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clostridium perfringens food poisoning

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"Round about the cauldron go;
In the poisoned entrails throw."

An ancient witches' rhyme — used while mixing an evil potion.

"Make the gruel thick and slab;
Add thereto a tiger's chaudron,
for the ingredience of our cauldron."

At one time, people believed witches' chanting was necessary to cause an evil happening.

"Double, double toil and trouble,
Fire, burn; and, cauldron, bubble."[1]

Today, as in the past, it is possible to unknowingly create evil by causing illness through improper handling of prepared food. The witches' chant is unnecessary . . . only sloppy kitchen habits, and not understanding what causes food-borne disease nor how to prevent it.

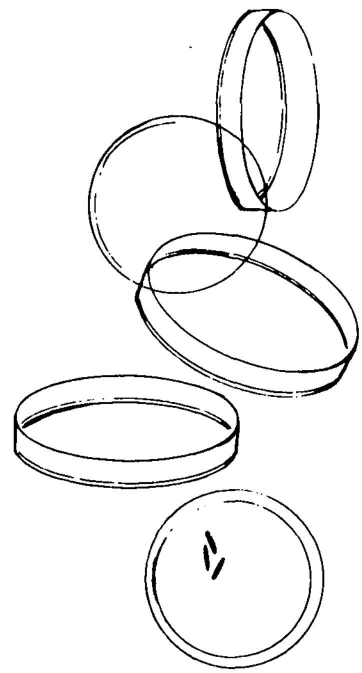
Classically, food-borne disease is divided into two general types. True food poisoning or food intoxication, the first type, is caused by eating food containing poison or toxin from bacteria growing in the food. **Botulism** and **Staphylococcus food poisoning** are this type. A food-borne infection, the second type, is caused by eating food containing certain organisms that may or may not have grown in the food. Once these organisms are in the body system, illness and microbial growth can result. **Salmonellosis** is an example of this type of food-borne disease.

It is difficult to classify the food-borne illness caused by *Clostridium perfringens* in either of these categories. Researchers know extensive organism growth in the food and consumption of live organisms are necessary for the sickness to occur, but they have not found a free toxin or poison. On the other hand, eating food containing small numbers of C. *perfringens* does not cause the illness, suggesting that extensive growth does not occur within the intestinal tract or at least does not result in illness. Therefore, I will call the food-borne disease under consideration **Clostridium perfringens food poisoning.**

[1]Witches chant from Act IV, Scene 1 of *Macbeth* by William Shakespeare.

Increased Occurrence

In recent years, this type of food poisoning has become one of the major causes of *reported* outbreaks.[2] In 1968, 11.6 percent of the reported outbreaks were caused by *C. perfringens*, while in 1969, the number rose to 17.5 percent. You can judge the magnitude of the illness by the number of people made ill by this organism in these reported outbreaks. In 1968, 27.8 percent (close to 5,000 people) of the total reported outbreaks of food-borne illness were caused by *C. perfringens*. In 1969, the percentage increased to 64.9 percent — more than 18,500 people (1, 2).[3]



Like other food-borne diseases, it is difficult to determine the actual number of outbreaks because most outbreaks go unreported. It has been suggested that reported outbreaks represent only 10 percent of the actual number of food-borne illness outbreaks that occur. If this suggestion is true, then the real number of food-borne illness outbreaks must be overwhelming. Any steps to reduce these numbers should indeed be welcome.

Clostridium perfringens food poisoning has often been tagged a problem of the food service industry, since most outbreaks are associated with mass-feeding operations. Foods most often involved in outbreaks of **C. perfringens food poisoning** are usually meat or poultry that have been cooked and held for some time before serving. Outbreaks more often occur after large banquets or at schools or hospitals where large amounts of meat, poultry, and their gravies are prepared. However, this does not mean that **C. perfringens food poisoning** is limited to meals eaten away from home. It is highly possible to develop home kitchen conditions that will cause an outbreak — indeed this has happened many times. Symptoms of the illness are abdominal cramps, diarrhea, occasionally nausea, and rarely fever or vomiting. The symptoms usually appear 4 to 22 hours after eating and may persist for 1 to 5 days. Mortality rate is extremely low.

Since the symptoms are relatively mild, the illness may go unreported or if the ill individual does consult a doctor, the illness may be diagnosed as "stomach flu" or a "virus" and disregarded or forgotten. However, if the outbreak occurs at a large gathering, such as a banquet or picnic or at a public institution, steps usually are taken to determine the cause of the illness and to report and document the outbreak.

In previous years, preoccupation with **salmonellosis** and **staphylococcus food poisoning** often obscured this microbiological problem. Recent developments in bacteriological investigation techniques have helped to bring the problem more clearly in focus and to delineate its occurrence. The apparent increase in reported outbreaks may be a reflection of better isolation and identification techniques and a greater emphasis on the part of public health officials in reporting food-borne disease outbreaks.

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[2] An "outbreak" is an occurrence of an illness that involves a number of individual cases or persons who become ill. Thus, the number of reported cases will always be greater than the number of reported outbreaks.

[3] Numbers in parentheses refer to references on page 14.

Conditions Needed for Outbreak

In order for **Clostridium perfringens food poisoning** to occur, several conditions are necessary (3):

1. the food must contain the microorganism, *C. perfringens*
2. the food must be suitable for organism growth
3. food temperature must be suitable for growth
4. there must be sufficient time for bacterial growth
5. the contaminated food must be eaten

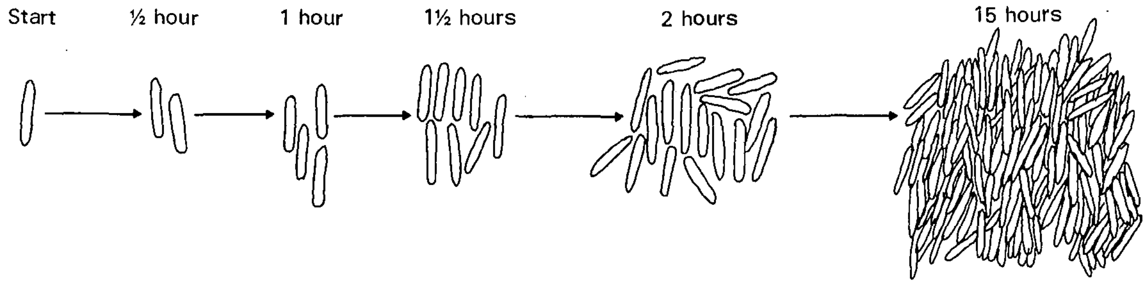
Clostridium perfringens grows anaerobically, that is, it grows best when there is no air or free oxygen present in its environment. The organisms are rod-shaped bacteria and have the ability to form spores. In the spore form, they are more difficult to destroy than when in the vegetative or growing form.[4] These organisms are present almost everywhere, but chief sources are: soil, man or animal intestinal tracts, fecal material, and sewage. Because they are found everywhere, it is difficult to keep them out of the food supply.

Vegetative *C. perfringens* cells in food are destroyed by the heat of a thorough cooking, but heat-resistant spore forms of the organism are not. Thus, we cannot rely on cooking food to destroy this bacteria. The three principles related to the control of food-borne disease are:

1. limit or prevent contamination of the food by the microorganism
2. destroy the microorganism by some treatment of the food
3. prevent or inhibit the growth of the microorganism

Of these three, the last principle seems to be the most practical preventive measure of **C. perfringens food poisoning** (4). To utilize this control principle, we must try to understand what influences the organism growth in foods and how to prevent it.

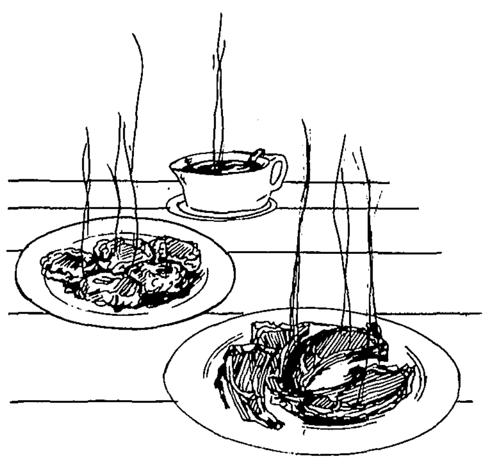
[4] *Vegetative* microorganisms are actively growing. *Spores* are dormant, that is, inactive or not growing and must *germinate* to become vegetative cells. The term "germination" refers to the processes involved when a spore changes into a vegetative cell.



Growth Requirements

Bacterial growth is measured not as an increase in size but as an increase in numbers. Many bacteriologists, when talking about bacterial growth, use the term "multiplication," which really describes how bacteria grow. One cell divides and becomes two, two become four and so on until millions of cells develop. Growth in this manner continues until the source of the microorganism's food is exhausted. Since microorganisms are extremely tiny, a very small amount of food can support the growth of millions of bacteria. Consequently, bacteria in a human food supply are in a favorable environment and can grow very rapidly, if other conditions also are favorable.

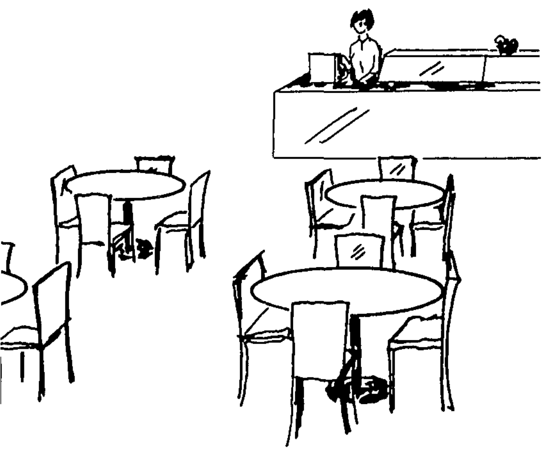
Clostridium perfringens is rod-shaped, appearing under the microscope as a short, thick, blunt-ended rod, usually alone or in pairs but occasionally in short chains. *C. perfringens* has exacting nutritional needs, requiring 13 to 14 amino acids and five to six vitamins. These nutritional requirements may play a role in the types of foods associated with this illness. Foods usually involved are often high in protein, such as meat, meat gravies, and meat dishes.



The organism can grow over a wide temperature range. It has been observed growing at about 60°F., although growth at this low temperature is extremely slow. Maximum growth temperature (highest temperature at which growth is observed) is close to 125°F. The organism grows best (optimum growth temperature) between 110° and 117°F., temperatures quite frequently found in warm food storage areas. At these temperatures, sufficient numbers of *C. perfringens* can develop in a relatively short time to cause the illness.

As was pointed out earlier, these bacteria grow extremely well where there is no air or oxygen present. Heating of food, particularly liquids such as gravies or soups, drives out air and oxygen and creates an ideal environment for the organism growth, if proper precautions are not taken after heating to prevent growth.

Scope of the Problem



Public Health statistics indicate an increase in **C. perfringens food poisoning.** But one must question whether this increase is due to greater reporting activity or to a real increase in occurrence. It is not a new disease because **C. perfringens food poisoning** was first reported in 1895 and again in 1899 in Europe (noted in reference 4). In England, this microorganism has been identified as a cause of food-borne illness for many years. Only in the past few years has *C. perfringens* been implicated in food poisoning outbreaks in the United States. This is despite the fact Dr. L. S. McClung, a bacteriologist at the University of Indiana, called attention to it as a cause of food poisoning more than 25 years ago (5).

Another factor influencing the apparent increase in **C. perfringens food poisoning** is the recent change in U.S. food consumption patterns. Not too many years ago, almost all meals were eaten at home. Now, nearly 50 percent of the meals are eaten away from home. More than 100 million meals are served daily by 400,000 food service establishments. Of these meals, 82 percent are served in public eating places and the rest are served in hospitals and other institutions. Food preparation is in a transitory period, shifting from the traditional use of basic ingredients to the use of prepackaged, frozen, ready-to-cook, reconstituted foods, portion-control prepared foods, and many other types of convenient ready-to-serve foods (6). Thus, people have a greater chance to become sick from contaminated food prepared away from home under unknown conditions.

Foods Involved

Many types of foods have been implicated in outbreaks of **C. perfringens food poisoning.** Those involved most frequently are:

1. meat, mainly roast beef and its gravies
2. poultry, usually turkey, dressing, or gravy; chicken less frequently
3. gravies made from red meat, poultry, and mushrooms
4. prepared dishes containing vegetables, or macaroni products usually with meat, poultry, or fish

In general, any food prepared and kept warm for long time periods before eating may be a source of this type of food poisoning. Thus, persons attending large banquets where foods are prepared ahead of time and kept warm for several hours are prime targets for this illness.

Reported Outbreaks

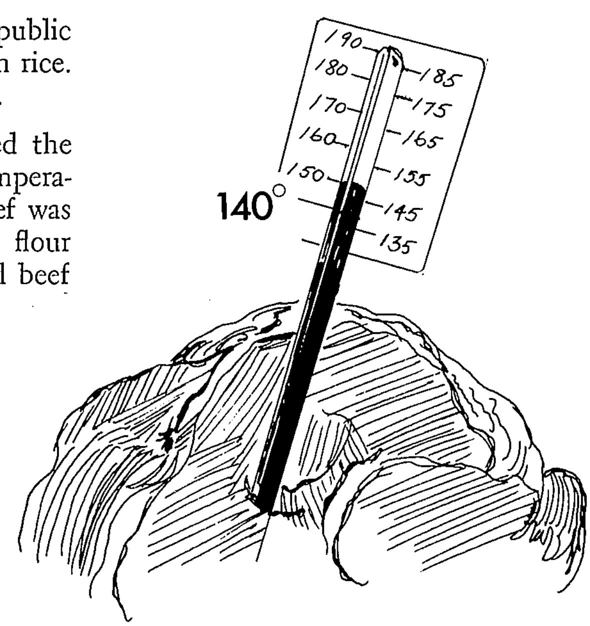
A few examples of recent outbreaks of **Clostridium perfringens food poisoning** may be the best way to demonstrate how simply the illness can occur and how easily it can be prevented.

An outbreak occurred a few years ago in the dormitories of a large midwestern university. The illness was confined to students eating at three of the six dining halls that serve 3,000 students through a common kitchen. A total of 2,954 students ate the evening meal. Of these, 366 developed an illness characterized by diarrhea, abdominal cramps, and little or no fever. Food samples were analyzed microbiologically, but the analysis did not indicate *salmonellae, shigellae,* or *staphylococci.* Heat-resistant *C. perfringens* was shown to be the cause and the food vehicle was gravy.

Apparently, the gravy was contaminated during preparation. While the gravy kept warm on the steam table, *C. perfringens* grew to such an extent that food poisoning resulted. The meat gravy provided an ideal environment for the growth of these bacteria: a nutritious food source, anaerobic growth conditions, and ideal growth temperature. This outbreak could have been prevented if the gravy had been kept at a temperature high enough to prevent growth, **above** 140°F. (7).

A large outbreak occurred in school cafeterias in a Tennessee public school system. The entrée for the noon luncheon was braised beef on rice. Of the approximately 67,000 persons served, about 13,500 became ill.

The beef had been delivered to the school kitchens and cooked the day before serving. The meat was allowed to cool slowly to room temperature and then was refrigerated overnight. The next morning the beef was cut into cubes and added to tomatoes, green peppers, onions, and flour and cooked approximately one hour at 450° F. The rice and braised beef were kept on steam tables at 140°F. while served.



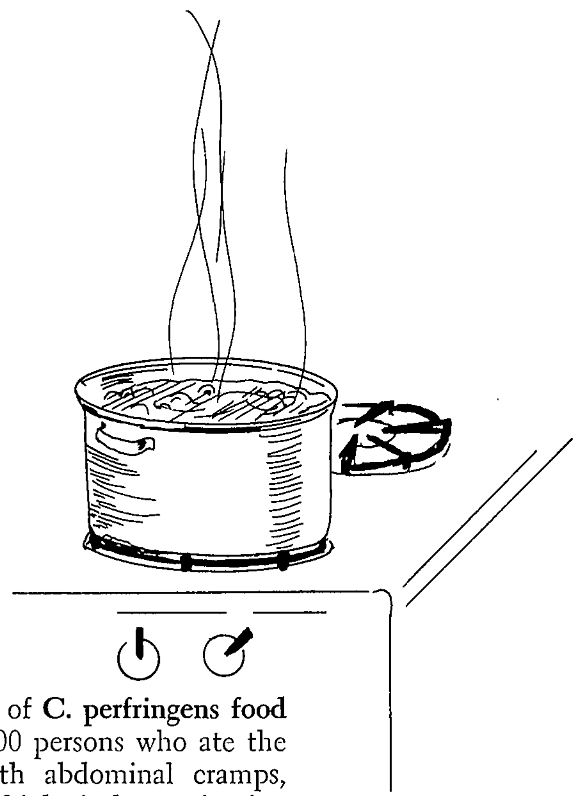
What caused the outbreak? Why did the meal make the people ill? Apparently, inadequate cooking of the beef followed by slowly cooling it to room temperature allowed *C. perfringens* to grow on the beef. Reheating for one hour the following day may not have been sufficient to kill the organisms, and when the meal was eaten, food poisoning resulted.

How easily this outbreak could have been prevented! Adequate cooking of the beef plus rapid cooling to below 45°F. would have prevented growth of *C. perfringens* and the outbreak of food-borne illness (8).

Improper sanitation practices were the cause of an outbreak at a banquet in New York City. A roast beef dinner was served to 1,800 people. From 2 to 26 hours after the meal, approximately 900 people became ill with headache, nausea, abdominal cramps, and diarrhea. The illness was mild and lasted 12 to 24 hours.

Investigation of the outbreak revealed several problem areas. The roast beef scraps were found to be contaminated with *C. perfringens*. The kitchen equipment that had been used to slice and prepare the roasts had not been cleaned or sanitized during or prior to use. The meat was probably contaminated when received by the hotel restaurant. Subsequent handling contaminated the equipment which in turn recontaminated the meat after cooking. The sliced meat was placed in warm cabinets — an ideal environment for microbe growth. Equipment contamination really was implicated when it was shown that the whole, cooked roast beef was not contaminated while the sliced meat did have the organism.

This outbreak could have been prevented if two precautions had been taken: 1) never use equipment to handle cooked food that has been used to prepare raw food unless you properly clean the equipment between uses, and 2) keep food that is served warm at a temperature **above 140°F.** (9).

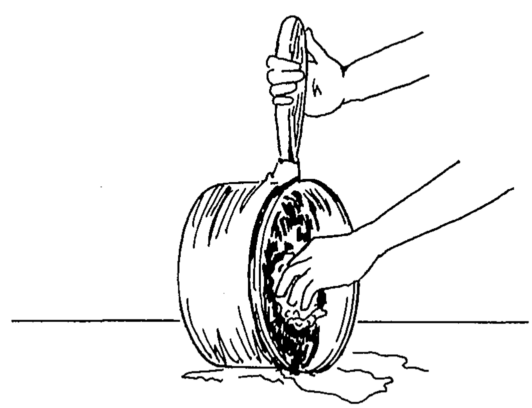


Mushroom gravy was the cause of an outbreak of **C. perfringens food poisoning** at a Texas military base. Of a total of 900 persons who ate the evening meal, approximately 500 became ill with abdominal cramps, diarrhea, mild nausea, and some vomiting. Microbiological examination of the food showed the salisbury steak and mushroom gravy were contaminated with *Clostridium perfringens*.

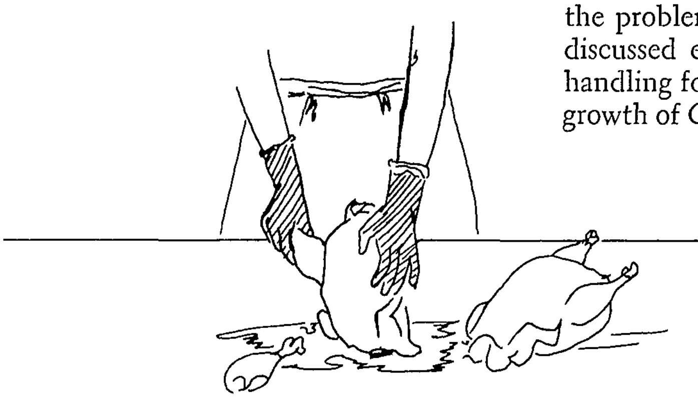
Investigation of kitchen preparation procedures suggested the gravy had been contaminated during preparation by the food handlers. The gravy had been prepared 3 hours prior to the meal, placed in a 20-gallon kettle, and kept warm until served. The temperature of the gravy in the upper part of the container was 100°F., and 140°F. at the bottom. The salisbury steak was contaminated when the gravy was poured over the meat. Proper personal hygiene would have helped prevent the outbreak by eliminating the contaminating source. Of course, storage of the entire batch of gravy at a temperature greater than 140°F. also would have prevented the outbreak (10).

These examples illustrate several modes of transmission of **C. perfringens food poisoning.** They also show that prevention is a relatively simple matter of following recognized kitchen practices necessary to prevent food-borne illness. These documented outbreaks clearly show that the potential exists for **Clostridium perfringens food poisoning** of a large number of people.

Although this food-borne illness occurs more frequently in food-service establishments, it *does* occur in the home. The frequency of reporting home-caused outbreaks of food-borne illness is low, but in 1969, eight outbreaks were reported (1). The foods involved include: chicken, turkey, roast beef and gravy, corned beef, and olives. The number of people involved in each of the outbreaks varied from 2 to 27. The potential exists and outbreaks do occur in the home, emphasizing the need for cleanliness and good kitchen habits in the home, too.



Prevention and Control



Eliminating **Clostridium perfringens food poisoning** outbreaks requires constant attention to correct food handling practices and an awareness of the problem and methods of prevention. Examples of reported outbreaks discussed earlier emphasize this fact. The following general practices in handling foods must be observed to prevent contamination and subsequent growth of *Clostridium perfringens* in food.

Good Sanitation Practices

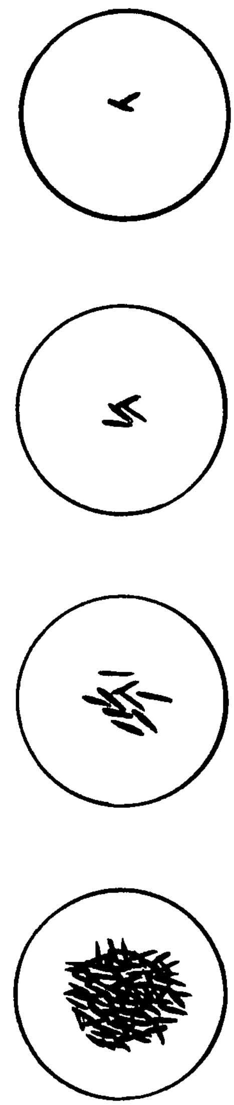
People handling food either at home, at a food service operation, or in a food processing plant should observe good sanitation practices to minimize chances for contamination. All buildings, equipment, and utensils used for processing food should be designed and constructed so that thorough cleaning is easy and practical. Personnel handling food should be encouraged to practice sound personal hygiene and to report any illness, skin infection, rash, or boils.

Food handlers should be encouraged to wear plastic or rubber gloves that can be cleaned and sanitized frequently. Every effort should be made to prevent contamination of the food with bacteria. These precautions will help prevent all types of food-borne diseases.

Those handling food should:

1. always work with clean hands. Never use your hands to mix food when clean, sanitized utensils are available.
2. always wash hands thoroughly after going to the toilet or handling raw food.
3. wear clean and sanitary plastic or rubber gloves whenever possible, particularly if you have a cut or skin irritation on your hands.
4. keep hands away from mouth, nose, hair, and skin infections.
5. cover coughs and sneezes with tissue.
6. not use cooking utensils or fingers to taste food while cooking or serving. Don't lick fingers or eat while preparing food.
7. carefully scrub and sanitize kitchen equipment to prevent cross-contamination between raw and cooked foods.

Principles of Control



As indicated earlier, there are three general principles related to the control of food-borne disease (4). How does each of these apply to the control of **C. perfringens food poisoning?**

1. **Limit or prevent contamination of the food by the microorganism.**

Foods become contaminated with bacteria in many ways. It is impossible to produce food (grow, process, and prepare) in a nice, little, sterile bag that keeps out bacteria. Consequently, most foods are contaminated from the time they leave the farm. Some others become contaminated during subsequent handling and processing.

Meat and poultry may be contaminated during slaughtering and processing operations by organisms carried in animal waste material. These raw products may carry the organisms into food preparation areas and contaminate equipment and personnel handling the food. From these sources, other foods may become contaminated. Any food may be contaminated with C. *perfringens* from dirty equipment, dust, insects, rodents, and fecal-borne organisms of animal or human origin. Obviously, the observance of proper personal hygiene and processing techniques will reduce contamination, but it does not always prevent it. Consequently, there does not appear to be a reliable way of assuring that C. *perfringens* can be kept out of food.

The mere presence of C. *perfringens* in food is not enough to cause illness because millions of growing cells are needed. Contamination alone cannot account for such numbers. *Growth* of the organism must occur. Therefore, control lies not only in reducing the incidence of contamination but in preventing organism growth.

2. **Destroy the microorganism by some treatment of the food.**

The heat treatment involved in the thorough cooking of most foods is sufficient to destroy vegetative cells of C. *perfringens*, but heat-resistant spores can survive. When the food has cooled to a desired growth temperature, these spores can germinate and grow. Thus, with this particular type of bacteria, cooking cannot be considered as a reliable control method.

Outbreaks of **C. perfringens food poisoning** could be avoided if the food could be eaten immediately after cooking while still hot. Since in many instances this is extremely difficult to do, other control methods must be used. The heat of cooking forces air out of the food and creates an ideal air-free environment for C. *perfringens* growth. While cooking does destroy vegetative cells and therefore has some effect in controlling C. *perfringens food poisoning*, the more effective means of control is limiting the growth of the organism in the food.

3. **Prevent or inhibit the growth of the microorganism.**

The key to control is preventing organism growth in cooked and cooling meat, poultry, meat broths, and other foods that might support their growth. Under circumstances commonly encountered in food preparation and service, the best way to prevent growth is to adjust the food temperature to such a degree that growth is inhibited.

Clostridium perfringens grows best from 110° to 117°F. The farther the temperature deviates from the optimum, the slower the growth until a temperature is reached where growth is stopped. The control mechanism is, therefore, temperature adjustment of the food. Prevention of *C. perfringens* growth can be achieved by the effective use of refrigeration, storage of food **below 45°F.** or keeping hot food at **140°F. or above.**

Precautions

Here are some guidelines for handling or preparing food to prevent **Clostridium perfringens food poisoning.**

1. Preparing food several hours or a day before serving is hazardous and should be avoided.
2. Leftover, cooked meat should not be merely warmed up but heated to at least 165°F., internal temperature, to destroy vegetative cells of *C. perfringens*. Or, cut the meat into small pieces and boil it until the meat is completely heated to assure destruction of vegetative cells.
3. Once reheated, leftover foods should be eaten while hot or kept hot until consumed.
4. Food to be served hot should be kept **above 140°F.** until served.
5. All foods not eaten while hot or that cannot be held at 140°F. must be chilled rapidly and refrigerated at 45°F. or below.
6. **Never** allow hot foods to cool slowly to room temperature before refrigerating. The slow cooling period provides an ideal growth temperature for the bacteria.
7. Room temperature should not be used to cool foods. Mechanical refrigeration, particularly large walk-in type rooms with circulating air, are more efficient for rapidly cooling food.
8. Foods should be refrigerated immediately after removal from a steam table or warming oven.
9. Food in shallow pans cools much faster than food in deep pans. Ice baths or cold running water also can be used to rapidly cool food for storage.

Observation of these precautions will not only help prevent **Clostridium perfringens food poisoning** but also other food-borne illnesses, such as **salmonellosis** and **staphylococcus food poisoning.** In addition, food spoilage caused by the growth of other types of bacteria will be minimized.

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