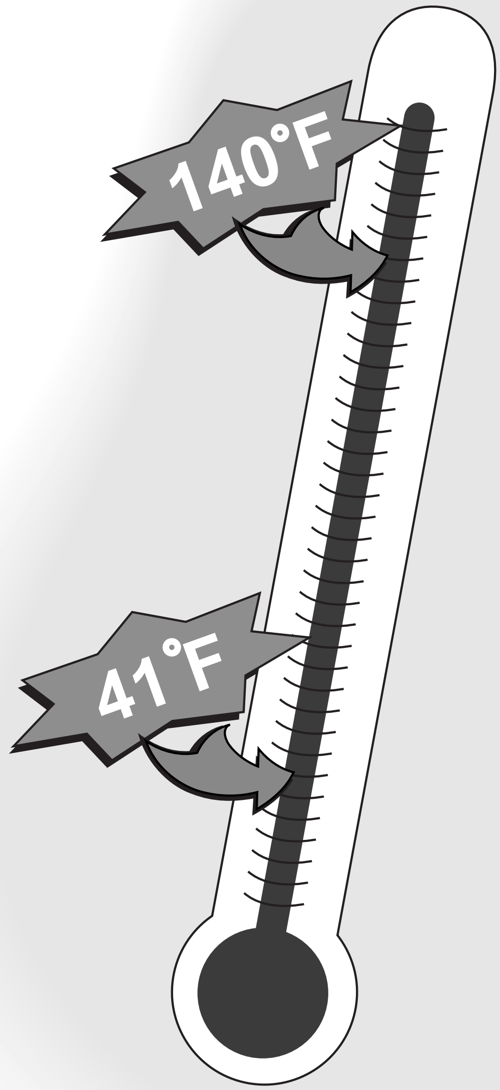
# Cooking & Cooling of Meat & Poultry Products





Food Safety &
Inspection Service

Association of
Food & Drug Officials

# Cooking and Cooling of Meat and Poultry Products

**Distance Learning Training Course**

**Sponsored by:**

**U.S. Department of Agriculture**
**&**
**Association of Food and Drug Officials**

**In Cooperation with the U.S. Food and Drug Administration**

**AAC Consulting Group, Inc.**
**7475 Wisconsin Ave., Suite 850**
**Bethesda, MD 20814**

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# COURSE INTRODUCTION

*Notes:*

This course is designed to provide information and demonstrate the proper application of basic microbiology, the Food Code, and applicable regulations as they pertain to the cooking and cooling of meat and poultry products at the retail level. Participants will enhance their ability to identify potential problems, evaluate the adequacy of and discuss proper heating and cooling practices.

This is a distance learning course delivered via satellite. Course content is presented using a variety of formats including lectures, interactive Q&A sessions and pre- and post-course tests. The lecture material parallels the information contained in this training material. It is a useful guide to follow during the video presentation and will serve as a valuable reference in the future. Ample space has been provided for taking notes. A panel of experts has been assembled to respond to questions that participants might have following each lecture segment. You are encouraged to ask any clarifying questions you might have during these Q&A sessions. The testing element of this program is designed to reinforce the key teaching points and to give participants a grasp of how well they understand the subject matter. Don't worry – these tests will not be collected and graded. They are simply tools for your use.

## COURSE OBJECTIVES

Upon completion of this course, participants will be able to:

- Recognize inadequate processes associated with the cooking and cooling of meat and poultry at the retail level.

- Discuss the hazards associated with foods and the cooking and cooling processes with management at the retail level.

- Determine the adequacy of control methods to prevent microbiological hazards in cooking and cooling at the retail level.

- Understand the principal for determining temperature with various temperature measuring devices.

## AUDIENCE

Attendance is appropriate for Federal, state and local investigators, inspectors, sanitarians and microbiologists who

**Notes:**

routinely conduct inspections of retail stores, conveyances or restaurants in which the cooking or cooling of meat and poultry products take place.

## CONTRIBUTORS

The US Department of Agriculture, Food Safety and Inspection Service, Human Resource Development Staff and the Association of Food and Drug Officials are the sponsors of this course. Its contents were prepared under contract by the AAC Consulting Group, Inc., with the valuable support and collaboration of the FSIS Retail Workgroup. The USDA Video, Teleconference and Radio Center produced the video conference.

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## BACKGROUND

Notes:

Foodborne illness is a serious problem throughout the world, and long-standing activities have been in place to identify, control and prevent foodborne disease hazards. To augment those efforts, FoodNet, a foodborne illness surveillance system was established during 1996 by the Centers for Disease Control (CDC) in collaboration with the Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA). During 1997, there were five sites where FoodNet data was collected, and the population of those sites was 20.3 million, approximately 7.7% of the population of the United States (U.S.). For the year 1997, FoodNet reported a total of 8,557 confirmed cases of infections caused by the pathogens under surveillance. Figure 1 tabulates those illnesses associated with pathogenic bacteria, and accounts for 8,051 of the total. As you can see, of these illnesses, the three leading causative agents were *Campylobacter*, *Salmonella* and *Shigella*.

**CASES OF INFECTIONS CAUSED BY SPECIFIC PATHOGENS**

| PATHOGEN | CA | CT | GA | MN | OR | TOTAL |
|---|---|---|---|---|---|---|
| ***Campylobacter*** | 1038 | 528 | 469 | 1175 | 737 | 3974 |
| ***E.coli 0157:H7*** | 19 | 19 | 8 | 199 | 80 | 340 |
| ***Listeria*** | 14 | 12 | 20 | 18 | 13 | 77 |
| ***Salmonella*** | 370 | 413 | 475 | 619 | 330 | 2207 |
| ***Shigella*** | 293 | 78 | 577 | 138 | 177 | 1263 |
| ***Vibrio*** | 31 | 4 | 2 | 2 | 12 | 51 |
| ***Yersinia*** | 35 | 15 | 43 | 31 | 15 | 139 |
| **Total** | 1800 | 1084 | 1621 | 2182 | 1364 | 8051 |

*Figure 1. Table from CDC FoodNet, CDC/USDA/FDA Foodborne Diseases Active Surveillance Network, CDC Emerging Infection Program, 1997 Surveillance Results, April 1998.*

FoodNet currently covers only a small portion of the population of the U.S. It is estimated that in the U.S. there may be as many as 33 million cases of foodborne illness annually, with an estimated 9,000 deaths. A significant number of these illnesses are associated with the consumption of meat and poultry products in restaurant settings or with ready to eat foods produced at retail.

Since this course is designed to address microbial hazards at retail, it will not contain information relative to those thermal processes not typically used at retail. However, you should be aware that there are a number of other thermal

*Notes:*

processes designed to reduce or eliminate microbial hazards associated with meat and poultry products. These applications are routinely employed by meat and poultry processors, and have an impact on the microbiological load of foods received as raw materials at retail. These pretreated foods have been subjected to processes that eliminate competitors, which would normally inhibit the growth of pathogens. In this module, we will discuss the importance of preventing recontamination and controlling time and temperature to prevent pathogen growth

Proper heating and cooling of meat and poultry products at the retail level are critical steps to the prevention of foodborne illnesses. The purpose of this course is to provide you with knowledge about the types of pathogenic organisms which may be present on these foods, the proper interventions at retail to control them as a public health hazard, and with procedures for assuring proper cooking and cooling procedures have been applied. You will gain a working knowledge of the equipment and processes used at retail for proper cooking, hot holding, cooling, cold holding, and reheating. The course will also address the use of time as a public health control, will include a session showing the proper use of temperature measuring devices, and discuss hazards related to specific foods.

# MODULE ONE:
# COOKING MEAT AND POULTRY PRODUCTS

Notes:

## OBJECTIVES

Upon completion of this module, the participants will:

- Have an understanding of the use of cooking to achieve the death of microbes.
- Have an understanding of the factors involved in the destruction of microbes by cooking.
- Recognize various cooking methods and the controls necessary to assure proper reduction of hazards through the cooking process.

## 1. PURPOSE OF COOKING

Cooking of meat and poultry products changes the foods' color and texture, halts enzymatic action and generally makes food more palatable; however, from a safety standpoint, the most important purpose of heating is to kill or inactivate spoilage and pathogenic organisms.

## 2. TYPES OF HEATING

This module will discuss the various types of cooking methods and the control procedures to assure the elimination of pathogens; however first let's discuss the way heat is transferred in the cooking processes.

### TYPES OF HEATING

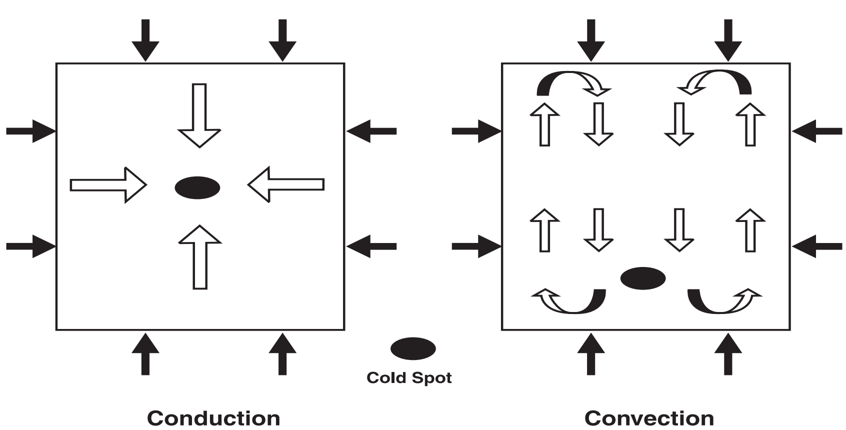


*Figure 2.*

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## 2.1 CONDUCTION

The first method of heat transfer we will discuss is conduction. Heating by conduction is a slow process in which heat is applied to the food container, and the heat is passed on to the food. In conduction heating, heat is transferred through the food being cooked one particle at a time (from one molecule to the next). This type of heating is typical for solid foods such as a turkey or a roast being cooked in an oven. To evaluate the adequacy of cooking, we must know where the coldest point is in the food. The coldest point in conduction heating is usually either the geometric center, or farthest point from the heat source.

## 2.2 CONVECTION

A faster method of heating is convection heating in which heat penetration is augmented by movement in the food. Convection heating can only occur in foods that can move within the cooking vessel. This movement is referred to as convection currents, and uneven heating within the food brings them about. For example, in a pot of stew heat moves through the food container walls and heats the material nearest to the wall of the pot. As this part of the food becomes warmer it tends to rise, and the cooler material at the center of the container sinks. We usually observe this type of heating in the form of boiling liquids. These convection currents speed the heating process, and make it more uniform. The coldest spot in convection heating is no longer the geometric center but is nearer the bottom center of the container where the currents diverge.

## 2.3 FORCED CONVECTION

For even faster heating and more uniformity, forced convection is used. This is convection heating that is facilitated by stirring or agitation. Stirring moves the food around in the heating container and by doing so speeds the heating process. There are a variety of methods for stirring foods at the food processor level, but at the retail level the cook simply stirring the pot usually accomplishes it. The location of the cold spot in forced convection heating depends on the type of stirring involved, however if very active stirring is involved, cold spots are virtually eliminated. Forced convection can also be observed in forced air ovens where forced air circulation facilitates faster heat transfer on the surface of the product.

## 3. WHAT AFFECTS HEAT RESISTANCE IN BACTERIA

**Notes:**

Understanding the penetration of heat into a cooked food is the easy part. Somewhat more difficult to understand is how this heat affects microbes in the food. Not all species of microbes die at the same rate as the result of heat application. In addition, the same species of microbes contained in different types of foods may have very different resistance to heat due to the nature of the food product in which they are contained or their previous growing conditions. There are a number of factors that influence the resistance of bacteria to heat applied during the cooking process and we will discuss some of them.

### 3.1 NATURE OF BACTERIA (psychrophiles/mesophiles/thermophiles)

Before we discuss the effect of heat on microbes, you should understand that different microorganisms have significantly different tolerance to heat. Because of their very nature, microbes can grow over a wide range of temperatures from about 14°F to 194°F. Microbes are grouped into three categories based on their temperature growth ranges as shown in figure 3.

**TEMPERATURE GROWTH RANGES**

| Category | Temperature | |
|---|---|---|
| | Optimum Growth | Growth Range |
| Psychrophiles | >68°F | 32° - 86°F |
| Mesophiles | 98°F | 50° - 110°F |
| Thermophiles | 131°F | 110° - 194°F |

*Figure 3.*

Psychrophiles, which includes such organisms as *Listeria monocytogenes* can live and grow at refrigerated temperatures. Mesophiles grow at temperatures between 50°F and 110°F, while thermophiles grow at elevated temperatures of 110°F to 194°F. Figure 4 shows the temperature growth ranges of specific pathogens.

*Notes:*

## GROWTH RANGE TABLE

| ORGANISM | GROWTH RANGE (°F) |
|---|---|
| *Bacillus cereus* | 39.2 to 131.0 |
| *Clostridium perfringens* | 50.0 to 125.6 |
| *Clostridium botulinum*<br>*Types A&B*<br>*Others* | <br>50.0 tp 118.4<br>37.9 to 113.0 |
| *Escherichia coli* | 44.6 to 120.9 |
| *Listeria monocytogenes* | 31.3 to 113.0 |
| *Salmonella* | 41.4 to 115.2 |
| *Shigella spp* | 43.0 to 116.8 |
| *Staphylococcus aureus* | 44.6 to 122.0 |
| *Vibrio cholerae* | 50.0 to 109.4 |
| *Vibrio parahaemolyticus* | 41.0 to 111.0 |
| *Yersinia enterocolitica* | 29.7 to 107.6 |

*Figure 4.* Information from the Second Edition of the FDA Fish and Fisheries Products Hazards and Control Guide, 1998.

Most, but not all, of the microorganisms of public health concern in foods are mesophiles and their optimum growth temperature corresponds to the human body temperature. Typically, the higher the temperature (within the growth range), the more rapid the growth of the organism. This can be explained by the fact that growth is catalyzed by enzymatic reactions. The rule of thumb is that for every 18 degrees of F increase in temperature the catalytic rate of an enzyme doubles.

It is not only temperature that affects the rate of growth or destruction of organisms, but also the time of exposure to a set temperature. The goal is to reduce the amount of time that a food is exposed to optimum growth temperatures. Therefore, it is recommended that food products be maintained either above 140°F or below 41°F. In module 2 we will discuss minimizing the time in the “Danger Zone” by rapid cooling procedures, but for now we will concentrate on the reduction of microbes by cooking. Cooking easily destroys the vegetative cells of psychrophiles and mesophiles, however thermophiles are much more heat resistant.

THE DANGER ZONE

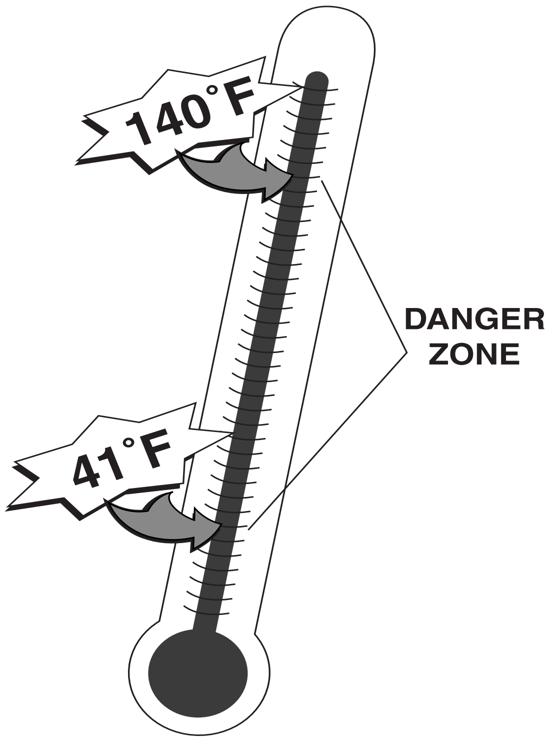


*Figure 5.*

## 3.2 SPORES VS. VEGETATIVE CELLS

Since we have mentioned vegetative cells, lets discuss another inherent characteristic of some bacteria. The active growing stage of microbes is known as the vegetative stage of the organism. Vegetative bacterial cells are much more sensitive to heat than are spores. However, many vegetative cells are resistant to cold temperatures, and may survive freezing.

Spores are a dormant stage of the bacteria, and are much more resistant to heat than the vegetative stage. Some spores can survive boiling water for more than an hour, they also hold up well under freezing, and may resist some sanitizing compounds. A spore usually develops from a vegetative cell during unfavorable environmental conditions. This is the cell’s way of surviving such adverse conditions. Spores, themselves, do not reproduce and grow and would be of little concern if they could never grow again. However, like plant seeds, spores can germinate and grow. Ironically, it takes adverse conditions, such as the thermal shock that occurs during the cooking process, to cause these cells to germinate and once again grow into vegetative cells. These cells possess all of the pathogenic characteristics of the originating cells.

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Figure 6 lists some of the common spore forming and non-spore forming pathogens:

**SPORE FORMING/NON-SPORE FORMING PATHOGENS**

| Spore Forming Pathogens | Non-Spore Forming Pathogens |
|---|---|
| *B. cereus*<br>*C. botulinum*<br>*C. perfringens* | *Campylobacter jejuni*<br>*E. coli*<br>*L. monocytogenes*<br>*S. aureus*<br>*Salmonella spp*<br>*Shigella spp*<br>*Yersinia spp* |

*Figure 6.*

## 3.3 TYPE OF FOOD

Characteristics of some foods influence how heat affects the pathogens that may be contained in them. For example, pathogens are more easily destroyed in foods having a low pH (acidic). Also, moisture in a food product improves heat penetration and aids in the destruction of pathogens. On the other hand, sugars or oils in a food can surround bacteria and can insulate and protect them from heat.

## 3.4 GROWING CONDITIONS

A pathogen that is already under stress is easier to destroy by the heating process. For example, microbes that have grown under unfavorable water activity conditions are easier to destroy by heat. However, sometimes changes in the environmental conditions can favor the survival of microbes. For example, in a 1978 experiment, beef rounds dry roasted to an internal temperature of 145°F were found to have *Salmonella* on their dry surface that survived the cooking process. (S.J. Goodfellow and W.L. Brown "Fate of *Salmonella* Inoculated into Beef for Cooking.") It was postulated that this resistance was due to rapid dehydration, which in turn resulted in the *Salmonella* having a higher resistance to heat.

## 3.5 HUMIDITY OF THE COOKING VESSEL

Moisture is an excellent conductor of heat, and therefore its presence in a high humidity oven or steamer can greatly increase heat penetration and cooking. To demonstrate, you can place your hand in a dry oven at 350°F, and although you will feel the heat, you would not be burned. However, if you placed your hand in steam from boiling water (212°F), you would immediately receive a severe burn. Moisture or humidity in an oven or other type of cooker has a significant impact on heat transfer. Many cooking processes require either the introduction of moisture into the cooker, or sealing of the container in which the food is cooked to prevent the escape of moisture which is already present. For example, a browning bag which seals moisture in significantly reduces the cooking time for oven roasted turkey. If these required steps are not adhered to, then the cooking process may not achieve the kill step indicated for the recipe.

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### 3.6 WATER ACTIVITY

Bacteria need water as well as food for growth and development. Water in a food product may be freely available, or it may be bound by sugar, salt or other ingredients in the food, and not be available to microbes. The availability of water is described as water activity. Water activity is measured on a scale of 0 to 1.0 with 1.0 being equal to distilled water. The lowest water activity value at which pathogens will grow is 0.91; however, toxin production can occur at a water activity as low as 0.86.

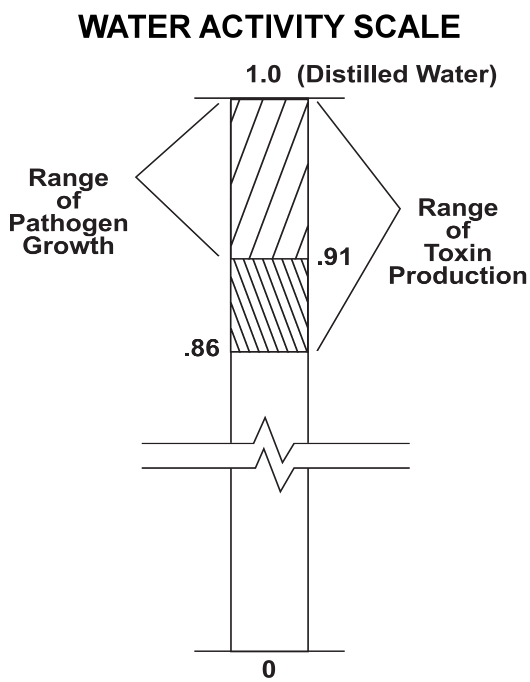


*Figure 7.*

Although foods with a high water activity level allow for optimal bacterial growth, heat penetration in these foods can be faster because of their moisture content, allowing for faster killing of pathogens contained in them. Figure 8 is a listing of water activity for some typical meat and poultry products:

*Notes:*

**APPROXIMATE WATER ACTIVITY LEVELS**

| Food | Water Activity |
|---|---|
| Fresh meats (beef and chicken) | 0.98 and above |
| Fermented and cooked sausage<br>Lightly salted pork and beef | 0.93 to 0.98 |
| Dried sausage<br>Dried beef | 0.85 to 0.93 |

*Figure 8*

## 3.7 EFFECT OF pH

Most bacteria grow best in a medium that is neutral or slightly acidic, and the growth of most bacteria are significantly inhibited in very acidic foods. pH is measured on a scale of from 0 to 14.0 with 7.0 being exactly neutral. pH levels from 7.0 to 14.0 are basic while those below 7.0 are said to be acid. Foods having a pH above 4.6 are considered to be low acid foods, and their pH will not inhibit pathogen growth. Meats and poultry are low acid foods. Foods that have a pH range of 4.6 or below are considered high acid foods. Tomatoes and citrus fruits and a variety of prepared foods such as mayonnaise fall into this category.

**pH Scale**

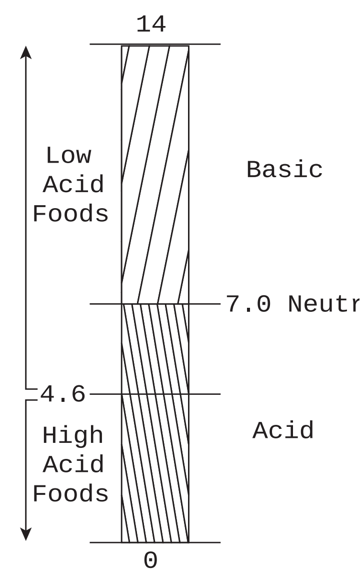


*Figure 9.*

High acid foods are seldom the vehicles for pathogens; in fact many foods are acidified to prevent the growth of undesirable microbes. However, it should be pointed out that the pH or 4.6 is not an absolute barrier to pathogen growth. Some pathogens are more resistant to low pH than others.

For example *E. coli* has a pH tolerance range of from 4.0 to 9.0, and *E. coli* 0157:H7 in apple juice with a pH below 4.6 has resulted in foodborne illness outbreaks. pH is especially useful in preventing the germination of spores that are not destroyed by most retail cooking process. Figure 10 shows the approximate pH of meat and poultry products.

**APPROXIMATE pH OF MEAT AND POULTRY PRODUCTS**

| Food | pH Range |
|---|---|
| Fresh beef | 5.6 to 6.4 |
| Ground beef | 5.1 to 6.2 |
| Bacon | 5.6 to 6.6 |
| Ham | 5.9 to 6.1 |
| Veal | 6.0 |
| Chicken | 6.2 to 6.4 |

*Figure 10.*

### 3.8 CUMULATIVE EFFECTS OF GROWTH LIMITING FACTORS ON LETHALITY

There are many factors which affect the growth or destruction of microorganisms in food products. When several of these factors exist at the same time in a food product, they can have a synergistic effect on limiting the growth of microorganisms. For example, the combination of a low pH as well as a low water activity can have a cumulative effect on destruction of microbes during cooking. These same factors (barriers) can also prevent pathogen growth in a cooked food. By applying multiple barriers to a single food product, a higher degree of food safety is assured.

## 4. THERMAL DEATH CURVES

To understand some of the requirements for cooking of meat and poultry, it is important to know some of the concepts of how microorganisms are destroyed by heat. The destruction of microorganisms by heat is a factor of both <u>time</u> and <u>temperature</u>. Microbes in a food subjected to heat do not die all at the same time. As with any living organism, the weaker cells and those subjected to greater stress die first. Generally, the longer organisms are subjected to heat, and the higher the temperature to which they are subjected, the more of them will die. A typical graph showing the death of microorganisms from cooking is a straight-line graph.

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### 4.1 D VALUE = (TIME)

The first concept we will discuss is referred to as the "D Value." This term is used to describe the time at a set temperature needed to kill 90% of the population of a specific microorganism in a specific food at a specified temperature. Figure 11 shows the effect on an organism held at 180°F for a period of time, and time is the only variable. We start with 1,000,000 ($10^6$) organisms, and after 8 minutes, 90% of them have been destroyed, leaving 100,000 organisms ($10^5$). This is referred to as a one decimal log reduction. In this instance D Value = 8 minutes. For every additional 8 minutes at 180°F this process kills an additional 90% of the organisms present.

You may have observed that at this rate, we never reach absolute zero. However, if we apply a sufficient number of D Values, we can reduce the number of pathogens to an acceptable public health level. In the Food Code, a 3, 5, or 7 D Value is applied to meat and poultry cooking processes depending upon the specific food product.

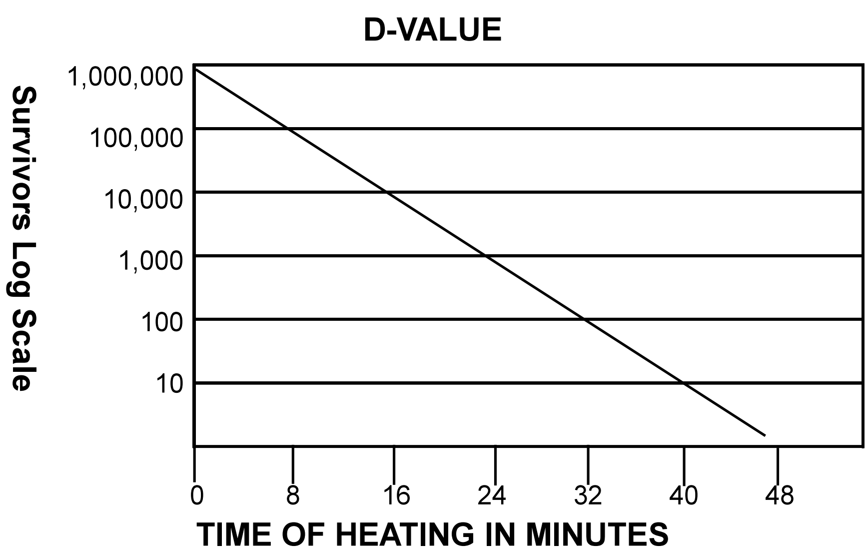


*Figure 11.*

It is important to remember that the D Value for an organism is significantly different at different temperatures. The following graph demonstrates the D Value for the same organism at three different temperatures. As you can see, the D Value changes dramatically when the temperature is varied. It is easy to understand that, as the temperature increases, it takes less time to destroy a population of organisms. Therefore, the D Value (the time needed to kill 90% of the population) becomes smaller as the temperature rises.

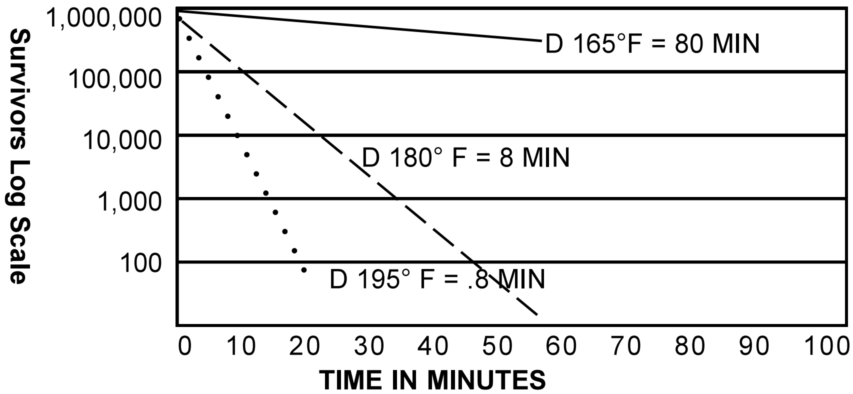


*Figure 12.*

## 4.2 Z VALUE = (TEMPERATURE)

Remember we said that the destruction of microorganisms by heat is a factor of time and temperature. We have already discussed the factor of time, which is the D Value. The next concept we will address is known as the Z Value, and the Z Value is the number of degrees of temperature necessary to reduce the D Value one log cycle, that is, to kill 90% of the population of a microorganism.

For Z Values, temperature is the variable, with time being constant. If we limit cooking time to a certain number of minutes, then we will have to increase the temperature of the cook in order to reduce the numbers of the target microorganism to a safe level.

In figure 13 the D Values from the previous graph are plotted, and you can see the log of the D Value falls in a straight line. In this example an increase of 15° F is needed to achieve each additional D Value. In other words, for each15° F the temperature is increased, we need only one tenth of the time to kill 90% of the microbes as follows:

a. D Value at 165°F = 80 minutes.

b. D Value at 180°F = 8 minutes.

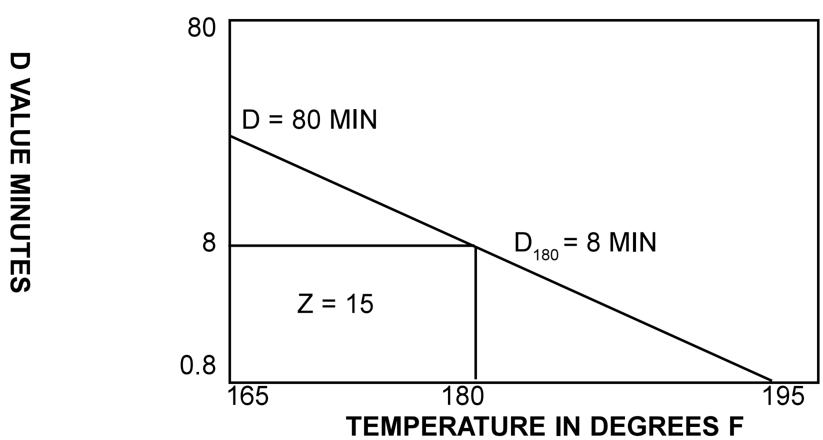


*Figure 13.*

**Notes:**

*Notes:*

## 4.2 F VALUES

The D Value describes how sensitive a certain organism is to time at a set temperature. The Z Value describes the organism's sensitivity to temperature for a specified time. Therefore, if we know the D and Z Values for a pathogen we are able to predict how much time is required to destroy the desired numbers of the pathogen at <u>any temperature or any combination of temperatures.</u>

In the real world, however, we do not instantaneously heat to 180°F. Also it is improbable in the processing of meat and poultry that a constant temperature will be established and maintained. Because of these variations in the cooking process, the concept of F Value was established.

If an expert knows the D and Z Values for a food, they are able to calculate lethality tables such as the one in figure14. From these tables, they are able to add up the lethal rate for each minute that the food was held at a certain temperature.

**LETHAL RATE AT 180° F = 1**

| TEMPERATURE (F°) | LETHAL RATE |
|---|---|
| 150 | 0.010 |
| 155 | 0.021 |
| 160 | 0.046 |
| 165 | 0.100 |
| 170 | 0.215 |
| 175 | 0.464 |
| 180 | 1.000 |
| 185 | 1.154 |
| 190 | 4.642 |
| 195 | 10.000 |
| 200 | 21.544 |

*Figure 14.*

You can see from the table that for this food, 1 minute at 170°F is equivalent to slightly less than half of the lethality rate at 180°F. By adding the lethality rates for each minute that the food is held at a certain temperature, you end up with an equivalent number of minutes at the reference temperature (In this case-180°F). For example:

One minute at 160°F = 0.046 plus
One minute at 170°F = <u>0.215</u>
Total 0.261

This means that a cook held one minute at 160°F and another minute at 170°F is equivalent to 0.261 minutes at 180°F. This is a simplification of the math process actually used by experts to determine the adequacy of a thermal process. In real world situations, many more factors are considered, and the mathematical formulas are much more complex.

**Notes:**

## 5. IDENTIFYING THE PATHOGENS OF CONCERN

Foodborne Illnesses fall into two categories, the first being an infection and the second being an intoxication. The microorganisms that cause infection and intoxication are all pathogens, but differ in how they affect the body.

Foodborne infections result when viable pathogens are ingested and attack the host cells. As with any infection, the organism requires time to multiply, therefore the onset of symptoms is rather slow. A common symptom of this type of foodborne illness is fever. Salmonellosis is an example of a foodborne infection. In addition, the illness caused by *C. perfringens* falls under the foodborne infection classification.

Foodborne intoxication is caused when a specific pathogen grows and produces either an enterotoxin, a toxin contained within the bacterial cell or an exotoxin, which is a waste product of the cell, that is released into the food or the gut of the host. When foods containing either type of toxin are consumed, it is not the organism that causes the illness, but instead, the illness is the result of the toxin. The onset of this type of food illness is much more rapid than a foodborne infection, and a fever does not normally occur in the host. An example is the foodborne intoxication caused by *S. aureus* toxin.

## 6. PRESCRIPTIVE REGULATORY LIMITS

The critical limits for cooking meat and poultry are the minimum temperatures that are found in the FDA Food Code, 3-401.11 (A) (2) or 3-401.12, and USDA Title 9 Code of Federal Regulations part 318.17 or 318.23. The regulatory limits set by USDA allows for alternative cooking procedures if they are validated to meet the Food Safety and Inspection Service (FSIS) lethality performance criteria of a 5-decimal log reduction of *Salmonella* within the product. Production requirements for roast beef were established in 1977 and 1978 following several outbreaks of *Salmonella* foodborne

***Notes:***

illness. The requirements covered time, temperature, and in some cases, relative humidity.

The FDA Food Code places emphasis on time and temperature as a unit. Previous model codes placed very little significance on this relationship, however, with the new science of today, and our knowledge of emerging pathogens as well as factors contributing to foodborne illness, it is imperative that time and temperature be considered together. The FDA Food Code incorporates the practical application of this principle by integrating it into the model for states to adopt as state laws and regulations.

Most of the regulatory requirements used by USDA and FDA for time and temperatures are designed to destroy *Salmonella*, and are based on a 1978 Goodfellow and Brown study "Fate of *Salmonella* inoculated into beef for cooking." Based on that study, the parameter of 165°F or above for 15 seconds for cooking poultry provides a 7D reduction. Cooking at 155°F for 15 seconds provides a 5D reduction, while cooking at 145°F cook for 15 seconds provides a 3D cook.

Some cooking processes are based on the destruction of pathogens other than *Salmonella*. For example, the process for cooking ground beef, in addition to providing a 5D reduction in *Salmonella*, also provides an 8D reduction in the number of *E. coli*. The cooking process for pork is based on the destruction of trichina.

## 7. IMPORTANT FACTORS IN THE COOKING PROCESS

The following are some of the important factors in the cooking process.

### 7.1 HEAT STABLE TOXINS

Although cooking destroys most vegetative cells of pathogens as well as their toxins, not all toxins are easily destroyed by heat. *Staphylococcus aureus* produces a toxin that results in one of the more economically important diseases in the US. *S. aureus* is very salt tolerant while other foodborne pathogens are not. Because of this tolerance, *S. aureus* can survive well on salted meat products, such as hams and sausages where other organisms cannot compete. It has been found in open sores on the hands and arms of food service employees. The infective dose of *S. aureus* is less than 1.0 micrograms of its toxin, and this level is reached when *S. aureus* population reaches 100,000 organisms per gram in the food. It can produce its toxin at a water activity as low as 0.86. Also, the toxin produced by *S. aureus* is extremely heat-stable, and can survive even boiling or retorting temperatures. Therefore, cooking is not a sufficient barrier to eliminate pre-formed toxin in food. In fact, cooking destroys microbes, which would normally compete with *S. aureus*. The best way to prevent *S. aureus* is through eliminating hand contact with ready-to-eat foods, restricting employees who have infected sores on their hands and arms, and maintaining proper temperatures.

**Notes:**

## 7.2 EFFECT OF STUFFING

*Figure 15.*

Many meat and poultry products are prepared with stuffing, and the stuffing may have a significant effect on heat penetration. Recipes may call for the addition of raw potentially hazardous foods such as eggs, oysters and other foods that may introduce high bacterial initial loads. It is always a good recommendation to cook stuffing separately from the meat or poultry. When adding stuffing, close attention must be paid to the required oven temperatures and times to bring the internal temperature to the level necessary to destroy pathogenic organisms in the food. To assure that the proper internal temperature is reached, a thermometer should be used. In order to reach the coldest spot, the temperature probe should be located as near to the geometric center of the mass as possible.

## 7.3 SIZE AND WEIGHT OF THE FOOD

Weight and shape have a significant effect on the penetration of heat to the coldest spot in the food product. For this reason oven temperatures at which roasts are cooked are based on the weight of the roast. In addition to weight, the size and shape of the food being cooked is also significant. For example, a roast weighing more than 10 pounds, but with its greatest thickness being 4 inches will cook faster than a similar roast having a thickness of 8 inches.

***Notes:***

**SIZE AND WEIGHT**

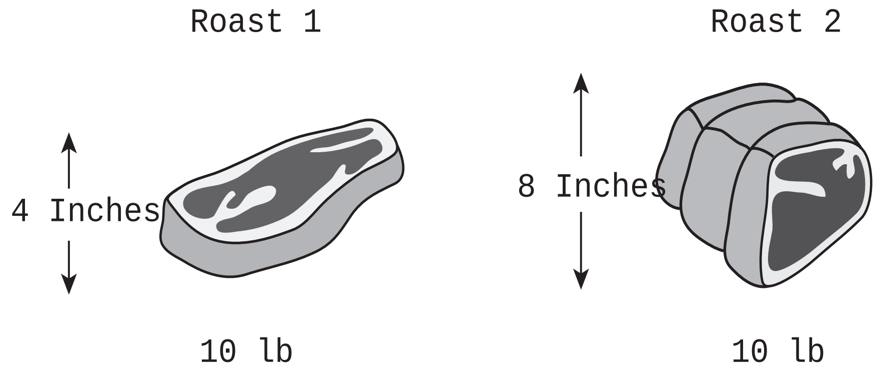


*Figure 16.*

## 7.4 MICROWAVE COOKING

Most of the same factors that affect traditional cooking also influence microwave cooking. However, the moisture and the salt content of foods being subjected to Microwave cooking play a more important role. This is due to the nature of the electric field involved in causing molecular friction, which is the principle of microwave cooking, and the effect that moisture and salt have on this process. Covering foods during microwave is recommended since this aids in maintaining moisture levels.

Since cold spots will exist in microwave cooking, it is important to measure the internal temperature of the food in multiple sites. Also, it is important during microwave cooking to stir and rotate the food since such actions increase uniformity in cooking by reducing cold spots.

Due to uneven heating of the foods, it is recommended that foods be held for two minutes after the cooking process before serving to allow for thermal equilibration and exposure of pathogens to the heat.

The wattage of microwave ovens varies, and this has a significant effect on the amount of heat generated. For this reason, internal temperatures should be relied upon to assure a proper cook rather than relying on the amount of time specified in recipes.

In a traditional cooking process, the cumulative effects of heating time in the oven contribute to the destruction of pathogens. Oven time includes:

- The time the food is being heated to the cook temperature (come-up).
- Time the food is held at the cook temperature.

- The time during cooling (come-down).

When these cooking processes are developed, the come-up as well as the come-down times are added to the equation. In microwave cooking, the rapid increases in temperature that is achieved results in a cook process that does not include come-up time. Therefore microwave cooking times are calculated differently. To be comparable, the food being subjected to microwave cooking must achieve a comparable internal temperature and hold that temperature for a specified time.

***Notes:***

# MODULE TWO: COOLING AND HOLDING MEAT AND POULTRY PRODUCTS

Notes:

## INTRODUCTION

In this module we will explore the requirements, and the controls necessary for hot holding, cooling, cold holding, reheating, time as a public health control and temperature measuring.

## OBJECTIVE

Upon completion of this module, the participants will:

- Understand the concepts and principals of hot holding and the microbiological implications of not maintaining foods at the proper temperatures.
- Understand the reasons and methods for rapid cooling to a safe temperature and the effect of cooling on the growth of microbes.
- Have an understanding of the equipment and methods necessary for proper cold holding, the difference between cold holding and cooling.
- Understand the requirements for reheating.
- Understand the requirements for using time as a public health control.
- Understand various methods of measuring product temperatures.

## 8. HOT HOLDING

Many foods are cooked for immediate consumption; however, foods produced at retail may be advanced prepared for many hours after cooking. Not all pathogens are killed during the cooking process, and even if they were, subsequent handling can reintroduce pathogens that may grow in foods if proper temperatures are not maintained. It is critical to either hold these foods at safe elevated temperatures, or rapidly cool to safe cold temperatures. Cooling and cold holding will be discussed later in this module. Let’s turn our attention now to the procedures used for and the controls necessary for the hot holding of food products.

*Notes:*

Foods may be taken directly from the cooking process to hot holding. In other instances, a food product is cooked, cooled, then reheated and placed into hot holding. It is crucial for holding that the minimum product temperature of 140° F be maintained. The danger during hot holding is that spores of organisms such as *C. perfringens* will germinate and begin rapidly reproducing.

**HOT HOLDING**

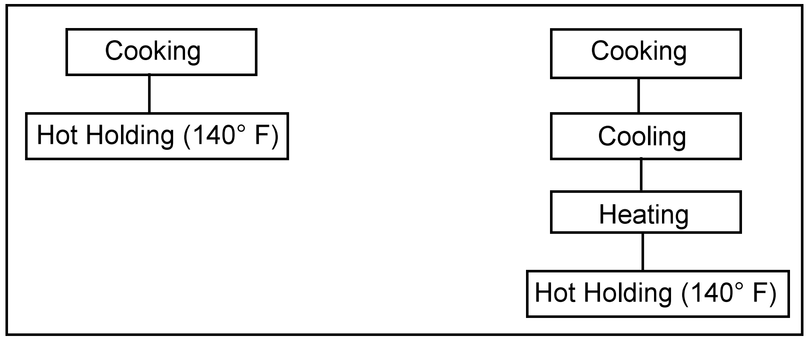


*Figure 17.*

## 8.1 FOOD CODE REQUIREMENTS

The FDA Food Code specifies that potentially hazardous foods are to be held at 140°F or above. An exception to this rule is allowed for whole beef roasts and corned beef. It allows a minimum hold temperature of 130°F if they have been cooked or reheated to the temperatures and time specified for these products in the Food Code under Section [3.402.11(B)]. See Figures 18 and 19.

| OVEN TYPE | OVEN TEMPERATURE BASED ON ROAST WEIGHT | |
|---|---|---|
| | Less than 4.5 kg (10 lbs.) | 4.5 kg (10 lbs.) or More |
| Still Dry | 177°C (350°F) or more | 121°C (250°F) or more |
| Convection | 163°C (325°F) or more | 121°C (250°F) or more |
| High Humidity[1] | 121°C (250°F) or more | 121°C (250°F) or more |
| [1] Relative Humidity greater than 90% for at least 1 hour as measured in the cooking chamber or exit of the oven; or in a moisture-impermeable bag that provides 100% humidity. | | |

*Figure18.*

And

All parts of the food must be heated to the temperatures and held for the time that corresponds to that temperature as specified in Figure 19.

| TEMP °C (°F) | TIME[1] IN MINS | TEMP °C (°F) | TIME[1] IN MINS | TEMP °C (°F) | TIME[1] IN MINS |
|---|---|---|---|---|---|
| 54(130) | 121 | 58(136) | 32 | 61(142) | 8 |
| 56(132) | 77 | 59(138) | 19 | 62(144) | 5 |
| 57(47) | 47 | 60(140) | 12 | 63(145) | 3 |
| [1] Holding time may include post-oven heat rise. | | | | | |

*Figure 19.*

For several reasons, the food manager may wish to hold food products hot enough to serve, but below safe food holding temperatures. An example is maintaining prime ribs at below safe temperatures to assure that they are kept rare. Other reason may include maintaining marginal temperatures to prevent drying of the food, over cooking it or the development of a film on soups or gravies. It is therefore important to attempt to educate food managers to assure that they understand that it is critical to maintain proper hot hold temperatures. It is important that decisions about holding temperatures are based on food safety and not on food presentation. If presentation is important, these foods should be prepared for immediate service.

## 8.2 METHODS FOR HOT HOLDING

There are several methods and types of equipment used in the hot holding of foods. The most common use of hot holding is in the cafeteria style serving of foods. Meats and poultry served from cafeteria or buffet lines can be placed in typical hot hold pans on steam tables, in bain-maries, storage units, etc.  Regardless of the method employed, it is important to remember that it is not the thermostat setting of the hot holding equipment, but the temperature of the food that must be controlled.

Remember that some of the equipment designed for hot holding of food should not to be used for heating. This equipment is designed to hold temperatures that have already been reached, and may not have sufficient heating capacity to adequately reheat food products that have already been cooled.   Cold foods placed in food equipment could remain too long in the temperature danger zone, allowing for the growth of pathogens. Other considerations in hot holding

**Notes:**

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should include:

- The amount of food placed into hot holding equipment must not exceed its capacity.

- The occasional stirring of food in hot hold to assure uniform temperatures. Temperatures in the top of deep containers can cool to favorable growth conditions. Occasional stirring of these containers will promote temperature uniformity.

- There must be safeguards to prevent contamination of the foods from contact with the customers.

## 9. COOLING

The cooling of meat and poultry products is critical for prevention of pathogens. The following sections deal with cooling factors that are important at the retail level.

### 9.1 PURPOSE OF COOLING

Holding food temperatures above 140°F for extended periods can have an undesirable effect on the quality of foods due to such things as loss of nutrients, flavor changes, and drying of the food. Cooked foods are usually cooled in order to be stored for longer periods at refrigerated temperatures. Refrigerated foods must be held at 41°F or below.

Improper cooling of potentially hazardous foods is consistently identified as a leading cause of confirmed foodborne illnesses in this country. Outbreaks occur because foods can contain spores or be re-contaminated with vegetative cells of pathogens during cooling. Re-contamination occurs through a variety of poor sanitation practices such as hand contact, contact with raw foods, unclean equipment, etc. If such contaminated foods are allowed to stay within the danger zone for extended periods, pathogens can grow to levels sufficient to cause food illness.

### 9.2 COOLING STANDARD

To assure that potentially hazardous foods are cooled safely through the danger zone, a two-part cooling standard has been developed. They must be cooled from 140°F to 70° F within two hours, and then from 70°F to 41°F within four hours.

**COOLING STANDARD**

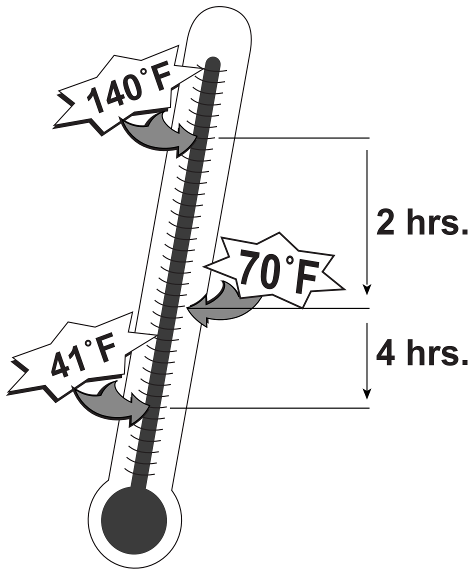


*Figure 20.*

Most pathogens' optimal growth temperatures fall between 140°F and 70°F, therefore it is crucial to move the temperatures of foods rapidly through this range. Once this temperature range has been passed, pathogen growth slows, and an additional 4 hours can be taken to finish cooling to 41°F. If a potentially hazardous food has been previously held at temperatures in the danger zone, the time they were held at those temperatures must be accounted for.

You should be aware that this two-part standard may not apply to all foods. The Food Code specifically addresses foods prepared from ingredients held at room temperature, for example, canned chicken. Since the starting temperature of the food is generally around 70°F, they must be cooled to 41°F within four hours. The Food Code also recommends that all ingredients for cold salads be refrigerated prior to assembly.

## 9.3 FACTORS THAT AFFECT COOLING

Cooling of food products is affected by a number of factors, such as the temperature of the food at the start of cooling, its size, density, shape, surface area, and other factors that influence the rate of heat transfer from the food. Remember we discussed heating of foods by conduction, convection and forced convection. These same principles also apply during the transfer of heat out of a food product during cooling. We will discuss the cooling factors Initial temperature, pre-cooling, stirring, use of ice, size and shape, density, and insulation.

***Notes:***

*Notes:*

## a. INITIAL TEMPERATURE

The initial temperature, or IT is a term that refers to the temperature of a product at the beginning of a process. The IT of a food can influence the amount of time necessary to cool the food to a safe temperature. The difference between temperature of the food and its surrounding refrigerator air temperature dramatically affect the cooling rates. At first, when the hot food is exposed to the very cold air in the refrigerator, the rate at which the food is cooled is rapid. However, as the temperature of the food and the air temperature of the refrigerator come closer together, the rate of cooling of the food becomes slower and slower.

**COOLING RATE**

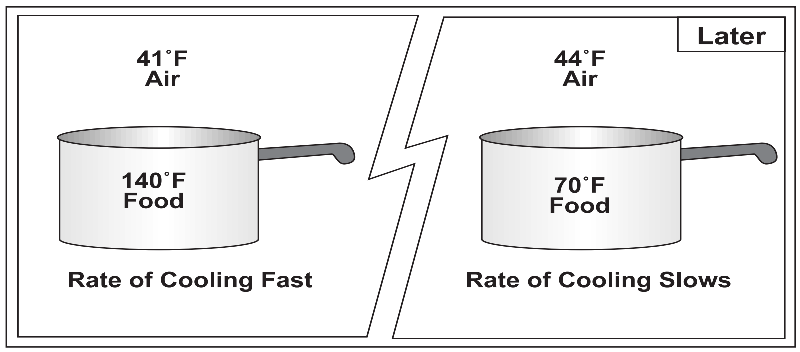


*Figure 21.*

In addition, the hot temperature of a food at 140°F may tax the capacity of the refrigerator or cooler. For this reason, very hot products should not be taken from cooking and placed directly in a refrigerator. It is much preferable to pre-cool to a more acceptable temperature before the product is placed in the refrigerator.

**AFFECT ON COOLING CAPACITY**

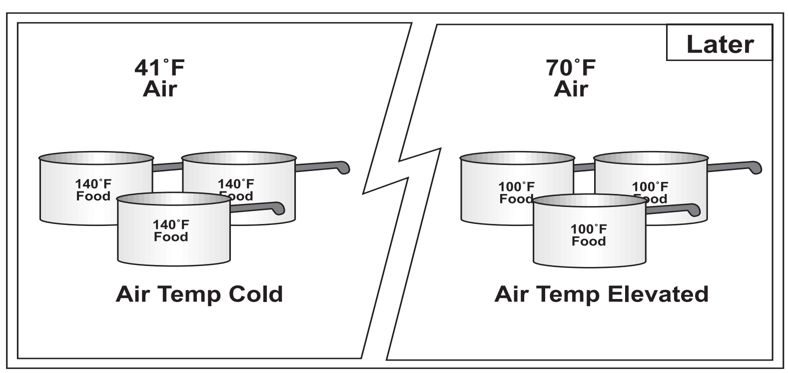


*Figure 22.*

## b. PRE-COOLING

Adequate refrigeration capacity is essential to proper cold holding. However, a normal commercial refrigerator or walk-in cooler is designed to <u>hold</u> foods at refrigeration temperature rather than provide rapid cooling of large volumes or very hot products. Refrigerators usually need some help to rapidly chill foods, depending on the type, size and temperature of the food to be cooled, and the design and capacity of the refrigerator.

The use of ice baths is an excellent way of reducing the food temperatures to a point where a refrigerator should be able to handle further cooling. For example, a 10-gallon container of thick soup or stew could take as much as 24 hours or longer to cool if the hot container was placed in the refrigerator as one unit. By dividing this product into 10-one gallon containers, we reduce the distance that the heat must be transferred through and the time needed to cool the product to a safe temperature can be significantly reduced. However, it may still take longer than the time allowed in the two-part cooling standard if we place the containers of food in the refrigerator while they are still hot. By placing these one-gallon containers in an ice bath and occasionally stirring the product we can more easily pre-cool the product to 70°F within the required two hours.

The two-hour limit for passing from 140°F to 70°F must be met. If pre-cooling only lowers the temperature to 90°F, and this takes one hour, then the refrigerator must be capable of reducing the temperature from 90°F to 70°F in one hour, and subsequently to 41°F within an additional four hours. Remember that during any pre-cooling steps, products must be protected from contamination.

**PRECOOLING**

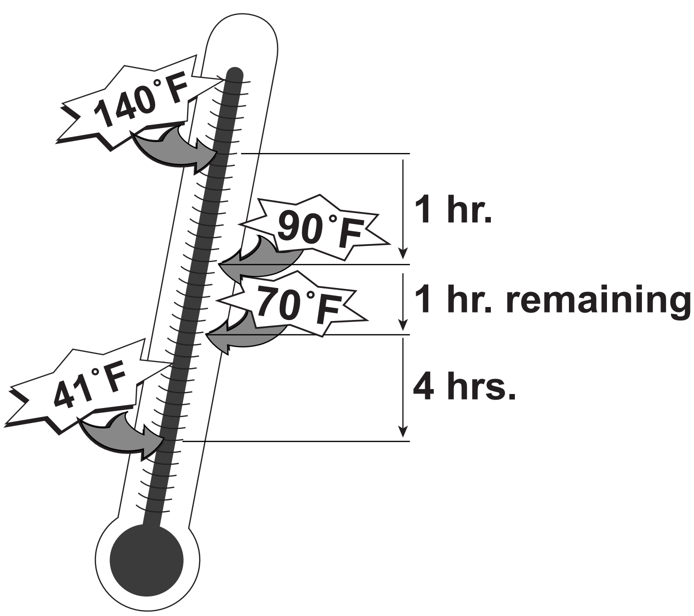


*Figure 23.*

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### c. STIRRING

Stirring of the liquid product is critical to assure uniform and overall rapid cooling. Stirring provides a forced convection environment for heat transfer that may not exist. If products are not stirred, the product will continue to have warm spots that can support the germination and growth of microbes such as *C. perfringens*. This is especially true of thick materials where the development of convection currents is not likely to occur. A food having a thick consistency placed in an ice bath and not stirred can continue to have a temperature above 70°F near its geometric center well beyond the two hours allowed in the standard. In cooling we are concerned about the elimination of hot spots in the product.

### d. USE OF ICE, ICE PADDLES AND METAL PINS

To rapidly reduce the temperature of some products, ice can be added directly to the product. However, the melting ice may dilute the product, and the food handlers and cooks would need to compensate for the added water in the recipe. Ice paddles can be used to cool the product and avoid the dilution problem. These metal paddles are hollow, allowing ice to be placed in them. Since the metal is an excellent conductor of heat, these paddles are a very effective way of rapidly cooling hot products. However to obtain rapid efficient cooling, the product must be stirred frequently during cooling. Another use of metal to cool a product is metal cooling pins that are inserted into a food item leaving a portion of the pin exposed to cooling air currents. The metal acts as a heat sink and absorbs heat from the food item and subsequently transfers it to the surrounding air.

### e. SIZE AND SHAPE

Conduction cooling involves heat transfer out of a solid product from molecule to molecule. The distance from the surface to the center of a food mass influences the rate at which the food cools to a safe temperature. The size and shape of large food masses should be reduced and surface area increased to improve heat transfer and speed cooling.

Turkeys, hams or roasts should be deboned or cut into slices and then layered not more than a few inches deep for cooling. This decreases the thickness, and increases the surface area exposed to cold air currents, resulting in faster cooling.

Large quantities of foods should be placed in shallow pans for cooling. The depth of the food in these pans should not exceed four inches, and they should be placed to allow the free flow of air around them during cooling.

### f. DENSITY

As a general rule, higher density foods contain more water, and since water is an excellent conductor of heat, foods with high water content transfer heat faster. In addition to aiding the removal of heat from solids and semisolids by **conduction**, when the water content reaches levels that causes the food to be fluid, cooling may be increased due the development of **convection** currents. For example, a thick mass of turkey dressing, in which cooling is by **conduction,** will cool much slower than a thin soup stock, where **convection** currents aid cooling. Stirring this same soup stock will create forced convection currents that will cause faster cooling.

### g. INSULATION FACTORS

It is important to recognize the insulating properties of some food containers, and guard against their use during cooling. Stainless steel is an excellent conductor of heat, and food containers of this material will facilitate cooling. Plastic containers do not conduct heat rapidly and can serve to insulate foods against cooling. Covering of food containers also serves as an insulator.

The free movement of air at the surface of a food facilitates rapid cooling. Clear plastic wrap that adheres to the sides of the food container and seals air in, and other covers that tend to insulate the food should be avoided. Since cooling is much faster when a food is uncovered, it is preferable to leave food uncovered unless there is a danger of cross contamination. If covers are needed to prevent contamination from dripping or other contaminants, a loose fitting cover should be applied. An offset lid or aluminum foil, which is tented over the food container, serves to protect the food and allows for free air movement over the surface of the product which promotes cooling. Once a food reaches 41°F, a more secure lid can be used.

## 9.4 TYPES OF COOLING UNITS

### a. REFRIGERATORS AND COOLERS

As mentioned earlier, most refrigerators are designed to keep cold foods cold. They are not designed to quickly cool large volumes of hot foods through the danger zone. Foods can be cooled in refrigerators if proper procedures such as pre-cooling foods described earlier are followed.

There is a variety of cooling units available for use in retail including walk-in coolers, reach-in and pass-through units. A small reach-in or pass-through unit may be all that is needed by a small retail operation. Care should be taken to not over

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fill these refrigerators beyond their cooling capacity. In addition constant opening of the doors can have a dramatic effect on the units ability to maintain proper temperatures causing undue stress on the cooling unit. This is especially true in pass-through units that have doors on both sides.

Some refrigerators have fans that move the air to improve cooling. Air movement is important to proper cooling, and care should be taken to assure that the manner of storing foods in these refrigerators does not impede this flow of air. Shelving in walk-in coolers is designed to be open to facilitate air movement. Occasionally food managers line these shelves to prevent contamination of foods stored on lower shelves. If you encounter this during your inspection, you should discourage this practice since it can prevent proper air movement and limit the ability to cool foods rapidly.

The adequacy of refrigerators depends on the amount, types, as well as the temperatures of foods being cooled in them. The refrigerator's ambient air temperature is important, however, the significant factors are the temperatures of foods being held in them, and the amount of time a food product remains at temperatures between 140°F and 41°F.

In order to evaluate the adequacy of the refrigerator to adequately cool a food, temperatures must be measured throughout the time it takes to move the food through the danger zone.

**b. RAPID CHILLING METHODS**

There are pieces of equipment that are designed specifically for rapid chilling of hot foods, for example tumble chillers and blast freezers. While a tumble chiller may not be economical for small operation, they may be found in larger retail facilities that produce large volumes of foods. The basic principle is that uniform size food items are sealed in plastic and then dropped into ice cold water where they are tumbled to chill quickly. Foods can easily pass through the temperature danger zone in these chillers within two hours. Blast freezers are freezers that can also cool foods to safe temperatures very rapidly. There are also rapid chill refrigerators that have large capacity compressors and fans to blow cold air over the foods to chill them quickly. When shallow pans are used to hold the foods in these refrigerators, temperatures can be lowered rapidly through the danger zone.

## 10. COLD HOLDING

*Notes:*

During the last section, we discussed the rapid movement of the temperatures of potentially hazardous foods through the Danger Zone. During this portion of the program, we will discuss the reasons and methods used for keeping food temperatures below the Danger Zone.

### 10.1 PURPOSE

Refrigeration and low-temperature storage equipment is designed to maintain perishable foods at chill temperatures and prevent pathogen growth. In addition to inhibiting microbial growth, refrigeration temperatures also slow enzymatic actions and other biological and chemical actions that may enhance rancidity, and quality deterioration of foods.

### 10.2 PATHOGEN GROWTH RANGES

Our focus in this section will be the inhibition of pathogen growth through cold holding. *L. monocytogenes* and *Y. enterocolyticus* continue to grow at very low refrigeration temperatures. In fact, some growth of these organisms occurs at temperatures slightly below freezing. Unlike many other pathogens, cold holding does not control these two microorganisms. Fortunately, the growth of most other foodborne pathogens does not occur at temperatures below 41°F. It should also be pointed out that, although some growth does occur at low temperatures, this growth is relatively slow for most pathogens in the range of from 40°F to 60°F.

An excellent source of information on the growth of various pathogens can be found on the internet at www.arserrc.gov/internet/mfs/pathogen.htm. This site contains a pathogen-modeling program for windows that users can download free of charge. With this software, you can plug-in various growth parameters and obtain growth curves for the pathogens. Figure 24 is an example of the information you can obtain from this program. It shows the dramatic difference in Salmonella growth at the temperature of 60°F and 80°F. These types of charts can be useful for demonstrating the significance of temperature and other growth factors to retail managers. Instructions for downloading, installing and using the software can be found at the listed internet web site address.

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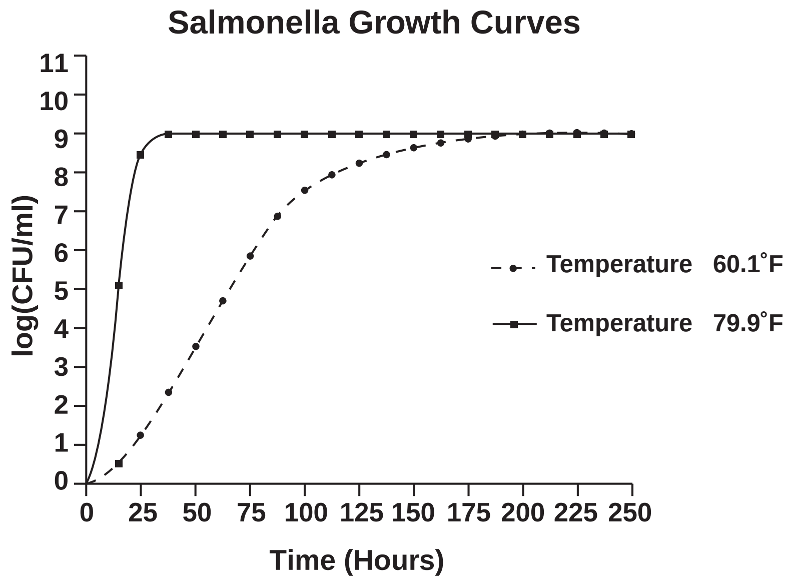


*Figure 24.*

## 10.3 METHODS OF COLD HOLDING

The cold holding temperature required in the Food Code for potentially hazardous foods is 41°F or below based on controlling the growth of *L. monocytogenes*. Temperatures can be controlled during cold holding by ice, chemical coolants such as gel packs, and by mechanical refrigeration. If controlled by ice or chemical coolants, temperature control can be assured by determining if there is an adequate supply of ice or chemical coolant present.

In determining if there is adequate mechanical refrigeration to maintain a food at proper temperatures, the ambient temperature of the refrigerator should be used as an indicator. Internal food temperature measurements are the only way to assure that the product is being maintained at the proper cold hold temperature.

## 11. DATE MARKING

The Food Code effectively establishes a time by which Ready-to-Eat foods should be consumed or discarded under section 3-501.17, (**Ready-to-Eat, Date Marking**). The amount of time Ready-to-Eat foods may be held depends upon the temperature at which it is stored. Products stored at or below 41°F must be date marked and may be held for up to seven-days, while those stored at 45°F or below must be date marked and may be held for up to four days. It should be noted that these holding times include the day of preparations, and are based on the predictive growth model for *L. monocytogenes*.

**Date Marking of Products in Storage**

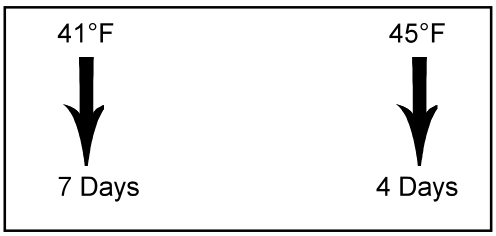


*Figure 25.*

## 12. REHEATING

Following cooling of a potentially hazardous food, it may be may be reheated for hot holding. There are some particular concerns relative to this reheating that should be addressed and we will discuss them under this section.

### 12.1 REHEATING TEMPERATURES

The Food Code addresses reheating under section 3-403.11 “Reheating for Hot Holding.” This section requires that all parts of the food must be heated to temperatures as follow:

a. Microwave reheated foods must be heated to 165°F, and allowed to stand for two minutes after reheating. In addition, the food must be stirred or rotated and covered during reheating.

b. Ready-to-Eat foods from hermetically sealed containers, or an intact package from a food processor that is under routine inspection by a regulatory authority must be reheated to 140°F.

c. Unsliced portions of beef roast cooked under the conditions specified for beef roast in Food Code must be

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reheated using those same cooking parameters. This allows for an internal temperature of as low as 130°F if the proper oven temperatures and humidity requirements are met.

d. Foods except those we just discussed, must be reheated to 165°F.

### 12.2 REHEATING CONCERNS

Proper reheating provides a final lethal step of protection against pathogens before service to the customer. Reheating of the food will destroy the vegetative cells that may have developed in the food. The same cautions must be observed during reheating as during the original cook. The internal temperature at the coldest spot of the food must reach the required temperature, and be held there for the specified period of time. Equipment used for reheating must be capable of bringing the food to the required internal temperature.

Reheating does not destroy heat stable toxins that may have been produced in the food by pathogens. This is why cooling and cold holding are so important.

## 13. TIME AS A PUBLIC HEALTH CONTROL

We have just talked about the time a food product may be held at certain controlled temperatures (below 41°F or 45°F). Let's now explore the requirements for foods held at room temperature. Throughout the Food Code, time and temperature are used together to assure adequate control over the possible development of pathogens in foods served at retail. This means food establishment must adhere to both the time and temperature requirement for cooking, hot hold, cooling, cold holding, and reheating.

There is one provision in the Food Code that does not address temperatures. Section 3-501.19 of the Food Code allows for the use of time alone as a public health control for a supply of Potentially Hazardous Food if these foods are displayed or held for service for immediate consumption. This means that the temperature at which the food is stored is not controlled, only the time of storage is considered. The Food Code provides specific requirements for this process, and no exceptions are allowed.

To rely on time alone:

a. Such food must be marked to show the time four hours after the food was removed from temperature control. In other words, if the food product was removed from the refrigerator at 12:00 (noon), then the product must be marked to show it must be discarded at 4:00 PM.

b. If the food requires further cooking, it must be served immediately after cooking, or discarded four hours after it has been removed from temperature control.

c. If the manager finds that these foods have been improperly marked, that is to say they have not been marked at all or have been marked to indicate a time in excess of four hours after they were removed from refrigeration, they must be discarded.

d. In addition, the procedures used by the manager to assure compliance with the above requirements must be in writing. These procedures must be provided to the regulatory authority if requested.

## 14. THERMOMETERS AND THEIR USE

Throughout this program we have emphasized the use of temperatures as a control to prevent the unwanted growth of pathogenic microorganisms in our food supply, and we have discussed the need to monitor temperature in these products. There are a variety of different types of temperature measuring devices, and we will discuss their use and limitations in this section. The measuring devices that will be discussed are the mercury-in-glass thermometer, the bimetallic metal stem thermometer, the digital thermometer, the maximum indicating thermometer, a thermocouple, infrared thermometer, and recording thermometer.

Although we will not discuss the calibration of thermometers, it is important to understand that to assure accuracy, thermometers should routinely be calibrated to a known temperature. Each thermometer should be marked to show the last calibration date, and written standard operating procedures should establish the maximum time a thermometer can be used before re-calibration.

Each type of thermometer has features that make it the most ideal tool to obtain needed temperature measurements. It important to know the features of each type of thermometer, so you can use the appropriate tool for the job at hand.

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*Notes:*

## 14.1 TYPES OF THERMOMETERS

### a. MERCURY-IN-GLASS

Mercury-in-glass thermometers are usually accurate and reliable. However because of possible breakage, care must be exercised in their use around unprotected foods. For this reason their use in retail food establishment is limited.

### b. BIMETALLIC STEM THERMOMETERS

A bimetallic metal stem thermometer is commonly referred to as a dial thermometer, and it is the most frequently seen thermometer in use in the food industry. It is about 5 inches long, and usually there is a dimple near the end of the stem. They contain a coiled helix that expands and contracts in reaction to temperature changes, and therefore are slower to react than digital thermometers. These thermometers are intended to take temperatures of relatively thick foods. To get an accurate reading, the metal stem must be inserted several inches into the food and left in there for at least 20 seconds. More time is needed for particularly cold foods. The dial thermometer is usually accurate to plus or minus 2°F. Due to the size of the probe, they are <u>not</u> recommended for measuring the temperatures of thin products such as a hamburger patties, or small amounts of food.

### c. DIGITAL THERMOMETERS

Digital thermometers have a wide spread use in the food industry. Their advantage is that they read temperatures rapidly, and they can be fitted with various size probes for specialized purposes such as a thin probe to measure the temperatures of small food items. Their disadvantage is that they can not be calibrated in the field, but must be sent to the manufacturer for this purpose.

### d. MAXIMUM INDICATING THERMOMETERS

The maximum indicating thermometer is used to record the maximum temperature that is reached in a food or a process such as the final rinse in a dish washing machine. An example of a maximum indicating thermometer that we are all familiar with is the fever thermometer. These thermometers are very good in indicating the hottest temperature of a food or food process, however they do not provide information about how long that maximum temperature was maintained.

### e. THERMOCOUPLES

The thermocouple is an electronic device, and may have one or several temperature sensing probes to measure temperatures at several locations at the same time. Thermocouples measure the electric potential at the point where two dissimilar metals touch. They give faster reaction to temperature changes and provide immediate read-out of temperatures, which can be recorded

**Notes:**

### f. INFRARED THERMOMETERS

The infrared thermometer is a new device that can read the temperature of a food without touching it. The device is simply pointed at the food and the surface temperature is read. It has the advantage of fast read-out, and since it does not touch the product, there is no problem with contamination of the food from taking the temperature, and the device does not have to be cleaned between temperature reading of different foods. The major disadvantage is that the device reads only the surface temperature, and this limits its use in retail foods.

### g. RECORDING THERMOMETER

The recording thermometer is used extensively to keep a permanent record of temperature during processes. In retail, the most common place to see this type of thermometer is as a recorder of refrigeration temperatures. In the food processing industry, these devices are widely used to record the temperature of various heat treatment processes such as internal temperatures of cooked roast beef.

## 15. HAZARD ANALYSIS CRITICAL CONTROL POINT (HACCP) APPROACH TO COOKING AND COOLING

As we have discussed, there are many microbial hazards associated with the cooking and cooling of meat and poultry products. Cooking these foods is the most effective operational step in food processes for reducing and eliminating microbial contamination. It is at this step that a food is made safe to eat. Therefore, internal food temperatures and time measurements are very important. Cooking meats and poultry is considered a Critical Control Point. Critical limits are based on the time and temperature parameters in the Food Code.

In a similar manner, the cooling, cold holding and reheating of meat and poultry also present microbial hazards that can be addressed through the use of HACCP. We are touching only briefly on HACCP in this program. Your role as a sanitarian is to promote HACCP, and to verify the adequacy of HACCP you find being used. A later program in this series will focus on HACCP and its implementation.

***Notes:***

A variety of different controls are necessary to maintain the safety of meat and poultry products at the retail level. In this section, we will review some of these controls. We will discuss injected meat products, taco meat, chicken salad, chili, rotisserie chicken, egg rolls, peking duck, gyros, wok fried meat products and barbecued and smoked meats.

## 15.1 INJECTED MEATS

Since the cooking process is designed to eliminate *Salmonella* in the centers of many meat products, you may ask yourself how the *Salmonella* can find its way to that location. In addition to the possible entry from an inadvertent stab, *Salmonella* can be introduced into the center of meat products through the process of injecting liquids into them. Water injections are a common practice in meat products such as hams, turkeys, formed roasts, etc. The fluids used for injection contain water, seasonings and a variety of spices. These fluids are kept cold to reduce pathogens, and the equipment used for the injection process has required cleaning schedules. Although processors are required to have these procedures to minimize the possible contamination of the internal portions of meat products, such contamination does sometimes occur. Therefore, the cooking processes are established to eliminate internal as well as surface contamination with *Salmonella.*

The Critical Control Point to assure safety of this food is proper cooking. The Critical Limits are the internal cooking temperatures as specified in the Food Code.

## 15.2 TACO MEAT

Taco meat consists of ground meat that is routinely cooked in large quantities. This product is often held for extended periods of time and, therefore, it is essential that proper temperature be maintained. Because of the significant hand manipulation of the taco meat in building the finished taco, it is important that incidental hand contact be minimized. It is also important that proper holding temperatures are maintained and, if the food is held for next day use, that rapid cooling techniques be employed. Because of the large volumes of taco meat, rapid cooling must be carefully monitored. It is also important that newly cooked taco meat is not mixed with previous day's supply.

Critical Control Points with this food are hot holding, measures to prevent contamination during serving, and rapid cooling of any food carried over to the next day.

## 15.3 CHICKEN SALAD

Chicken salad and similar cold Ready-to-Eat foods traditionally have a variety of raw ingredients added to them after the cooking step. Some of these raw ingredients, such as celery and onions, contain a wide variety of microorganisms that can be introduced after final cooking. In addition, cross-contamination from raw chicken can occur if the final food is not properly separated from it. It is important to wash and sanitize the cutting boards that are used for both the raw meat and the ingredients that are incorporated after the final cook. It is also essential that proper cooling and cold holding of the finished chicken salad be employed.

Critical Control Points for preparing chicken salad are cooking, prevention of cross-contamination, rapid cooling and cold holding of the chicken salad.

## 15.4 CHILI

Chili is routinely prepared in large quantities, and because the food maintains its flavor, leftovers may be carried over to the next day. Cooling large quantities can be difficult, so dividing the product into smaller containers and pre-chilling is advisable. It is critical that the two part cooling standard is met, and that proper cold holding temperatures are maintained to prevent possible pathogen growth.

Critical Control Points are initial cook temperatures proper hot holding temperatures, rapid cooling and cold holding of any leftover chili.

## 15.5 ROTISSERIE CHICKEN

Fully cooked rotisserie chickens may become contaminated when fresh raw chickens are added to a spit. This may occur from actual contact with the raw product, from the hands of a restaurant employee, or from contamination of the spit and subsequent contamination of the cooked chicken. It is important not to mix raw chickens on a spit with cooked chickens, and that employees wash their hands after handling raw chicken to prevent cross-contamination.

Critical Control Points to prevent this problem consist of cooking, prevention of cross-contamination and proper hot holding.

***Notes:***

*Notes:*

## 15.6 EGG ROLLS

During cooking, egg rolls are subjected to an initial glazing cook and later to a final cook. The initial glazing cook may eliminate competitive microbes, which may allow faster growth of organisms such as *S. aureus*. It is essential that proper cooling is employed to prevent *S. aureus* from growing and producing enterotoxin, which the final cook will not destroy.

Critical Control Points to eliminate this problem is proper hot holding between the two cooking steps.

## 15.7 PEKING DUCK

Peking duck is prepared by a variety of methods. Generally, frozen duck is thawed at room temperature overnight. After they are thawed, they are seasoned with sugar, salt, monosodium glutamate and spices. In some instances the ducks are stuffed with parsley and green onions. The ducks are then dipped in hot water (around 160°F) for several minutes. Following this step they are basted, coated with, or dipped into a vinegar and honey sauce. The pH of vinegar is 2.4 to 3.4 and the water activity of honey is about 0.75. Although this sauce has some effect on the pH and water activity of the duck, most of this effect is surface only.

Next, the skin of the duck is inflated with air from a hose and refrigerated overnight. The following day they are cooked in an oven at 550°F. They are then displayed on counters, or in glass cabinets which are heated with incandescent light bulbs, infrared lamps, or a combination of both. In some instances cooked ducks are displayed at room temperatures for extended periods of time. Ducks that are not consumed are cooled overnight, and are chopped for sale the next day. This chopping subjects the ducks to cross-contamination. A 1981 study by F.L. Bryan and colleagues revealed that when the chopped ducks were reheated, the internal temperatures were not high enough to be lethal to vegetative pathogenic bacteria.

Although these ducks are seldom implicated in food illnesses, studies have determined that the final product will support pathogen growth. For example, water activity values for cooked duck ranged from 0.87 to 0.99 in the 1981 F.L. Bryan and colleagues study.

The Critical Control Points to assure safety of peking duck are proper hot holding, cooling and proper reheating. One of the critical limits is the time at which the whole duck is held at room temperatures. This holding time plus the time needed to cool the food to 41°F must not exceed the two part cooling standard in the Food Code. Reheating must be sufficient to raise the internal temperature to 165°F, and cross contamination must be prevented.

**Notes:**

## 15.8 GYROS

This product is a combination of ground beef and ground lamb prefabricated into an oblong-shaped roll. The rolls can vary in weight from 10 to 65 pounds, with the rolls being as thick as 10 inches in diameter and 18 inches long.

The rolls are cooked by placing them lengthwise on a spit, which is cooked in a vertical position. The roll is rotated past an electric cooking element, which cooks the outer surface of the product. The cooking process takes approximately five minutes, and the outer layer is then sliced away leaving the inner uncooked portion of the roll exposed. When this area of the roll passes by the cooking element, a new layer is cooked. This process goes on until the entire roll is cooked. However, the process does not go on uninterrupted, as cooking is dependent upon customer flow.

The main concern from a public health standpoint are the time and temperature relationships related to the cooking and cooling of the rolls. It is particularly important to keep the rolls at safe temperatures, (below 41°F or above 140°F) during storage and cooking. The proper size roll should be used for the serving period to prevent carryover to the next day. The roll should be used as soon as possible, but in no event should it be allowed to stay on the broiler for more than four hours. A 1979 study by F.L. Bryan and colleagues, revealed that reheating sliced Gyros in a microwave oven or on a grill resulted in safe food temperatures; however, when these slices were heated on broilers, temperatures lethal to vegetative pathogens occurred only at or near the surfaces of the product.

Critical Control Points are proper cooling and cold holding of the rolls after they are formed, cooking the entire roll within four hours and rapid cooling of any portion of the roll carried over to the next day.

## 15.9 WOK FRIED MEAT PRODUCTS

Cooking meat dishes in a wok produces temperatures sufficient to eliminate pathogens only near the surface of the food. It is recommended that only small size pieces of meat products are cooked in a wok to assure proper cooking. It is also important that foods prepared in a wok be consumed promptly or rapidly cooled and held at proper cold temperatures to prevent pathogen growth.

***Notes:***

Critical Control Points are proper cooking, small piece size ingredients, rapid cooling and proper cold holding of any left over food.

### 15.10 BARBECUED AND SMOKED MEATS

Barbecued and smoked meats come in a variety of shapes and sizes, and this variation can influence heat penetration. It is critical that proper internal temperatures are achieved, and the internal temperatures should be measured to assure adequate cooking. Once the meat has been cooked, it is critical that hot hold temperatures be maintained to prevent pathogen growth.

Critical Control Points are cooking to the proper internal temperature and proper hot holding.

# SELF EVALUATION TEST

The following is a test that will allow you to evaluate your knowledge about the cooking and cooling of meat and poultry products. You will be given some time at the beginning of the training to complete the test. After you have received the training you will be given additional time to review your answers and make any corrections. The program monitor will then provide you with the correct answers so you can evaluate how you did.

This is a self-evaluation test, and you will not be graded on it. Some of the questions are multiple choice and some are true/false.

1. Most bacteria of public health concern will not grow below a water activity 9.1, however *S. aureus* can produce toxin at a water activity as low as 8.6.
   __ a. True
   __ b. False

2. Temperature can be used to control microbiological hazards. However, it is usually linked with another important factor. What is it?
   __ a. pH
   __ b. Water activity
   __ c. Time
   __ d. Ingredients in a food

3. *Staphylococcus aureus* produces:
   __ a. Heat resistant spores and heat resistant toxin
   __ b. Heat resistant toxin
   __ c. Heat sensitive toxin
   __ d. A food infection

4. Pre-cooling large volumes of hot food is necessary because:
   __ a. Normal commercial refrigerators or walk-in coolers are designed to hold foods at refrigeration temperatures rather than cool down large volumes of food
   __ b. Once the food is rapidly pre-cooled, there is no concern about maintaining refrigeration temperatures
   __ c. The internal food temperature should be lowered quickly because psychrophiles will not grow in the food at temperatures below 70°F
   __ d. All of the above

5. Which statement concerning freezing is correct?
   __ a. Freezing slows enzymatic actions that can enhance rancidity
   __ b. Freezing kills all vegetative bacterial cells
   __ c. Freezing kills all bacterial spores
   __ d. All of the above

6. Conduction heating is the fastest method for heat transfer to a food product
   __ a. True
   __ b. False

7. Stirring during cooking increases the:
   __ a. Time required to kill pathogens
   __ b. Rate of heat transfer
   __ c. Heat resistance of some bacterial spores
   __ d. Number of cold spots in a food

8. The cooking times and temperatures stated in the FDA Food Code will provide a 12D cook when applied properly.
   __ a. True
   __ b. False

9. The type of cooking employed for a beef stew cooked on a stove top with occasional stirring is referred to as:
   __ a. Conduction Heating
   __ b. Convection Heating
   __ c. Forced Convection heating
   __ d. All of the above

10. Which is true about Ready-to-Eat Foods that have been date marked?
   __ a. The food may be held for 7 days at 41°F or below
   __ b. The food may be held for 5 days at 45°F or below
   __ c. Holding time includes the date of preparation, and is based on the predictive growth model of *C. perfringens*
   __ d. All of the above

11. What is the minimum hot holding temperature in the Food Code?
   __ a. 170°F for poultry
   __ b. 140°F for all Potentially Hazardous Foods
   __ c. As low as 130°F for roasts
   __ d. None of the above

12. The spore stage of pathogenic microorganisms:
   __ a. Can survive cooking processes employed at retail
   __ b. Can survive freezing
   __ c. May be stimulated to germinate into vegetative cells by the cooking process
   __ d. All of the above

13. Moisture affects the cooking process if it:
   __ a. Is contained in the food product
   __ b. Surrounds the food product being cooked, so that heat from the heat source is transferred to the food
   __ c. Is contained within the bacterial cell wall
   __ d. All of the above

14. Growth limiting factors such as the pH and water activity of a food can have a cumulative effect on the resistance of microbes to heat.
   __ a. True
   __ b. False

15. Which of the following completes this sentence accurately? The D Value is a measure of cooking time and is specific to:
__ a. Temperature
__ b. The food being cooked
__ c. A microbe
__ d. All of the above

16. The Food Code recognizes both temperature and time as a unit in the cooking process.
__ a. True
__ b. False

17. All toxins produced by pathogens are heat stable.
__ a. True
__ b. False

18. The two part cooling standard in the Food Code:
__ a. Describes the process of dividing large quantities of foods into two separate parts to speed the cooling process
__ b. Describes a process for cooling which requires some Potentially Hazardous Foods to be cooled in a refrigerator while other such foods must be cooled in a blast freezer
__ c. Requires the temperature of potentially hazardous foods to be reduced from 140°F within two hours and then cooled to 41°F within an additional four hours
__ d. None of the above

19. Which of the following completes this sentence? The temperature range referred to as the "Danger Zone" is:
__ a. The optimum growing temperatures for foodborne pathogens
__ b. 70°F to 140°F
__ c. 41°F to 140°F
__ d. 60°F to 120°F

20. A foodborne infection attacks the host cells, and normally causes a fever.
__ a. True
__ b. False

At the end of the test, please record the number of correct answers you gave at the beginning, and at the end of the training in the space provide below. You will be asked to provide this data on the course evaluation sheet. You will not be required to identify yourself on the evaluation sheet.

**Number of correct answers at the beginning of the training:** ____

**Number of correct answers at the end of the training:** ____

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