





SECTION 2

FOOD MICROORGANISMS		
Pathogen	Hazard	Control
 Parasites	<i>Trichina</i> spp., <i>Anisakis</i> , beef tapeworm, <i>Toxoplasma gondii</i> Live within animals and fish (in muscle, intestinal tract): 1 to 10 will cause illness.	Reduced to safe level by cooking to 145°F, 15 seconds. Killed by freezing, -4°F, 7 days.
 Molds	Most molds in kitchen are spoilage. <i>Aspergillus</i> spp., <i>Fusarium</i> , penicillin grow on stored grain and peanuts. They can form aflatoxins and can cause cancer.	Cut off / throw away moldy food. Keep grains and nuts dry. Government testing controls
 Viruses	Noroviruses, hepatitis A, rotavirus. Source is human feces and vomit.	Double wash fingertips after using the toilet.
 Bacteria	Vegetative bacteria: <i>Salmonella</i> , <i>E. coli</i> , <i>Vibrio</i> , <i>Shigella</i> , <i>Streptococcus</i> , etc. Spores: <i>Clostridium perfringens</i> , <i>Bacillus cereus</i> , <i>Clostridium botulinum</i> in hot food survive pasteurization as spores (dried hibernating vegetative cells).	Reduce to a safe level with pasteurization, 100,000-to-1; 145°F, 3 minutes; 150°F, 1 minute; 155°F, 15 seconds OR Double wash fruits and vegetables (100-to-1 reduction). Hold ≥135°F / >130°F roasts to prevent outgrowth. Cool 135 to 41°F, 6 hours <1 gallon / <2 inches deep). Cold hold 41°F.

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Food Microbiology

Understanding how and why pathogenic microorganisms in food cause foodborne illness makes it possible to use HACCP to anticipate and control contamination and growth of pathogens.

Microorganisms are so small that the individual cells cannot be seen without a microscope. There are four classes of microorganisms: bacteria, viruses, yeasts, and molds. Yeasts are really not a food safety problem and are not discussed in this text. Parasites are micro- or macroorganisms that exist at the expense of the host.

Bacteria

Bacteria are composed of one cell. They are classified according to their shape: bacilli (rod), cocci (round), and spirilla (spiral). Some bacilli form spores that are very heat resistant and survive pasteurization cooking. Examples include *Clostridium* spp. and *Bacillus* spp. They are in food when it is taken home as leftovers or as take-out food. To inactivate spores, one must heat the food in a can or jar in a pressure retort to 250°F for 3 minutes. This makes the food commercially sterile.

Viruses

Viruses are not true living cells and are much smaller than bacteria. A virus is composed of a protein coating around DNA and RNA material. To multiply, viruses must use compounds from other living cells. For example, the hepatitis A virus uses material from human liver cells to reproduce. Typical illnesses caused by viruses are colds, flu, hepatitis, and Norwalk gastroenteritis. Viruses are difficult to inactivate with sanitizers and heat. Since the only sources of this hazard are the feces and vomit of others, double hand washing after using the toilet is the BEST control.

Molds

Some molds produce mycotoxins such as aflatoxin (a nerve poison). They can also cause allergic reactions in people. Molds appear as cottony, powdery, or fuzzy tufts and patches. Most molds have a pungent odor. Molds can grow above 14°F during frozen storage. They grow in acid foods such as salad dressings, tomato ketchup, salsa, and fruit drinks.

The presence of mold on products is an indication of poor farm practices, poor sanitation, poor refrigeration, and/or over-extended shelf life. If, for example, a cheese is moldy with a white, fuzzy mold, the moldy portion can be cut off (½ inch below the mold) and thrown away. It is important not to touch the mold in order to prevent it from spreading to other food. While molds can be a quality and a minor food safety issue, the FDA does not mention molds in the model food code or food safety rules.

Parasites

Parasites are organisms that live at the expense of some other living cell, plant, or animal (including humans). Parasites of major concern in foods are tapeworms found in fish, trichinae found in pork, and *Giardia* found in water and feces. Although bacteria, viruses, yeasts, and molds are not effectively destroyed by freezing, parasites can be destroyed if food containing them is frozen. The FDA and USDA have specified temperatures at specific times, depending on the type of parasite and the size of the product. The colder the temperature, the more rapid the destruction. For example, -4°F for 7 days is an effective control. Parasites are also destroyed when food is heated to 145°F for 15 seconds or above for a time sufficient to kill *Salmonella* spp.

THE BIOLOGICAL HAZARD

- All food has pathogenic and spoilage organisms. They come on food, people, water, air, and insects, and multiply during processing.
- They multiply well in most of the foods that we normally eat.
- Cooking only reduces the number of vegetative microorganisms, activates spores, and does not touch toxins and poisons.
- During warm holding and slow cooling, spores outgrow, and cell population increases rapidly.



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Purchasing Food

No USDA, FDA, or commercially inspected raw food can be assumed to be safe. To assure food safety, food must be purchased from suppliers who can identify the level of pathogenic substances in their food and certify the safety of their product(s). The government inspection process of raw food does not control the microbiological, chemical and physical hazards in food that are known to produce foodborne illness. The number of pathogens present in the food must be below a level that will make consumers ill. The food must then be received, stored, prepared, and served at temperatures within times that keep microbial growth, particularly that of toxin-producing microorganisms, to less than 10 generations (to multiply 10 times, or increase by a factor of 1 to 1,024). The FDA Food Code allows enough time at 41°F (7 days) and 100°F (4 hours) for 10 multiplications of pathogens. If the food is cooked, it should be heated sufficiently to reduce salmonellae from 10,000,000 to 1 per gram.

Microbial Contamination

Raw, refrigerated, and frozen foods are contaminated with many spoilage microorganisms and some pathogenic microorganisms when delivered. The normal load of spoilage microorganisms on food items varies from several thousand to millions of bacteria per gram. (There are 28.4 grams per ounce.) Hamburger, chicken, fish, and vegetables often have at least a million spoilage bacteria per gram by the time these food products are cooked for service.

Temperature Influences: Multiplication

The biological hazard in foodservice is the ability of pathogenic microorganisms to multiply (grow): in raw food during refrigerated holding; in food during slow cooking (more than 6 hours to 130°F), in cooked food during slow cooling, or holding of food at 85 to 120°F for more than 2 hours. [Note, the FDA recommends that food should be cooled from 135 to 70°F within 2 hours, followed by further cooling to 41°F (6 hours, total time)]. USDA Guidelines for cooling recommend continuously cooling food, within 90 minutes after cooking, from 120°F to 55°F within 6 hours, followed by further cooling to 40°F (no time limit) before boxing.)

Growth or multiplication of pathogenic bacteria in food during these hazardous procedures may be sufficient to cause illness when the food is consumed. The optimum temperature range for rapid pathogen multiplication (more than once an hour) is 85 to 120°F. At 95 to 115°F, doubling in population can occur every 8 to 25 minutes. Pathogen growth slows as the temperature approaches the high temperature growth limit (125°F for *Clostridium perfringens*) or low temperature limit of 30°F for *Yersinia enterocolitica* and *Listeria monocytogenes*. Therefore critical temperatures for food storage or holding to prevent pathogenic microorganism growth are less than 30°F and higher than 125°F.

Reduction of Microorganisms through Cooking

Cooking in foodservice only pasteurizes the food, that is, reduces pathogenic vegetative microorganisms in the food to a safe level. Cooking has essentially no effect on spores, toxins, and poisons.

HOW DO YOU KNOW IF FOOD IS HAZARDOUS OR SAFE?

You control the process.

Food Spoilage Microorganisms

Do not cause illness.
Change the flavor, odor, and appearance of food.
Inhibit growth of pathogens.

Food Process Microorganisms

They "spoil" / ferment the food. Do not cause illness.
Used in the production of food products
(e.g., vinegar, bread, sauerkraut, cheese).

Food Pathogens

Cause illness.
Often do not change the flavor, odor, and appearance
of food to indicate that the food is hazardous.
If in doubt about how food was handled after cooking,
throw it out.



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food) that cause illness have no effect on the taste, odor, or appearance of the food. Many people even say that the food such as roast beef, cake icing, tuna salad, or other food that made them sick was the best they had ever tasted. The old rule, "**If in doubt, throw it out,**" must be followed. Doubt, though, cannot be based on odor, appearance, or taste. Doubt is measured by knowledge about whether or not the food was handled and stored correctly. For example, food found in the wrong place, at the wrong temperature must be thrown out. It should not be tasted. It could kill you.

Potentially hazardous foods that are involved in foodborne illness outbreaks include: meat, fish, poultry, dairy products, baked products, eggs, infant foods, candy, vegetables and fruit, Chinese food, salads, sandwiches, and beverages. As this list indicates, any food can become hazardous if not purchased from a safe source and if not prepared, stored, and handled properly.

Food Spoilage Microorganisms

Food spoilage microorganisms are good in HACCP and do not cause illness. Excessive, prolonged growth of spoilage microorganisms changes the odor, flavor, and texture of the food so much that it becomes unpalatable. If the growth of spoilage microorganisms is minimal, spices can be used (as they have been used for thousands of years) to cover up the effects of spoilers so that the food can be eaten.

In raw food, spoilage microorganisms are usually present in much higher numbers than pathogenic bacteria, and are able to grow more rapidly at temperatures below 80°F. Hence, spoilage microorganisms that often produce acid in many cases are able to stop or inhibit the growth of pathogens by a process called competitive inhibition. Competitive inhibition occurs when spoilage bacteria and pathogenic bacteria compete with each other for nutrients in food in order to multiply.

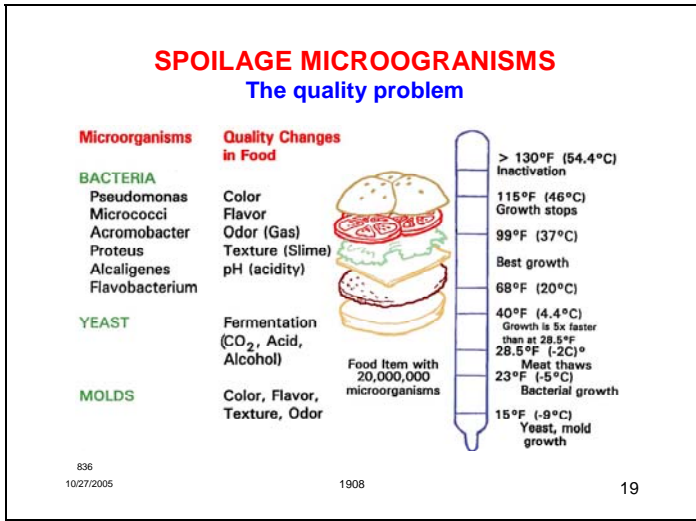
When raw food is cooked above 160°F for 15 seconds, vegetative pathogenic microorganisms and most of the spoilage microorganisms are destroyed. The food is safe but the spoilage competitive microorganisms are gone. This makes the cooked food far more vulnerable to a few pathogens on hands or from cutting board cross-contamination of cooked food. With correct temperatures and no competition from spoilage microorganisms, the contaminating pathogens grow well. Temperature abuse also allows spores to outgrow into vegetative cells.

Food Process Microorganisms

The food process microorganisms that are used to produce many food products such as beer, sour cream, sauerkraut, wine, bread, cheese, soy sauce, and salami actually make the food safe. Bacterial counts become very high – 100,000,000 or higher. The growth of food process microorganisms produces by-products such as acids (lactic and acetic), carbon dioxide, and alcohol, which help preserve the food and destroy the pathogens. When these same microorganisms are allowed to grow in foods where their presence is not desired, they are called spoilage microorganisms.

Food Pathogens

How can the safety of food be verified? Food safety cannot be judged by the taste or smell of the food. Most food pathogens (pathogenic bacteria, viruses, yeasts, molds, and parasites in



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Balancing Spoilage Organisms and Pathogens

Most food, especially raw food, which is eaten every day, contains thousands to millions of spoilage microorganisms per gram. Some of these microorganisms are critical to keeping a healthy intestinal microflora and maintaining a high infection resistance in the body. Actually, it appears that people should eat a mixture of spoilage microorganisms to stay healthy. However, it is also essential to keep pathogens in food at low levels to assure food safety.

Spoilage Microorganism Growth Conditions

Spoilage microorganisms are the real problem in terms of customer satisfaction. They begin to grow when food is still frozen. Yeasts and molds start to grow at 15°F. Spoilage bacteria begin to grow at 23°F. They actively grow at 28°F when meat, poultry, and fish are thawing. Spoilage microorganisms grow best at 70 to 80°F and are inactivated at temperatures of 115°F and above.

Normal Spoilage Organism Contamination

When fresh foods are received, they have a mixture of spoilage microorganisms. These include bacteria such as *Pseudomonas*, *Achromobacter*, *Micrococci*, *Proteus*, *Alcaligenes*, *Flavobacterium*, yeasts, and molds. The growth of these microorganisms produces the typical changes in food associated with signs of spoilage. These changes include color change, slime, odor, flavor change, and texture change. Fermentation of sugar occurs and CO₂, acids, and alcohol are produced.

The Importance of Refrigeration at 28 to 32°F

Foodservice refrigerators and coolers used for meat, poultry, and fish product storage should be kept at 28 to 32°F in order to slow the growth of spoilage microorganisms and prevent pathogenic bacteria growth. Ground beef spoils 3 to 5 times faster at 45°F than it does at 32°F.

For example, average quality ground beef with 500,000 spoilage bacteria per gram upon delivery on Friday, if stored at 45°F, will have 360,000,000 spoilage bacteria per gram and obvious off-flavor and slime by the following Monday at noon. Spoilage microorganisms multiply once every 7.8 hours at 45°F, so between Friday and Monday there would have been 9.5 generations of growth. On the other hand, if the ground beef is kept at 32°F, there will only be 2.5 generations of growth. This means that there will only be 3 million bacteria per gram by Monday, and the hamburger will be quite acceptable. Maintaining storage temperatures of 28 to 32°F is also important for raw poultry and fish since they are just as contaminated with spoilage microorganisms as ground beef.