food Code recommendation for cooling food from 140 to 70ºF within 2 hours, and from 70 to 41ºF within 4 hours or less, should be enforced and all kitchens should have a $20,000 blast chiller, or the control standards for cooling food should be changed to what is practical and safe – 15 hours from 130 to 45°F with a 38°F driving force.

References

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Table 1. Cooling Alfredo Cream Sauce, 1" deep in a 12"x20"x2-1/2" stainless steel pan

Time (h)	Center Temp (°F)	Air Temp (°F)	Temp. Difference (°F)
0	140.6	47.5	93.1
0.33	120.4	48.0	72.4
0.67	104.2	45.5	58.7
1	91.3	43.0	48.3
2	65.1	41.0	24.1
3	53.6	39.6	14.0
4	43.2	36.9	6.3
4.33	46.2	41.4	4.8
4.67	44.4	40.4	4.0
5	44.2	41.2	3.0
5.33	43.9	41.2	2.7
5.67	42.8	40.9	1.9
6	42.1	41.1	1.0

Table 2. Cooling Alfredo Cream Sauce in a 1-quart mayonnaise jar (4 inches in diameter)

Time (h)	Center Temp (°F)	Air Temp (°F)	Temp. Difference (°F)
0	165.9	47.5	118.4
0.33	164.4	48.0	116.4
0.67	151.1	45.5	105.6
1	136.3	43.0	93.3
2	99.4	41.0	58.4
3	76.1	39.6	36.5
4	64.2	36.9	27.3
4.33	62.4	41.4	21.0
4.67	57.0	40.4	16.6
5	56.2	41.2	15.0
5.33	54.4	41.2	13.2
5.67	52.5	40.9	11.6
6	49.4	40.2	9.2

Figure 1. Schematic diagram of the placement of thermocouples in containers of Alfredo Cream Sauce

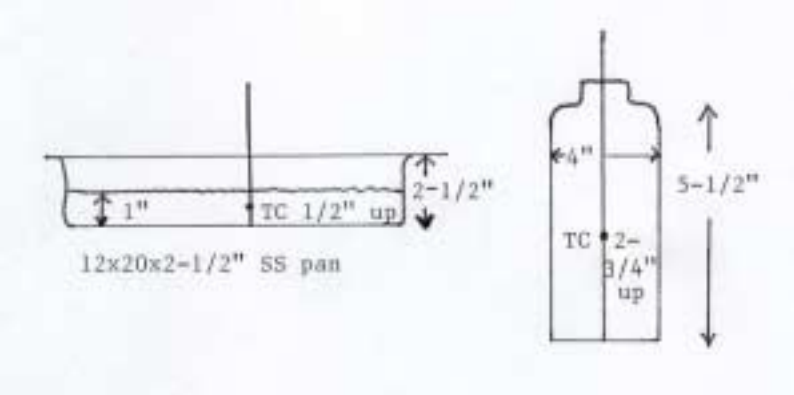

Figure 2. Picture of thermocouple placement in 1-quart mayonnaise jar

Figure 3. Picture of Alfredo Cream Sauce cooling 1" deep in a 12"x20"x2-1/2" stainless steel pan and in 1-quart mayonnaise jar

Figure 4. Alfredo Cream Sauce Cooling Study