Lesson 2: Problems with Food Deterioration

Food is subject to physical, chemical, and biological deterioration. The most obvious to the human eye, physical deterioration, will be discussed first.

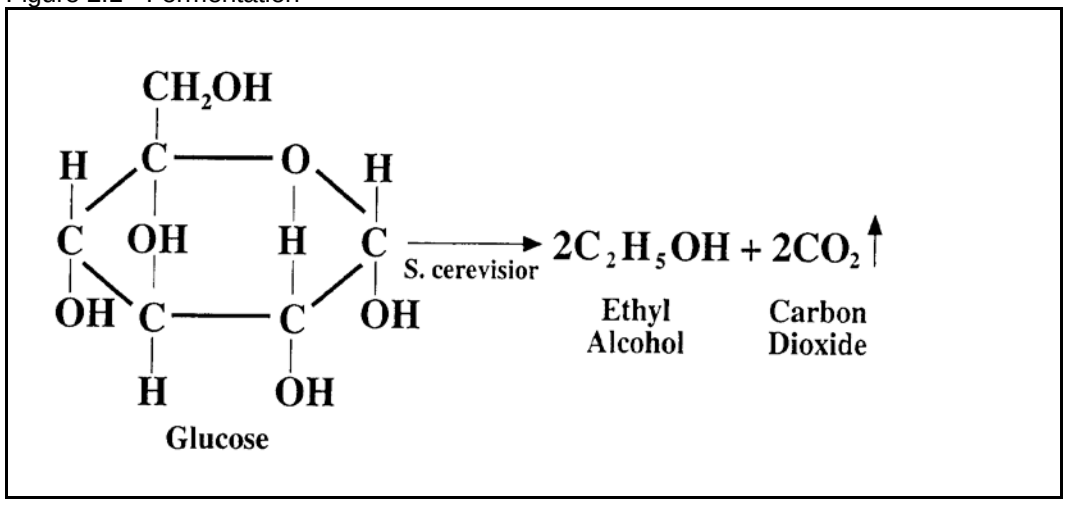
Physical Changes from Food Deterioration

When food is exposed to excessive amounts of heat, cold, or circulating air, it may become dehydrated. Cracked skin found on fruits that have been frozen and thawed is another type of physical change. A broken or separated emulsion (example, salad dressing) in liquid foods that have been frozen and allowed to thaw is a third type of physical change. A fourth is texture degradation. This can be found in fluid milk that has been frozen, which causes curdles to develop.

Lumping, caking, or crystallization may result from an excess of moisture. Surface pitting on fruit is the result of storage temperatures that were too cold.

External off-color development may be the most obvious physical change caused by food deterioration. Meat exposed to fluorescent or incandescent light too long develops a brownish-red color. Meat color is determined by its predominant pigment, myoglobin. Myoglobin is a purple red pigment due to its iron constituents. When exposed to air, myoglobin adds two oxygen atoms and becomes oxymyoglobin. Oxymyoglobin is responsible for an intense red color. Oxygen permeable wrapping is preferred on meat cuts to promote this appealing color. If insufficient amounts of oxygen are available, however, oxymyoglobin oxidizes to metmyoglobin, a brownish-red pigment. Mold growth on the surface comes in a rainbow of colors. Some fruits, when stored at low temperatures may develop internal browning.

Figure 2.1 - Fermentation



Chemical Changes

Chemical deterioration is due to a change in the chemical, or molecular structure, of food. Fermentation of sugars is a chemical change that, under controlled conditions, is a beneficial process in the production of bread, buttermilk, and yogurt. Fermentation can cause deterioration in uncontrolled environments. Fermentation splits a glucose molecule into two ethyl alcohol and two carbon dioxide atoms. (Figure 2.1)

Carbohydrates (starches) and proteins may undergo hydrolysis. Hydrolysis is defined as the splitting of a molecule by the uptake of a molecule of water. Corn syrup is produced by the hydrolysis of cornstarch with hydrochloric acid. The end product is called corn sugar. Hydrolysis of proteins is usually undesirable in foods.

A third type of chemical reaction that can cause deterioration is called lipolysis, or the reaction of a water and fat molecule that releases a fatty acid in the presence of heat or the lipase enzyme. This process alters the flavor and aroma of fats or oils and creates a rancid odor.
Proteins also can denature, losing their unique structure. If the protein is an enzyme, it loses its ability to be a catalyst. Often a denatured protein is less soluble. Denatured proteins often coagulate. Think about what happens when you fry an egg. The proteins in the egg white denature when heating. The once clear liquid becomes an opaque rubber solid. Denatured proteins may be more easily digested by microorganisms resulting in development of undesirable flavors, odors, or textures.

Toxin production is the sixth chemical change resulting from food deterioration. A food intoxication results from a toxic substance being produced in a food item before consumption. Certain molds can produce mycotoxins, which are poisonous. One well known mycotoxin is aflatoxin. Aflatoxins may be found on moldy grains and peanuts. Ergot is a mold toxin that can cause hallucinations. It may have been responsible for the Salem witch trials.

Enzymatic reactions are the advanced stage of normal enzymatic reactions. While the plant or animal is alive, enzymes are busy catalyzing chemical reactions. These reactions are kept in control by the living system. However, when the tissue is dead, these enzymes continue to work and ultimately cause degradation. These chemical changes may be inactivated by heat, chemicals, and/or radiation.

Pigment conversion is an eighth example of deteriorative chemical changes. For example, as the green pigmented chlorophyll molecule in plants is transformed into the pheophytin molecule, the bright green is converted to greenish-gray and olive green. A magnesium ion is replaced by hydrogen. Similarly, the oxymyoglobin molecule in red meat is chemically changed to metmyoglobin.

Environmental Conditions for Bacterial Growth

Bacteria, along with yeasts and molds, prefer warm, moist growing conditions. Most bacteria are mesophilic. Mesophilic bacteria survive in temperatures ranging from 60°-100°F. There are also cold-loving (psychrophilic) bacteria, which survive at temperatures down to 32°F. Conversely, thermophilic bacteria can grow in temperatures up to 180°F. Because moisture is required for bacterial growth, a zero or very low water activity level is the reason why salted and/or dehydrated foods are not overcome by bacteria. Because there are aerobic and anaerobic bacteria, the need for oxygen depends on the type of bacteria.

Microorganisms that Contribute to Food Deterioration

An important point to remember is that microorganisms are generally not found within the living tissue of a healthy plant or animal. Milk, for instance, is sterile when secreted. Fruits, vegetables, grains, and nuts become contaminated when their protective skin or shell is broken or weakened.

Bacteria - Not all bacteria cause food spoilage. Many types of bacteria are used to preserve food, like the lactic-acid producing organisms of cheese, sauerkraut, and certain types of sausage. Others are used for flavor production.

Bacteria are found everywhere from the hides and feathers of animals, to shells of nuts, in the soil, water, and air, and on processing equipment that has not been sanitized.

Bacteria are unicellular organisms; they are cells without a nucleus, known as procaryotes. They are classified based on their shape: spherical shapes are cocci; rod shapes are bacilli; and spiral forms are spirilla and vibrios. Many bacteria move by means of a flagella, a whip-like tail. Others produce spores, which are seedlike and incredibly resistant to heat, chemicals, and other adverse conditions. Bacterial spores are more resistant than yeast or mold spores. They resist most processing conditions to a greater extent than natural food enzymes. Needless to say, sterilization processes are aimed at these bacterial spores.

Bacteria are small, one to a few micrometers (um) in length, and can penetrate the smallest openings. Most bacteria multiply at 60°-100° F, the temperature range of mesophilic bacteria. Recall, however, that psychrophilic bacteria multiply at very low temperatures while thermophilic bacteria can withstand very high temperatures. Some bacteria are aerobic, while others are anaerobic.

Bacteria multiply in an exponential fashion. Under favorable conditions, their numbers can double every 30 minutes.

Bacteria are also classified based on their staining characteristics. Gram-positive bacteria retain a dark violet or purple color after a purple dye/iodine mixture is applied followed by an alcohol treatment in an attempt to decolorize. Gram-negative bacteria lose the dark violet color after the alcohol is applied. The Gram method of bacterial identification is one of the most important methods used. While this method is not absolute, it does provide valuable information in determining which bacteria are present. Thus, a corresponding method of treatment or sanitation can be established.

Fungi - Fungi, or yeasts and molds, are also helpful/harmful agents in food science, depending on which specific ones are present. Yeasts are necessary in making bread, wine, and beer because of their fermentation qualities. Molds are used to ripen Danish blue, Roquefort, and Camembert cheeses. They are also used to manufacture soy sauce and citric acid. The mold penicillium produces the antibiotic penicillin.

Yeasts and molds are found everywhere and can cause food spoilage. Yeasts and molds like warm, moist growing conditions. Yeasts are larger than bacteria, around 20 micrometers in length. Most yeasts are spherical or ellipsoidal in shape. Yeasts reproduce asexually in the form of spores. Most yeast colonies are creamy white in color and slimy in appearance.

Molds are larger than yeasts and grow by hairlike fibers call mycelia. Mold spores create the blackness of bread mold and the blue-colored veins in blue cheese. All molds are aerobic.

Organisms That Can Cause Diseases

Camphylobacter - The camphylobacter bacteria are responsible for causing camphylobacteriosis, which is the leading cause of acute gastroenteritis (inflammation of the stomach and intestines) in humans. Only a few bacteria are required to cause illness. This bacterium has been found primarily in raw milk and poultry, but it has also been found in cake icing, eggs, beef, and contaminated drinking water.

Clostridium botulinum - Botulism is caused by these bacteria, which are present throughout the environment. The bacteria can be found in damaged canned foods and home-processed foods that were not properly processed. Also, other foods such as potato salad, sauteed onions, chopped garlic, raw cabbage, and hazelnut yogurt have been found to contain the botulism bacteria. Infant botulism can be caused by honey, which often contains botulinum bacteria. That is why it is recommended that infants not be given honey. The most common symptoms of botulism are fatigue and blurred vision. Few people have the usual gastrointestinal symptoms of food poisoning. Death is common for people getting botulism.

Escherichia coli - These bacteria, commonly called E. coli, live naturally in the human intestinal tract. They are responsible for causing diarrhea in infants and travelers. One uncommon strain causes two life-threatening conditions: hemorrhagic colitis and hemolytic uremic syndrome. Bacteria found in raw and undercooked ground beef and raw milk have been linked to these illnesses. The bacteria can be controlled by cooking meat thoroughly and keeping cooked meat away from uncooked meat.

Hepatitis A virus - The hepatitis A virus can be contracted from food not properly prepared by a person infected with hepatitis or from eating contaminated raw shellfish or contaminated mollusks. Cooking does not always kill the virus. Hepatitis symptoms at onset of illness include: malaise, appetite loss, nausea, vomiting, and fever. As the illness progresses, the patient develops jaundice with darkened urine, and may have liver damage.

Listeria - Listeriosis disease is caused by the listeria bacteria. While the bacteria infect shellfish, birds, spiders, and mammals all over the world, it is uncommon in humans. Although there are not nearly as many cases of listeriosis as there are salmonellosis, it is a very deadly disease especially for fetuses, newborns, and people with weakened immune systems. People can get listeriosis by eating foods contaminated with the bacteria such as soft cheese, unpasteurized milk, seafood products, cooked shrimp, and cooked surimi (fish, sausage, artificial crab). The disease is also transmitted by direct contact with mud, sewage, or soils contaminated with the organism and by inhalation of contaminated dust particles. This tough bacteria can grow at refrigeration temperatures and can survive mild heat.

Salmonella - This bacteria causes salmonellosis. Very low levels of bacteria can cause this disease. More than 40,000 illnesses are reported each year, but experts believe there are many more cases that are not reported. Nearly half the reported cases of salmonellosis require hospitalization, and one to two percent result in death. The salmonella bacteria have been found on many foods, particularly on raw meats, poultry, dairy products, pasta, and chocolate. Symptoms range from none to very severe but most often include nausea and diarrhea.

Staphylococcus - Staphylococcal infections are caused by the staphylococcal bacteria. Staphylococcal bacteria are found in the nose and mouth and on the skin of healthy people. The bacteria multiply at warm temperature, which produces the toxin that causes illness. Infected people who prepare or handle food can spread the illness to others if proper hand washing and utensil cleaning are not followed. Also, the bacteria can multiply quickly if leftover food is not promptly refrigerated.

Toxoplasma - Cats frequently are infected with this parasite, which can be transferred to humans by contacting contaminated cat feces or by eating improperly cooked meat or poultry. The animals received the infection from infected cats. Infants can acquire the

parasite from their mothers before birth. Severe mental retardation may result. Meat, particularly lamb and pork, should be cooked thoroughly to kill the parasite. Individuals with a weak immune system are particularly susceptible to toxoplasmosis.

Trichinella - This parasite causes trichinosis. It is commonly found in animals that eat human garbage. It is mostly transmitted to humans by eating undercooked pork or bear. Symptoms include abdominal pain, nausea, fever, diarrhea, muscle pain, and fatigue. There are few cases of trichinosis in the United States.

Vibrio parahaemolyticus - Vibrio parahaemolyticus bacteria cause vibrio gastroenteritis, which can cause water diarrhea, abdominal cramps, vomiting, headache, chills, and fever. This organism can be ingested in contaminated uncooked or undercooked shellfish. The bacteria can also enter the human body when an individual with open wounds comes in contact with infected coastal waters. A very closely related microorganism, vibro cholera also can be transmitted by seafood, salt water, but it is most commonly found in areas with poor water treatment facilities.

Yersinia - Yersinia bacteria cause the plague. The rat is the primary carrier. If an infected rat leaves droppings in grain, for example, those contaminated droppings could get into the food supply for humans, thus spreading the disease. Unproperly cooked pork or raw milk may have the Yersinia bacteria present. Yersinia can grow at refrigeration temperature, but heating kills the bacteria.

Using a thermometer when cooking meat can reduce the incidences of these food-borne diseases.

Summary

Foods are a perishable commodity. Foods are subject to both physical and chemical deterioration. Dehydration, a cracked skin, a broken emulsion, off-colors, and a change in the texture are all physical deterioration examples. Chemical reactions that lead to deterioration include fermentation hydrolysis, toxin production, enzymatic reactions, and pigment conversions. Moisture and warm temperatures are necessary for growth of bacteria, yeasts, and mold. Bacteria, yeasts, and molds are the organisms responsible for the majority of food deterioration. A variety of human diseases result from microbial invasion. Examples include botulism, salmonella, trichinosis, campylobacteriosis, etc.

Credits

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