SINCE early humans began hunting and gathering food sources, the question of preservation has been present. Ages ago, people were confined to eating whatever food was present and had to consume that food before it spoiled. Today, with the development of food preservation techniques and massive supermarkets, we are able to purchase nearly any type of food product during any season of the year. We are no longer dependent on a hunting team or the summer months for abundant food.

Food additives and preservation techniques have allowed producers to package and store food products to be shipped anywhere in the world, while allowing consumers to enjoy food products for longer periods. These additives and techniques have improved the lives of all people.

Objective:

Examine several food preservation techniques and their benefits.

Key Terms:

- air-blast freezing
- blanching
- chemical drying
- commercial sterilization
- conduction
- convection
- drying
- fermentation
- flavor enhancers
- flavoring agents
Food Preservation Techniques

All food products, despite attempts at preservation, will ultimately spoil. **Food spoilage** is the condition in which food is no longer safe to eat. Some food products may spoil much faster than others because of their weakness to microbes and the favorable environment they provide to these invaders. Many times, spoilage is the result of the actions of microorganisms, such as bacteria, molds, and yeasts. Other times, spoilage is caused by the contamination of the food product with foreign matter, such as rodents, insects, or chemicals. Either way, **food preservation**, or the use of techniques meant to prolong the usable life of a food product, is needed to ensure a safe food supply.

All living organisms will some day experience **senescence**, or

![Food Preservation Techniques Image](image-url)
the terminal, irreversible, deteriorative change that leads to cell and tissue breakdown and finally to death. In fruit, senescence is the period following ripening when the tissue of the fruit ceases growing and begins to become soft or broken, allowing microbes to enter and cause further deterioration.

Food preservation not only helps to keep food fresh longer but also helps to retain nutrients in the food. Some foods, such as fruit juices, will lose their nutrient content over time in a process known as nutrient depletion. Scientists are working to slow down nutrient depletion to give consumers fresh and nutritious food sources.

Possibly the most important aspect of food preservation for consumers is the retention of food taste, or palatability. Palatability refers to the overall taste of a food. Food must be palatable for the consumer to enjoy eating it. Food manufacturers can add an assortment of additives to food products to retain taste and slow the effects of microbes. However, each additive must be carefully researched so as not to reduce nutritional value. Sugar can be added to food products to improve the taste, but the result is also a lower nutritional value.

PREVENTING CONTAMINATION

Most doctors would tell you that preventing a disease is better than treating it once a patient has been stricken. In the same way, food scientists would agree that preventing food contamination is better than dealing with the microbes once they have invaded a food.

Contamination of food can occur in an endless variety of ways and will sometimes occur even with our best preservation techniques. But unlike the variety of contamination possibilities, a few preventive techniques practiced today are able to control most of our food-borne problems.

Heat

The most widely used and probably most ancient technique for preventing food contamination involves the use of heat. Most problem-causing microbes grow well at warm temperatures (between 60.8° and 100.4°F, 16° and 38°C). For sterilization of a food or food container, a temperature of 249.8°F (121°C) must be maintained for at least 15 minutes. This should completely kill all microbes. Food manufacturers must be careful to use sterilized equipment when processing or packaging food products.

When using heat for food preservation, the heat can be transferred to the product in one of three ways. **Conduction** is the method of heat transfer in which heat energy moves between two objects in direct contact. Much like a domino effect, as the food particles are heated, they transfer the heat energy into other particles with which they are in contact. Think of touching a warm cup of cocoa. As you touch the warm mug, you feel the warmth due to the conduction of heat energy between the mug and your hands. Canned tuna or hams are often preserved through a heat conduction method.

Another method of heat transfer is convection. **Convection** is heating caused by the movement of air or liquid through the food product. Usually a kitchen oven works by convection. It superheats the air inside the oven, which then cooks the food. Imagine standing next to a
campfire on a cool night. As you hold your hands in front of the fire, you can feel the heat of the fire—not from the fire itself but from the air that the fire has heated. Canned soups are often preserved by convection heating.

The final method of heat transfer involves the use of radiation. **Radiation** is the transference of heat using the electromagnetic spectrum. All known forms of energy make up the electromagnetic spectrum. Some forms of radiation, such as ultraviolet and infrared, are used in preserving food. Molecules of water in food that are exposed to UV and IR radiation begin to vibrate, generating heat. In addition, the UV and IR light can kill microorganisms that may be present in the food. Microwaves work on the same principle as radiation. A microwave oven causes food moisture to vibrate and generate heat, cooking our food much faster than a traditional range, which uses conduction between the pan and the food.

Heat provides the most effective and most nearly complete form of food preservation. Unfortunately, any heat exposure will change the form and possibly the taste of the food. For this reason, heat preservation must be used carefully to preserve the food without altering the characteristics of the product that consumers desire.

**Sterilization** of food is the complete elimination of all microorganisms in the food. Sterilized foods, if sealed correctly, can last extremely long periods. Spam and military MREs (Meals Ready to Eat) are examples of foods that have undergone sterilization processes. Although sterilization makes a food safe to store and eat, the result of the exposure to high temperatures often changes the original characteristics of the food. **Commercial sterilization** is the destruction of all microbes except for some spores. Eventually, commercially sterilized foods will become unsuitable to eat as the spores reduce palatability.

A common heat treatment used in the dairy industry is pasteurization. **Pasteurization** is the heating of a substance, usually milk or another liquid, to destroy any pathogenic organisms (i.e., those that would cause illness in humans). Milk is usually pasteurized to allow it to be stored for a time under refrigeration.

**Blanching** is another method of food preservation using heat. Blanching requires food products, usually fresh vegetables or fruit, to be subjected to a high temperature (usually between 180° and 190°F, 82.2° and 87.8°C) followed by a period of rapid cooling. Blanching does not raise the temperature of a food enough to kill any microorganisms in the food.
process is solely used to inactivate enzymes that would normally cause the food to deteriorate and spoil.

**Cold**

Besides the use of heat as a food preservation technique, cold temperatures can also serve to slow microorganisms and prevent food spoilage. Refrigeration and freezing techniques were used by the earliest hunters as they packed fresh meat into snow and ice to keep it for later meals. Although this might have worked well in the winter, summertime made preservation a little more difficult to accomplish.

Unlike heat, cold will not kill all the microorganisms present in a food product. Instead, the metabolism of the microbes is slowed to where growth and reproduction are not possible and the food remains safe. Temperatures below 50°F (10°C) will have a negative effect on microbes present in the food. Freezing of a food product occurs at 32°F (0°C) as liquid water in the product changes to ice crystals and microbes are completely stopped. Extremely cold temperatures will have a deteriorative effect on some food products when they are thawed. As a food product is frozen, the water inside the cells expands and breaks cell walls, causing quick spoilage when the food is warmed up. Fresh fruit and vegetables do not freeze well unless they have been blanched before freezing. Food scientists have also discovered that a quick freeze will cause less damage than a slow freeze, as ice crystals are smaller and less damaging when they form quickly.

It is hard to image our lives without a refrigerator in the kitchen. Refrigerators, once luxuries, are now found in kitchens, dorm rooms, basements, and even hotel rooms.
**Irrigation** is the process of storing food products below room temperature but above freezing. Generally speaking, most refrigerators are set at around 45°F (7°C). Refrigerators are meant to slow the action of microbes for a short time before foods are prepared and eaten. Refrigerators are not meant for long-term storage. This is why you should periodically clean out your refrigerator and throw away old food (like that mystery container way in the back!). The cool temperature reduces microbial activity but does not stop it, resulting in spoiled food given enough time.

**Freezing** is the storage of food products during which the moisture inside the foods becomes solid ice. Freezing is an effective storage method but expensive, because foods must be kept frozen to ensure their safety. The food industry commonly uses three types of freezing processes.

**Plate freezing** is the process of rapidly cooling a food product between two metal plates. Each plate has cold fluid circulating inside that lowers the temperature of the surface of the plate to below freezing. As a warm food product comes into contact with both plates, it is quickly frozen. Heat will always flow toward a balance, or equilibrium, between two objects, as in a cold soda warming up to room temperature or a hot cup of coffee cooling down to room temperature. As the food product contacts the cold plates, heat is transferred from the food to the plates, dropping the temperature of the food to below freezing.

Another method of freezing is air-blast freezing. **Air-blast freezing** uses a high-speed blast of supercooled air to remove heat from a food product. In this case, the freezing method uses convection, or the transfer of heat using air or liquid.

Our final technique, known as **liquid freezing**, is similar to air-blast freezing. A liquid refrigerant, such as liquid nitrogen, is sprayed onto food products as they move along a conveyor belt. Meat products, such as patties, are commonly frozen using the liquid freezing method.

**Drying**

Microorganisms require a certain amount of moisture to live and reproduce properly. **Drying**, or the removal of moisture from a food product, succeeds in stopping microbial growth if moisture levels fall below 10 to 15 percent for the food product.

Drying is a popular choice for food preservation because of its effectiveness, but care must be taken not to change the taste or characteristics of the food by removing too much moisture. Dehydrated meals for soldiers may be handy on the battlefield,
Mechanical drying is one form of drying that involves the use of a machine to remove moisture. Some of you may even own a food dehydrator that you use at home to dry fruit slices or make your own beef jerky. Freeze drying is a method in which food is frozen and then placed in a container or chamber where all the moisture and air are removed from the product. Chemical drying is a process that uses a chemical, usually salt, to draw moisture out of a food product. Early sailors ate meat products that were heavily salted to keep them fresh while the sailors were at sea.

**Acid**

We don’t normally like to think of our food products being preserved with acid, but sometimes this is actually the case. An acid is any substance that has a pH value less than 7. Because microorganisms do not survive at acidic pH levels, substances with low pH values are wonder-

---

### ON THE JOB...

**CAREER CONNECTION: Winemaker**

Winemaking can be thought of as one of the oldest professions, dating back thousands of years. Viticulture is the growing and harvesting of grapes for making wine. The fermentation of grapes to produce wine is known as enology.

A winemaker has several tasks in the production of this ancient drink. First, he or she must closely observe the vineyards, monitoring the grapes for color and taste. When the time is right, the grapes are picked, crushed, and sealed to allow fermentation by yeast. The yeast converts the sugar and water in grapes to alcohol and carbon dioxide. After the appropriate aging, the wine is bottle, shipped, and sold to consumers.

Winemakers must also have knowledge of chemistry, as the level of acid, sulfur dioxide, and sugar must constantly be monitored. People skills are also important to winemakers as they promote their vineyards and wines during the winter months. Although grape harvesting and wine production are seasonal jobs, managing the vineyards and promoting the product is a year-round task.

The earnings of a winemaker vary widely, depending on the size and production volume of the vineyard. Employers look to hire people with bachelor’s degrees in viticulture and experience in the winemaking industry. A strong chemistry background is also helpful for potential employees. In high school, biology, chemistry, physics, and mathematics would be important courses for a career in winemaking.

---

A career in winemaking requires a person to work outdoors in a vineyard as well as indoors in a laboratory. (Courtesy, Agricultural Research Service, USDA)
ful preservatives. Natural substances such as acetic and ascorbic acid are commonly used to preserve plant products. Some foods themselves have acidic qualities that reduce the action of microbes. Tomatoes, citrus, and sauerkraut all have low pH levels that will inhibit the growth of microorganisms (at least for a while). Acids also serve to change the flavor of some food products, giving the foods more of a “bite” when eaten.

**Oxygen and Carbon Dioxide**

Oxygen and carbon dioxide are both directly related to the speed at which food spoils. Oxygen speeds up spoilage, while carbon dioxide can actually slow down spoilage. Knowing that some microbes enjoy oxygen to survive, food processors work to remove this gas from the packaging of their products. Carbon dioxide has been shown to inhibit and sometimes prevent cellular respiration, a common process in spoilage. Carbon dioxide will also slow ethylene production by fresh fruit. Ethylene is a gas given off by fruit that actually causes the fruit to ripen and deteriorate faster.

**Fermentation and Pickling**

Fermentation is often thought of as a flavor enhancement technique rather than a preservation method, but it is both. **Fermentation** is the breakdown of carbohydrates in a food source by the action of certain yeasts or bacteria. Fermentation can happen either in the presence of air (aerobic) or in the absence of air (anaerobic). As the yeasts or bacteria decompose the carbohydrates in the food source, they create several byproducts.

After complete oxidation of the product, carbon dioxide and water are released as byproducts. Partial oxidation will create acids that will lower the pH of the product to levels that will inactivate the microorganisms. Think of this process as like eating an entire box of candy bars. At first, you may love the taste and eat as many as you can, similar to the yeast and the carbohydrate. The more you eat, the worse you feel, until finally you stop eating the candy. (You probably will not want another bar for awhile.) As the yeast ferments and produces acids, the acid level eventually kills the yeast!

There are two main types of fermentation common in food preservation. Alcoholic fermentation produces alcohol as a byproduct and is used to produce breads, beers, and wines. Lactic acid fermentation happens in working cells and causes a buildup of lactic acid (resulting in that soreness you feel in your muscles after a hard workout).

When the fermentation process is coupled with the use of salt, the method is known as **pickling**. Pickling
can be accomplished without the use of microbes if food products are placed in solutions containing natural acids, such as vinegar or citric acid. Along with citric acid, lactic, malic, and tartaric acids, which are all found naturally in plant juices, can be used in the pickling process.

**Sugar and Salt**

When we consider food additives that preserve freshness, salt, not sugar, often comes to mind. Sugar, as in the case of fermentation, provides a food source for the microorganisms to survive and grow. But when enough sugar molecules are dissolved in water, the water activity is reduced and microbe growth is inhibited. Salt, in the same way, reduces water activity in foods and serves as an excellent preservative.

When microbes, such as molds, are placed in a heavy salt solution, or brine, water diffuses out of the microbe cells and into the salt solution. This movement of water from a high to a low concentration through a cell membrane is known as osmosis. In addition to dehydrating microbes, salt also acts to lower the freezing point or raise the boiling point of water, also aiding food preservation.

**Air**

It is not the presence of air but the absence of it that benefits food preservation. Oxygen will increase the decomposition of a food and aid in the work of microbes within a food. Sealing food in a partial or total vacuum can prevent aerobic microbes (those that need oxygen) from growing and reproducing. As fresh fruit and vegetables are picked and shipped, they continue a process of cellular respiration, in which carbohydrates are broken down into carbon dioxide and water. This respiration also causes a deterioration of the food tissues so that microorganisms can cause faster spoilage.

Scientists have found that respiration of fresh food products can be slowed down by limiting the amount of oxygen around the foods. The gases given off by respiring fruit, such as apples, also serve to increase ripening in other fruits. If the movement of air surrounding these foods is minimized, there will be less chance of contamination by microbes or other substances and less exposure to respiration gases.

**Irradiation**

When we hear the term irradiated food, most of us have visions of some greenish, glowing, radioactive sandwich. The truth is that irradiated foods are not dangerous and are actually very safe. **Irradiation** is the use of gamma rays to bombard a food, killing all microbes and inactivating enzymes that would normally cause spoilage. After irradiation, the food product is completely sterile and, if sealed correctly, can be stored for long periods. Once the product is reopened, it will again be subject to invasion by microbes and may spoil like any other food. The important thing to remember is that irradiated food is not radioactive and is not harmful.
FOOD ADDITIVES

In today’s world of food preservation, finding a manufactured food product that does not contain additives is nearly impossible. Food additives are substances designed to retain or improve the desirable characteristics of food. Some additives can change the flavor, make the food more chewy or crunchy, make the food appear more appetizing, or increase the shelf life of the product. Unless you grow your own food and cook your meals using only this food, you are eating food additives every day.

Most food additives are in the form of chemicals added to the food to prolong its useful life. The Food and Drug Administration (FDA) regulates the use of all food additives to ensure that treated foods are as safe to consume as untreated items. Food additives can be used for a variety of reasons, from preserving freshness to increasing nutritional value. Some additives, like the caramel coloring in a cola, are simply added to increase consumer acceptance of the food product. Other additives are introduced to make food preparation easier, which may be important to people on the go.

Although the FDA sets strict rules for the use of food additives, it is up to each food processor to meet them. For an additive to be allowed in a food product, it must meet several regulations and standards.

1. The additive must be safe for humans to consume. This means that the additive must be extensively tested by the FDA and proven to have no harmful effects on consumers.

2. The additive must perform as it is supposed to in the specific conditions of the food. The additive must actually do what it claims to do and not have any harmful side effects.

3. The additive must not reduce the nutritional value of the food item. The FDA will not allow an additive to make a food item less healthy for people to consume.

4. The additive must not deceive consumers, such as by hiding undesirable tastes or smells. Food processors cannot add substances to foods simply to mask the taste of other ingredients.

5. A specific test must be available to determine the presence and amount of an additive. An additive cannot be introduced into a food source if there is no way to tell if and how much of the additive is present in the food.

FIGURE 7. The label on this bottle of soda lists a number of food additives meant to enhance the product.
6. The additive may not be substituted for poor manufacturing processes. This means that the additive cannot take the place of quality processing so that the producer can gain more of a profit.

**Categories of Additives**

With all the regulations and guidelines that additives must meet to be used in food, it is amazing to think that thousands of additives are commonly used in everyday food products. Additives are used to affect nearly every characteristic of food, from texture and taste to color and nutrition. Flavor enhancers, flavoring agents, texture enhancers, and sequestrants are only a few of the categories of food additives.

**Flavor enhancers** are those additives specifically used to change or improve the flavor of food products. Most flavor enhancers have little or no flavor themselves, but because of chemical reactions with other ingredients and your tongue, there is an increase in the perception of taste. Monosodium glutamate (MSG) is a popular flavor enhancer made from seaweed extract. MSG itself has very little flavor but can be used to increase the taste of some foods.
**Flavoring agents** can be used along with flavor enhancers. A flavoring agent helps to regain a flavor lost during processing or to boost a flavor that will make a product more enjoyable. Oils and extracts, such as vanilla, are common flavoring agents.

Another category of food additives is texture enhancers. **Texture enhancers** are mainly used to improve the texture of foods, making them easier and more enjoyable to chew and eat. Texture enhancers also work to retain water in some food products, allowing the foods to remain moist and easier to consume. Enhancers such as glycerin, mannitol, propylene glycol, and sorbitol are commonly used in food products to improve texture. Think of cookies that are so dry they are tough to bite into. Texture enhancers would keep the cookies soft and moist for longer periods.

**Sequestrants** are food additives that help to inactivate metal ions that are naturally found in food. Without these additives, the metal would react with lipids and fats in the food in a process called oxidation. Oxidation of foods with high lipid contents causes off-flavors and smells, spoiling the foods. Sequestrants that bind the metal ions and interfere with the oxidation process are also known as antioxidants. Malic, tartaric, and citric acids are all examples of common sequestrants.

Many additives are used because of their ability to preserve or inhibit the growth of microorganisms. Sodium chloride (salt) lowers the water activity of a food product, reducing the ability of microbes to survive. Sodium or calcium propionate decreases the growth of mold and is commonly used in bakery products to extend the shelf life. Sorbic acid is commonly added to fruit drinks and cheese to inhibit the growth of unwanted molds and yeasts. Sodium benzoate and benzoic acid are preservatives that can be found in candied products and soft drinks. Processed meat products, such as sandwich meat and beef jerky, commonly contain the antioxidants BHT (butylated hydroxytoluene) and BHA (butylated hydroxyanisole). These additives reduce the oxidation of the animal fat found in meat products, keeping the products fresh longer. Sulfur dioxide, when applied to fresh fruit, allows the fruit to dry faster and inactivates the enzymes responsible for browning.
Summary:

Even with our best efforts, microbes will continue to spoil food products. Molds, yeasts, and bacteria are the microorganisms that cause most of the damage to packaged and fresh food products. The prevention of food contamination through the use of heat, cold, dehydration, chemicals, and irradiation is a priority in the food industry.

Additives are commonly used in food products to enhance or change the characteristics of food. The use of additives in food is closely monitored and regulated by the government and cannot negatively affect the food products. Additives are used for a variety of purposes, ranging from preserving fruit to making cookies crunchier.

Checking Your Knowledge:

1. What are the three ways that heat energy can be transferred? Explain each method of transfer.
2. Why is blanching important for fresh food that will be frozen?
3. List and describe the three types of freezing common in the food industry.
4. What are the six regulations a food additive must meet to be approved by the FDA?

Expanding Your Knowledge:

Schedule a field trip to a local food processing facility to observe techniques used in the industry to prevent contamination and prolong the freshness of food. As an alternative, visit your local grocery store and meet with the produce or fresh meat manager to discuss food preservation.

Web Links:

- How Stuff Works—Food Preservation

- National Center for Home Food Preservation
  [http://www.uga.edu/nchfp/](http://www.uga.edu/nchfp/)

- Agricultural Career Profiles
  [http://www.mycaert.com/career-profiles](http://www.mycaert.com/career-profiles)