

Appendix C

BASIC FOOD MICROBIOLOGY

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Microorganisms are tiny life forms capable of rapid reproduction under some growth conditions. Many have been found to be useful to the food industry. Examples include bacteria used in the production of yogurt and cheese, or yeast for bread production. Many have also been found to cause problems such as food spoilage and illness.

According to public health and food safety experts, millions of illnesses in the United States can be traced to foodborne bacteria each year. The U.S. Public Health Service has identified the following microorganisms as being the biggest culprits of foodborne illness either because of the severity of the sickness or the number of cases of illness they cause. Beware of these pathogens:

- **CAMPYLOBACTER** – raw and undercooked meat and poultry, raw milk and untreated water.
- **CLOSTRIDIUM BOTULINUM** – honey, root vegetables, home prepared foods.
- **E.COLI O157:H7** – undercooked meat, produce, raw milk.
- **LISTERIA MONOCYTOGENES** – dairy products, soil, water, deli meat products, poultry and seafood, and produce.
- **NOROVIRUS** – any food if handled by someone who is infected, or in a water storage system.
- **SALMONELLA** – raw and undercooked eggs, undercooked poultry and meat, dairy products, seafood, produce.
- **STAPHYLOCOCCUS AUREUS** – cooked foods high in protein, commonly found on human hands.
- **SHIGELLA** – salads, dairy products, and unclean water. Poor hygiene allows shigellosis to easily be transmitted from person to person to food.
- **TOXOPLASMA GONDII** – primarily pork products.
- **VIBRIO VULNIFICUS** – raw or undercooked seafood.

Least Wanted Foodborne Pathogens [fightbac.org](http://www.fightbac.org), the website of the Partnership for Food Safety Education (PFSE), is your resource for Fight BAC! food safety and safe food handling campaign information. © 2006 <http://www.fightbac.org/content/view/14/21>

Microbes are everywhere. They are found in:

- Air;
- Water;
- Food;
- Soil;
- Humans (nose, gut, skin, etc.); and
- Surfaces.

Although many are found in locations where environmental factors are ideal to support their multiplication, many also are able to survive and even multiply outside their natural surroundings.

1.0 MEET THE CULPRITS

There are more than 200 known illnesses that a person can get from eating contaminated food. These illnesses can result from disease-causing bacteria, viruses, toxins and parasites. These harmful microorganisms are known as pathogens.

Pathogens can cause illness in three ways:

- Pathogens found on contaminated food infect intestines causing illness;
- Pathogens on contaminated food produce toxins that cause poisoning; and
- Pathogens found on contaminated food infect intestines and produce toxins that cause illness.

1.1 Bacteria

These microorganisms are small, living, single-celled life forms that are easily carried by food, water, humans, insects and air. They can reproduce rapidly when exposed to ideal conditions and can be hard to control. Some bacteria can survive freezing, some grow easily when food is cold, and some can form endospores (change their structure to create very tough, resistance outer coatings etc.).

When bacteria first come into new surroundings (e.g. food source), they go through an adaptation phase. During this time, they do not multiply. This lag phase is a key time to use controls, such as temperature acidity, to inhibit bacterial growth. The next stage is called a logarithmic growth phase. This is when bacteria rapidly multiply under ideal conditions. (can double in number every 15 minutes). During this multiplication, by-products like acid and a reduction of food resources lead to a gradual slow-down and eventually limit further reproduction. Toxins are most commonly produced at this point. Since toxins can form before the bacteria are able to cause visible changes to the food, food that looks fine may cause poisoning and illness.

1.2 Viruses

Viruses are extremely small life forms that need living cells to grow. Viruses can also be described as a packet of genetic material that needs a host to reproduce. Infection can occur with very few viruses, which usually contaminate food through poor staff personal hygiene. All foodborne viruses have been shown to originate from the human gut, and therefore tend to affect the gut. Viruses have been known to survive cooking and freezing.

1.3 Parasites

Like viruses, parasites need to live in or on a host organism to survive and refer most commonly to protozoa or parasitic worms, which are too small to be seen with the naked eye. Many of these parasites have complicated life cycles where a human host is only one step. Commonly infected organs include muscles, the brain, eyes and the gut.

1.4 Yeasts, Moulds, and Other Fungi

These organisms are more commonly connected with food spoilage than food-related illnesses. However, a few moulds can cause illness in humans. Often this is due to the production of toxins during growth. These toxins have been shown to be able to cause cancer, hay fever and some forms of asthma.

2.0 FACTORS AFFECTING GROWTH

All microorganisms, like any other living organism, depend on their environment to survive. Unfavourable conditions have been shown to alter their reproductive rates or even kill them. By influencing what microorganisms need for growth, processors can gain control.

Toss the Sponge

Damp towels and sponges may provide the perfect environment for pathogen growth. Consider using paper towels for cleaning up surfaces or drying equipment and hands. If you use cloth towels, wash and sanitize them often.

Your company can take several steps to prevent or control food contamination by potentially harmful organisms. The most common controls involve altering one or more of the following:

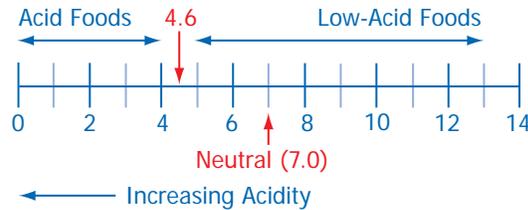
- Food;
- Acidity (pH);
- Temperature;
- Time;
- Oxygen; or
- Moisture.

2.1 Food

Like all animals, microbes require food or nutrients for growth and survival. The easiest method of control is cleaning. Cleaning removes visible soil and food residue from equipment and surfaces. Food residue left on equipment is a source of food for bacteria. If equipment and surfaces are not cleaned properly, these organisms multiply and contaminate the next batch of food.

2.2 Acidity

Bacteria do not like living in very acidic or low-acid, or basic (alkaline) environments. Many pathogenic organisms grow well somewhere between a pH of 4.6 and 7.5. Many foods are preserved by adding acid to their ingredients.



Acidic foods have pH values below 4.6. These foods include pickles, most fruits, and jams and jellies made from fruit. Acidic foods contain enough acidity either to stop the growth of bacteria or destroy the bacteria more rapidly when heated.

Low-acid foods include red meats, seafood, poultry, milk, all fresh vegetables and some tomatoes. Low-acid foods have pH values higher than 4.6 and do not contain enough acid to prevent the growth of bacteria. When low-acid foods are used in formulations, it is important that they be properly acidified before they have a chance to spoil.

2.3 Temperature

Like acidity (pH), there are minimum and maximum temperature values for optimal pathogenic growth. Keep food out of the 'Danger Zone', the temperature range when bacteria and spoilage organisms grow most quickly: between 4° C and 60° C. When food is left in the Danger Zone, bacteria can grow fast and reach unsafe numbers in your food product. Follow the simple rule of keeping hot foods hot and cold foods cold to help ensure that your product will be safe for your consumers.

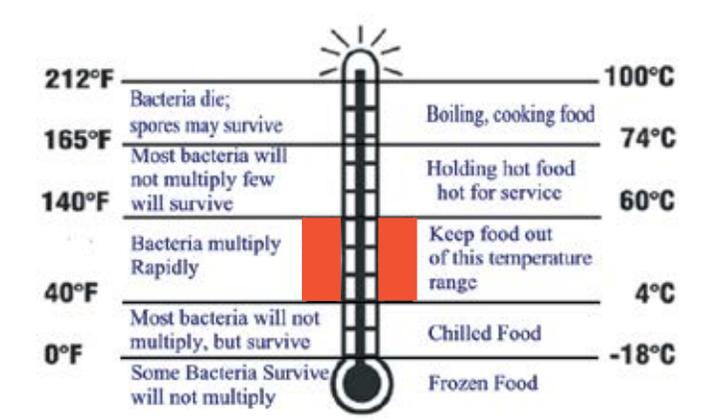


Figure 1

Courtesy the Marketing Food Safety – Farm Direct Advantage Manual developed in a partnership with Alberta Agriculture and Food and the Alberta Farmers' Market Association.

High-risk foods can support fast microbial growth and exposure to the Danger Zone should be minimized. These foods include:

- Meat, seafood, fish or poultry and foods that contain them, such as casseroles, deli meats, salads and sandwiches;
- Eggs and other protein-rich foods, like soybean products, and foods that contain these items;
- Dairy products and foods containing dairy products;
- Fresh-cut or peeled fruit or vegetables;
- Cooked vegetables, beans, rice and pasta dishes;
- Sauces, gravy, and other low-acid food products; and
- Sprouts, such as alfalfa and bean sprouts.

Appearance and touch are not reliable signs of safe temperatures. Taking food temperatures correctly and using a properly adjusted food thermometer is the only way to ensure that food is kept out of the Danger Zone.

Many food companies use heat processing to ensure safe products. These products are usually foods where other controls do not work and involve placing the food in extreme temperatures for a longer time. For commercial sterility, this period must be long enough to reduce the number of organisms by a factor of 10^9 . That means there are one billion times fewer organisms. Temperatures and processing times that destroy microorganisms may fail to get rid of enzymes and not destroy toxins that are heat stable. These toxins may cause illness in people who eat them. Thermal processing is no substitute for good quality raw materials, good raw-material safety and safe food handling and processing.

2.4 Time

If they remain in the Danger Zone for more than four hours, all pathogenic microorganisms can increase to unacceptable levels that can result in illness.

2.5 Oxygen

Microorganisms have different oxygen needs. Some need oxygen to grow, some will grow only when there is no oxygen, and some can grow with or without oxygen. Some packaging methods work by restricting or stopping availability of oxygen. These include modified-atmosphere packaging and vacuum packaging.

2.6 Moisture

Water is necessary for most life forms to grow. If a product is dry, then bacteria cannot grow as well as when there is water. Water in food that is not bound to food molecules can support the growth of bacteria, yeasts and moulds (fungi). The term water activity (a_w) refers to this unbound water.

The water activity of a food is not the same thing as its moisture content. Although moist foods are likely to have greater water activity than dry foods, it is not always so. In fact, certain foods may have exactly the same moisture content and yet have quite different water activities.

The Typical Water Activity of Some Food Products

Type of Product	Water Activity (a_w)
Fresh Meat and Fish	0.99
Bread	0.95
Aged Cheddar	0.85
Jams and Jellies	0.80
Plum Pudding	0.80
Dried Fruit	0.60
Biscuits	0.30
Milk Powder	0.20
Instant Coffee	0.20

The water activity (a_w) represents the ratio of the water vapour pressure of the food to the water vapour pressure of pure water under the same conditions. It is expressed as a fraction. If we multiply this ratio by 100, we obtain the equilibrium relative humidity (ERH) that the food product would produce if enclosed with air in a sealed container at constant temperature. Thus, a food with a water activity (a_w) of 0.7 would produce an ERH of 70 per cent. Maintaining a water activity of 0.85 or less holds back the growth of most pathogenic organisms that threaten public health.

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