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Cooling Gallon Containers of Food in a Commercial Walk-in Refrigerator

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SUMMARY

Many food items or ingredients used in preparing ready-to-eat food items are processed, jarred (in gallon containers), and canned (in number 10 cans) foods that are shelf-stable at ambient temperatures until opened. When cold, ready-to-eat food items are prepared for retail foodservice operations, major food ingredients should be precooled to 41°F (5°C) or less to comply with the FDA 1993, 1995, and 1997 Food Codes' recommendation on holding and storing cold food items. Furthermore, precooling major ingredients provides a means of slowing or inhibiting the growth of pathogenic bacteria, thus preventing foodborne illness. This report describes the cooling of mayonnaise in a 1-gallon plastic jar and tapioca pudding in a #10 metal can in a standard, commercial walk-in refrigerator. The data collected and plotted represent typical cooling of processed, shelf-stable food from a room temperature of 70 to 41°F (21 to 5°C) in approximately 8 hours. By extrapolation of the data, cooling times can be calculated for similar-sized containers of hot food. For example, the amount of time for cooling 1 gallon of soup or beef stew in containers of similar dimensions from 140 to 41°F (60 to 5°C) can be determined.

INTRODUCTION

FDA Food Codes of 1993, 1995 and 1997 *(1, 2, 3)* recommend that cold, ready-to-eat food items be maintained at a temperature of 41°F (5°C) or less. Many items used in foodservice facilities are canned or jarred, processed foods that, when left unopened, are shelf-stable and can be stored at ambient temperature. However, when containers of ready-to-eat, shelf-stable food are opened directly after being removed from ambient temperature storage areas, the temperature of the contents is that of the surrounding environment, [e.g., 70 to 85°F (21 to 29°C)]. Therefore, when these items are served or are used in the preparation of cold food combinations, they should be cooled before being prepared, served, or displayed, in order to comply with FDA recommendations for holding cold foods and to satisfy customer quality expectations for cold food.

If all ingredients used in the preparation of cold food items are precooled to <50°F (10°C) [e.g., to 41°F (5°C)], the growth of pathogenic bacteria such as *Staphylococcus aureus* and *Salmonella* spp. can be minimized or controlled *(7, 8)*. For example, if pre-cooled ingredients such as canned and fresh produce items or cooked pastas, rice, and potatoes are used in the preparation of mixed salads, the potential hazard for toxin production by *S. aureus* is reduced or eliminated, because this

TABLE 1. Data from cooling of mayonnaise and tapioca in a commercial walk-in refrigerator

Time (h)	Mayonnaise Temp. (°F)	Tapioca Temp. (°F)	Cold Air Temp. (°F)	Mayo. Temp. - Cold Air Temp. (°F)	Tapioca Temp.- Cold Air Temp. (°F)
0.0	75.0	73.0	34.0	41.0	39.0
0.5	71.2	68.7	34.0	37.2	34.7
1.0	68.2	65.4	34.0	34.2	31.4
1.5	65.7	62.3	34.7	31.0	27.6
2.0	62.5	59.3	34.5	28.0	24.8
2.5	59.5	56.5	34.0	25.5	22.5
3.0	57.5	55.1	34.5	23.0	20.6
3.5	54.3	52.3	34.0	20.3	18.3
4.0	51.8	50.0	34.0	17.8	16.0
4.5	50.1	48.5	34.0	16.1	14.5
5.0	48.1	46.7	34.0	14.1	12.7
5.5	46.8	45.5	34.0	12.8	11.5
6.0	45.2	44.2	34.0	11.2	10.2
6.5	43.8	43.0	34.1	9.7	8.9
7.0	42.5	42.0	33.6	8.9	8.4

pathogen does not produce toxin at temperatures below 50°F (10°C) *(9)*. When the temperature of salad ingredients is maintained below 50°F (10°C) during preparation and is then continuously cooled to less than 41°F (5°C) after preparation, the food preparer can safely use clean, washed hands to mix 5- to -10-gallon volumes of salad. There should be no risk of *S. aureus* toxin production as a result of the presence and growth of the small number of *S. aureus* from the food preparer's hands that may contaminate the salad.

The risk of production of toxin by *S. aureus* and growth of *Salmonella* spp. is further reduced by acetic and/or citric acid in salad dressings, mayonnaise, or some other acid-containing ingredient, because *S. aureus* does not produce toxin at pH below 5.15 *(6)*.

When canned or jarred foods such as canned fruits and vegetables, tuna, salad dressings, and mayonnaise are used in the preparation of combination foods that will require storage or display at refrigeration temperatures of 41°F (5°C) or less, it is beneficial for foodservice personnel to cool jars or cans of these items in advance of preparation and service. Therefore, foodservice personnel should know approximately how much time will be required for 1-gallon jars of food, and number 10 (#10) cans of food to cool to 41°F (5°C) in a standard, commercial walk-in refrigerator. Use of these data will enable foodservice personnel to allow sufficient cooling time for products. The allowance of adequate time for cooling large jars and cans of prepared, ready-to-eat food items can be used as a control point in the production of cold, ready-to-eat food items that are safe, as well as a way of obtaining proper temperatures for compliance with food codes.

METHODS

A standard, commercial walk-in refrigerator at a restaurant in St. Paul, Minnesota was used for this experiment. The airflow around the food in this refrigeration unit was approximately 50 feet per minute (fpm).

To measure food temperature, a type K, 30-gauge chromal aluminal thermocouple was fastened to a 1/8-inch diameter wooden dowel. The dowel was positioned so that the thermocouple was in the middle of a 1-gallon plastic jar of mayonnaise (6 inches in diameter and 9 inches high). A second dowel with an attached thermocouple was placed in

Figure 1. Position of 1-gallon jar and #10 can on rack in walk-in refrigerator

Figure 2. This photograph shows how wooden blocks fastened to the tops of the containers were used to hold thermocouples attached to wooden dowels vertically in place

the center of a #10 can of tapioca pudding (7 inches in diameter and 6 1/2 inches high). The containers of mayonnaise and tapioca pudding were placed on a rack in the refrigeration unit in order to ensure that there was airflow underneath as well as around the containers and thus, to allow uniform heat removal from all surfaces.

Figure 1 shows the position of the jar of mayonnaise and can of tapioca pudding on the shelf in the refrigerator. Figure 2 shows the wooden blocks that were used to stabilize the dowels to which the 30-gauge thermocouples were fastened in the geometric center of each container. An electronic datalogger was used to collect data. Air temperature and food temperatures were recorded simultaneously every 10 minutes during the cooling period. The data were analyzed according to the method described by Pflug and Blaisdell *(5)*.

RESULTS

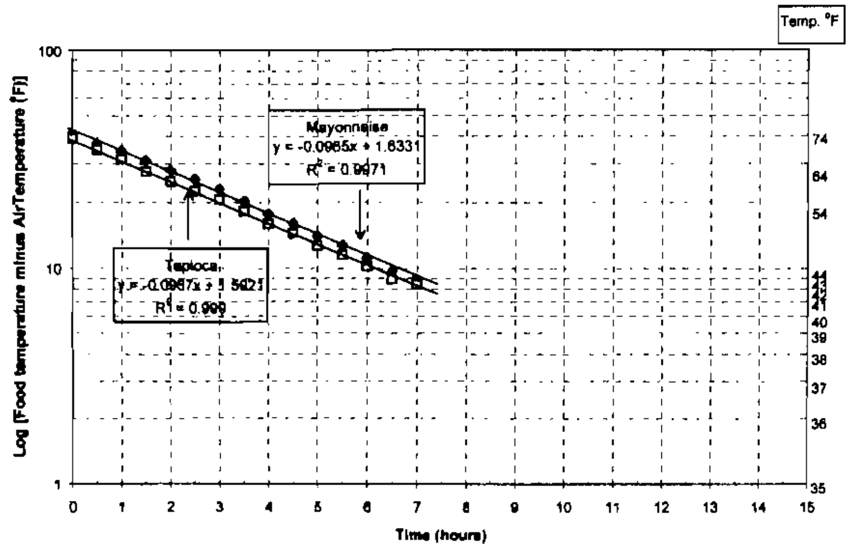
Collected data are shown in Table 1. Figure 3 is the logarithmic plot of the center food temperature of the two products, minus air temperature, during the cooling cycle. The slopes of the cooling curves are essentially identical. The temperature of the mayonnaise in the gallon jar was, initially, approximately 2°F (1.1°C) above the temperature of the tapioca pudding in the #10 can and remained so during the entire cooling cycle. The measurements were stopped after 7 hours, when the temperatures had reached about 42°F (5.6°C). The actual amount of time required to reach 41°F (5°C) would probably have been 30 to 60 minutes more, or 7 1/2 to 8 hours. (See Table 1 and Fig. 3.)

The mean circulating air temperature in the cooler was 34.1°F (1.1°C) for the experiment's duration of approximately 7 hours. Because of the exponential nature of the cooling curve, the initial cooling plot is not sensitive to a 2- to -3°F (1.1 - to -1.7°C) variance in refrigerator temperature. Whether the refrigerator temperature is at 38 or 34°F (3.3 or 1.1°C) is not significant to the driving force of cooling when the temperature difference is 100°F (55°C). However, near the end of the cooling cycle, when the temperature difference between the center of the product and the driving force (i.e., circulating air temperature) is in the range of 5°F (2.8°C), circulating air temperature constancy becomes critical. The effective air temperature blowing across the product toward the end of the experiment was about 34°F (1.1°C).

DISCUSSION

A plot of the data from this experiment shows that in a typical foodservice walk-in refrigerator with standard, low-airflow conditions of about 50 fpm, a 1-gallon plastic container of mayonnaise and a #10 can

Figure 3. Cooling mayonnaise (1-gallon plastic jar) and tapioca pudding (#10 can)



Mayonnaise
$y = -0.0965x + 1.6331$
$R^2 = 0.9971$

Example
$y = -0.0965\ (3\ h) + 1.6331$
$y = [-0.29 + 1.6331] = 1.3431$

Log 1.3431 = 22.03°F

Tapioca
$y = -0.0967x + 1.5921$
$R^2 = 0.999$

Example
$y = -0.0967\ (3\ h) + 1.5921$
$y = [-0.2901 + 1.5921] = 1.302$

Log 1.302 = 20.04°F

of tapioca pudding can be cooled from 70 to 41°F (21 to 5°C) in approximately 8 hours. These data suggest, therefore, that unopened jars of mayonnaise and/or other jars or cans of ingredients should be put into a refrigerator at least 8 hours prior to use. This practice cools the food sufficiently to ensure compliance with regulatory recommendations if these items are placed in refrigerated display for a period of more than 4 hours. Use of cold ingredients for the preparation of salads and sandwich fillings decreases the risk of *S. aureus* or *Salmonella* spp. multiplication. The temperature of these products should be low enough to assure that there will be little or no temperature increase in the temperature when the product is opened and used for immediate service or added to a salad or other cold food combination.

These data can be extrapolated to predict the time required for cooling food from 140 to 41°F (60 to 5°C) in these two types of containers. The estimated time required to cool food from 140 to 41°F (60 to 5°C) is 11 hours, and approximately 11 hours 30 minutes would be required to cool food to 40°F (4.4°C), assuming the same driving force air temperature of 34°F (1.1°C) and an airflow of 50 fpm. The FDA 1997 Food Code *(3)* recommends cooling food to 41°F (5°C) in less than 6 hours [from 140°F (60°C) to 70°F (21°C) within 2 hours and 70°F (21°C) to 41°F (5°C) or below within 4 hours]. However, research by Juneja et al. *(4)*, indicates that if food is cooled continuously from 130°F (54.4°C) to 45°F (7.2°C) within 15 hours, there will be minimal spore outgrowth of *Clostridium perfringens*.

CONCLUSION

Mayonnaise in a 1-gallon plastic jar and tapioca pudding in a #10 metal can were used to represent typical cooling of unopened containers of processed, shelf-stable food from a temperature of 70 to 41°F (21 to 5°C). The time required to accomplish this amount of cooling in a standard refrigeration unit with airflow of 50 fpm was approximately 8 hours.

These cooling data can also be applied to the cooling of other foods in the same or similar types of containers. For example, the data can be extrapolated to determine continuous cooling times from 140 to 41°F (60 to 5°C) for 1 gallon of soup or beef stew in containers of similar dimensions.

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