TYPES OF ILLNESS

FOOD POISONING: Vomiting and illness in 1 minute to 4 hours resulting from eating a substance or compound that the body cannot detoxify [e.g., some mushrooms, cleaning and sanitizing chemicals, MSG, sulfites, metal (lead) poisoning; also, scombroid fish poisons (histamine) and ciguatera toxin from dinoflagellates in tropical waters].
Normal cooking has no effect on poisons and will not make poisonous food safe. If in doubt, throw it out.

FOOD INFECTION: Diarrhea and vomiting in 6 hours to over 2 weeks as a result of consuming food containing living pathogenic microorganisms that then multiply in the body [e.g., *Salmonella* spp., hepatitis A virus, Trichinae].
Normal cooking and control of cross-contamination makes food safe to eat.

FOOD INTOXICATION: Vomiting and illness in 15 minutes to 4 hours caused by consuming food containing toxins produced by bacteria when they multiply in food [e.g., *Staphylococcus aureus, Clostridium botulinum, Bacillus cereus*].
Normal cooking will not always inactive the toxins and make food safe. If in doubt, throw it out.

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1283

Types of Foodborne Illness

In order to control hazards, it is important to know what illnesses the hazards produce. The major types of foodborne illness are:

- **Food poisoning.** This is illness that results from eating a substance that the body cannot detoxify (e.g., cleaning chemicals, MSG, sulfite, metal poisons, and some mushrooms). If these toxic compounds or chemicals are on the surface of the food, they might be washed off. If they are inside the food, nothing can be done to get rid of them. Heating has no effect on poisons. In order to avoid this problem, food should be purchased from a source that certifies safe levels of poisonous substances. The food supplier should know and control the types of chemicals used during growth and production of the food. In the foodservice facility, cleaning and pesticide chemicals should be locked up and kept separate from food supplies. Only the amount and kind of preservatives and other culinary chemicals allowed by law should be added to food.

  Ciguatera fish poisoning is the most common type of seafood poisoning caused by eating reef fish such as barracuda, snapper, eel, grouper, and amberjack are most likely to cause this type of poisoning. Scombroid poisoning is the second most common type of seafood poisoning, resulting from eating spoiled / decayed fish, particularly due to improper handling during storage or processing. It is often associated with fish such as mackerel, tuna, mahi-mahi, and anchovies.

- **Food infection.** This is illness that results from eating food containing live pathogenic bacteria (e.g., *Salmonella* spp.) or viruses (e.g., hepatitis) that multiply in the body. A few of some pathogens, 10 to 100 in a meal, can cause illness. They generally come from the feces of humans or animals. When fields are fertilized with animal manure, when animals are slaughtered, when humans use the toilet and get feces on their fingertips, infective microorganisms are transferred to the food. Ten to 100 cells or virus particles in the serving of food can make people ill. If a healthy person with a good immune system wants to eat uncooked meat, poultry, fish, etc., then, to be safe, he/she must know that animal and human fecal contamination is so low, due to careful processing of the raw food, that they will not be made ill. It is up to the grower-harvester and supply system to certify that these foods have a low pathogen count and that they have been handled in a way that keeps their pathogen count below a threshold that causes illness.

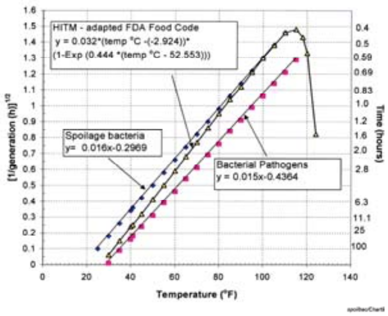
  Immune-deficient individuals such as children less than 5 years old, older people, people on antibiotics, and cancer and Aids patients should not eat raw meat, poultry, fish, or shellfish, because low levels of infective microorganisms could be dangerous.

  When food contaminated with pathogenic microorganisms that produce foodborne infections is given an adequate time-temperature pasteurization, for example, at 150°F (1 minute) / 155°F (15 seconds), these microorganisms are destroyed and the food is safe to consume. Food containing hepatitis A virus must be heated to temperatures above 180ºF. Viruses are best controlled by washing hands.

- **Food intoxication.** This is illness caused by eating food containing toxins produced by bacteria (e.g., *Staphylococcus aureus, Clostridium botulinum,* and *Bacillus cereus*) that have multiplied in a food or food product normally after cooking. The only control is to prevent the multiplication of these microorganisms in the food. The toxins (waste products from the multiplication of these microorganisms) will not be inactivated by ordinary reheating to 165ºF, and once these toxins are present in food, the food becomes hazardous. To prevent this type of pathogen multiplication and toxin production and to assure that food is safe, when food is cooked, it must be heated to higher than 130°F in less than 6 hours to prevent multiplication during heating. After pasteurization, food must be held at higher than 130°F (the FDA Food Code hot holding recommendation of 135°F is 5ºF higher than necessary), or cooled from 135 to 70°F within 2 hours, followed by further to 41°F (6 hours or less, total time), according to the FDA Food Code. (USDA Guidelines recommend continuously cooling food, within 90 minutes after cooking, from 120 to 55°F within 6 hours, followed by further cooling to 40°F (no time limit) before boxing.) The FDA food code recommends that food be stored at 41°F or less after cooling or preparation and consumed within 7 days. The FDA code also allows time as a control, and prepared food can be at any temperature from 41 to 135°F for 4 hours, if leftovers are destroyed.

GROWTH OF BACTERIA IN FOOD

BASED ON FDA FOOD CODE HOLDING / STORAGE RECOMMENDATIONS



Temp (ºF)	1 Generation	10 Generations
<30	Safe	Safe
30	297.14 hr.	123.8 days
35	46.34 hr.	19.3 days
40	17.99 hr	7.5 days
41	15.55 hr.	6.5 days
45	9.49 hr.	4.0 days
50	5.85 hr.	2.4 days
55	3.96 hr.	1.7 days
60	2.86 hr.	1.2 days
70	1.69 hr.	16.9 hr.
80	1.12 hr.	11.2 hr.
90	0,79 hr.	7.9 hr.
100	0.59 hr.	5.9 hr.
110	0.47 hr.	4.7 hr.
120	0.56 hr.	5.6 hr.
125	3.10 hr.	31.0 hr.

1382

5/19/2006 1908 21

1382

Growth of Foodborne Disease Bacteria

Bacterial growth conditions. For optimal growth, bacteria require the proper environmental conditions of temperature, adequate nutrients, free water, time, and the correct pH (greater than 4.6). Any imbalance of these factors can limit bacterial multiplication. Bacteria also require a proper atmosphere (proper amount of oxygen). Some bacteria are aerobic (i.e., require oxygen), some are anaerobic (i.e., require no oxygen) and some bacteria are facultative and can survive in atmospheres with and without oxygen. Any imbalance of these factors can slow down bacterial multiplication.

Growth Process

If the right conditions exist, bacterial growth occurs. There is a short period of time, however, after the correct growth conditions are met before bacteria begin to multiply. This is known as the "lag phase". During the lag phase, the bacteria adjust to the environment, and the metabolic cycle within the cells gradually begins to function. The lag phase can last for a few minutes to days. Its length is determined by the temperature, atmosphere, water, and pH of the surrounding environment. Normally it takes at least 2 hours for a spore to outgrow in cooked, improperly cooled food and begin multiplying at 110 to 120°F. After the lag phase, the bacteria begin to multiply logarithmically: 2 become 4, then 8, then 16, and so on.

Pathogens causing foodborne illness that grow at the lowest temperature include vegetative cells of *Listeria monocytogenes* and *Yersinia enterocolitica.* These pathogens are commonly found in soil and water. They begin to multiply at 29.3°F. *Listeria monocytogenes* is responsible for stillborn infants when pregnant women become infected with this pathogen. The table in the above illustration is a list of the safe times for storing food at specified temperatures before it should be eaten or cooked in order to limit the multiplication of *L. monocytogenes* and other foodborne bacterial pathogens.

Bacteria enter the stationary phase when there are so many (about 10,000,000 to 50,000,000 per gram) that growth is stopped. At this point, the supply of nutrients in the system is used up, and the population has produced a substantial amount of waste. This is the point at which food becomes slimy. Slime is simply layers of billions of bacteria, one on top of one another. The death phase occurs after this stationary phase when bacterial enzymes from the waste products dissolve the non-growing bacterial cells.

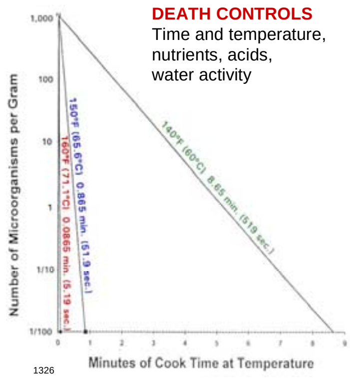
One of the most serious mistakes food handlers make is to add old product to fresh product. This gives a large population of microorganisms in the old product a fresh supply of nutrients in which they can begin to multiply, causing the fresh product to spoil rapidly and pathogens to grow.

The table and graph above are based on the FDA Food Code recommendations for storing food and the growth limits of bacterial pathogens. Bacterial pathogens that produce foodborne illness begin to multiply at 30ºF, but do not multiply above about 125ºF.

The FDA Food Code recommends that ready-to-eat food be held at 41ºF or below for no longer than 7 days, or no longer than 4 hours if held between 41 and 135ºF. The author has applied bacterial growth mathematics to develop the maximum holding times at various temperatures as shown in the table. Compared to actual pathogenic bacteria multiplication, the government-based recommendations are quite safe.

PASTEURIZATION REDUCTION OF *SALMONELLA*

D value: time at a temperature for 1 log (10 to 1) reduction



REDUCTION OF *SALMONELLA* SPP. IN FOOD

Temp. ºF (ºC)	5D Ground meat, fish (100,000:1)	6.5D Roast beef (3,160,000:1)
130 (54.4)	---	112 min.
135 (57.2)	---	35 min.
140 (60.0)	---	11.2 min.
145 (62.8)	3 min.	3.5 min.
150 (65.6)	1 min.	67.sec.
155 (68.3)	15 sec.	21 sec.
158 (70.0)	Instant	Instant

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Destruction of Bacteria

Time and temperature can be manipulated in order to destroy bacteria. Just as growth is logarithmic, destruction is also logarithmic. The higher the temperature, the shorter the time required to accomplish destruction of bacterial cells and spores. The figure above shows data that are typical of *Salmonella* spp. *Salmonella* spp. is a common foodborne illness-producing organism and hence, is suitable to use to develop safety standards. One thousand *Salmonella* spp. per gram can be reduced to 1 per 100 grams of food (a 5D or 5 log reduction) in 8.7 minutes at 140°F. (A 1D reduction is 1 log reduction.) At a temperature of 150°F, the process would take 1 minute, and at 155ºF, 15 seconds. At 158ºF, death is considered to be instant. Only 5.2 seconds would be needed to accomplish the same reduction at 160°F. Note that for each 10°F increase in temperature, the salmonellae die 10 times faster. Time and temperature control is far more important in pasteurization of food than in cold holding and refrigeration; 3ºF error in measuring the coldest spot in a food item can mean the survival of twice as many organisms. Precise cooking is essential if there is to be safety without overcooking.

Roasts can be made safe at 130ºF with a 112-minute hold. This is needed, because consumers demand rare prime rib. However, for chops, ground meat, and fish, the lowest temperature and time allowed is 145ºF, with 3 minutes hold. This is based simply on the difficulty of holding a food in the fryer or grill for a fixed time. Therefore, rare meat, unless the supplier certifies it as vegetative-pathogen free, cannot be done safely except in slow cooking, such as oven roasting of beef. Note, a hamburger, meatball, or other highly contaminated food can be made safe by holding the center temperature of the food at 145ºF for 3 minutes or 150°F for only 1 minute. In ordinary cooking, since the outside of the food is well above 150ºF, by the time the food is plated, if the item is taken off the grill at 150ºF center temperature, it will have spent more than 1 minute above 150ºF and will have a 100,000-to-1 kill. If the hamburger is ground from fresh product, not aged beef, and if there are no additives such as soy, the color will be a pleasing, medium pink at 150ºF center temperature. When meat is heated to 160ºF center temperature, there will be little red color left in fresh beef, pork, lamb, chicken, etc., and these items, which are medium well, are safe. Note, both the USDA and FDA prohibit cooking to color or until juices run clear for verification of a safe cook. A tip-sensitive thermometer must be used. Cooks have been taught to cook meat until the bright red color is gone, not because of safety, but rather, it was assumed that no one had a proper thermometer to measure temperature of the meat. Thus, color change of the meat to grayish brown color was considered to be an accurate indication of adequate cooking time and temperature

The addition of lemon juice, vinegar, and wine to food products not only adds flavor to the product but also lowers the pH of the environment by providing acids, which slow down or inhibit bacterial growth and aid in destruction of bacteria when combined with heat. It will also turn meat brown at lower cooking temperatures. If it is aged and acidic, it is brown at 150ºF. Meat with 15% textured vegetable protein is brown at 140ºF. On the other hand, if meat is cooked with onions and celery, high in nitrate, the meat becomes cured and does not turn completely brown, even at 180ºF.

Water Activity

Microorganisms require moisture to be destroyed easily. If the amount of water is restricted, destruction will take 10 to 100 times longer. Moist heat (steam or heating in water) destroys vegetative bacterial cells and spores on the surface of food more rapidly than dry oven heat.

When salt, sugar, and fat are added to food products, these ingredients bind water and make the destruction of vegetative bacteria more difficult. Foods containing higher amounts of salt, sugar, or fat, such as egg custards, need to be cooked to temperatures that are 10°F higher than those for *Salmonella* shown above, or should be pasteurized 10 times longer than normal to get the same inactivation of the bacteria present in the food.