by R. Andrew Braun, CDM, CFPP

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Unspoiled

Humanity's Quest to Save Food for Later

FOOD PROTECTION CONNECTION

The science of food preservation and the evolution of safeguarding foods

Food preservation is as old as humankind. Our ancient ancestors continuously sought ways to extend today's plenty against tomorrow's need, and keep food safe for consumption in the face of spoilage and the onslaught of disease-bearing pathogens.

This article will dive into the science of food preservation. We will look at a few ways humanity has come up with to safeguard foods, how they likely came about, and the science of why they keep food edible long after it should have expired. There are myriad ways to preserve food and keep it safe. Most of these methods alter the flavor, texture, and nutritional content of the foods they seek to preserve. The finished products are often staples that hold a deep cultural significance and a place in regional traditions. From kimchi to raisins, fermented shark to gravlax, smoked brisket to Polish sausage, what started as a necessity now links our past to our present, and will continue into the future for as long as people eat.

REFRIGERATION

Modern society mostly takes refrigeration and freezers (and even air conditioning) for granted, but they are crucial to our way of life. Without the ability to ship and store food and beverages safely, we would be unable to feed our exploding population. Refrigeration slows down bacterial growth to a

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manageable level at 40°F and below, and you likely have an entire filing cabinet drawer filled with temperature logs if you work in food service to highlight the importance of maintaining this measure.

People have known that keeping food cold helps it stay fresh longer for as long as there has been winter. Icehouses and iceboxes, root cellars, and other rudimentary methods have been used for centuries. It wasn't until the mid-1700s that science caught up to the challenge of using energy to remove heat, and not until 100 years later that the in-home refrigerator was mass produced. A new refrigerator initially cost more than a car! Air conditioners, refrigerators, and freezers (in keeping with the inviolate laws of thermodynamics) actually *create* more heat than they remove—they just vent it out somewhere other than the environment they are "cooling." That is why your air conditioner is either in a window or outside of your home. This is also why you can feel hot air being blown on your toes when you are cruising the fridge for snacks sometimes.

DRYING AND CURING

Drying (or dehydrating) food is quite possibly the earliest form of food preservation. It has been done for millennia,

with the oldest known examples starting around 14,000 years ago. Food spoils because it is under attack not only from bacteria, fungi, and other organisms, but also because the actions of enzymes naturally present in the food to begin with. Many of these spoilage pathways require water to proceed, and drying simply removes the water critical to this process. Removing the water also makes foods smaller and lighter, facilitating both transportation and storage. This means that dried foods are still incredibly widespread, although the method has been industrialized. Salt is often used to dry foods more quickly, and the high salinity acts as another barrier to spoilage. When you coat food in salt, it creates a *concentration gradient.* Nature loves equilibrium, and water is no exception. When there is a higher concentration of sodium ions on one side of a membrane, the water will flow towards that higher concentration until the concentrations are equal. Chefs take advantage of this in many ways, like salting eggplants to draw the bitter liquid out of them, curing salmon with salt and sugar to make gravlax, and salting pork loin to make pancetta.

Examples of traditional dried foods are often meats, like beef jerky, salt cod, and shrimp. Rice, beans, and corn have been dried for centuries.

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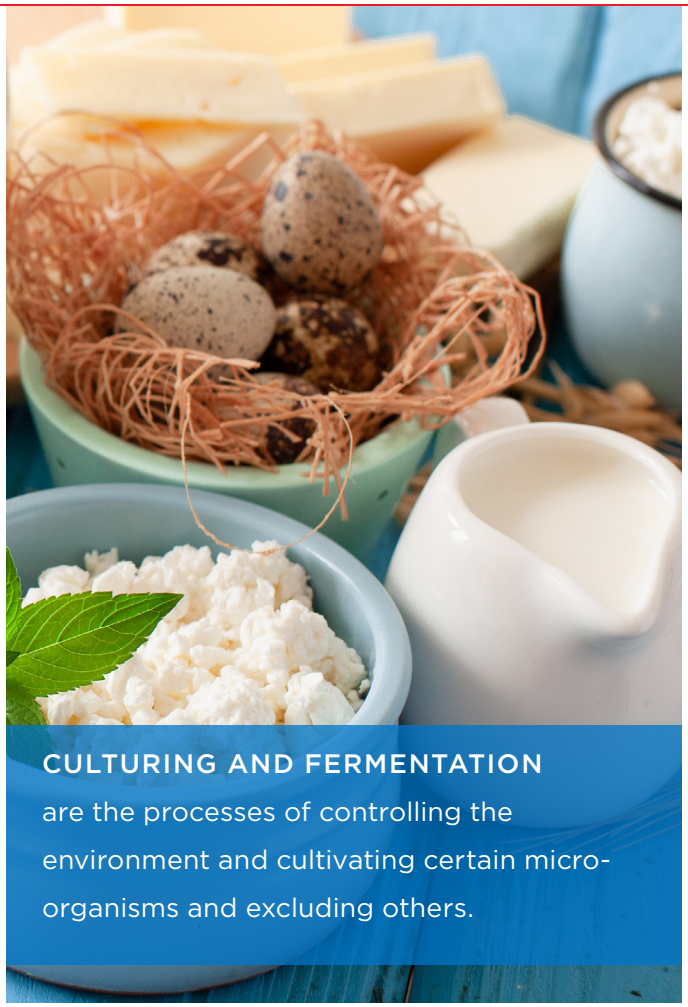
Dried rice was even used as currency by the Shoguns of feudal Japan. Cured meats, though more resilient to spoilage, are not foolproof, and sausages, hams, and other meats sometimes had the curious effect of randomly killing people almost instantly. The sudden food poisoning was linked to several deadly outbreaks involving sausages in the early 1800s. The Latin name for sausage, *botulus*, was used by doctors and microbiologists to name the bacteria that was eventually found to be the culprit: *Clostridium botulinum*. More on botulism and its effects below.

PASTEURIZATION

It is impossible to talk about pasteurization without talking about its inventor, Louis Pasteur. He was a French chemist, a pioneer of early biochemistry, microbiology, medicine, and more germane to this article, food safety. Pasteur proved that microorganisms existed, caused sickness and spoilage, and more importantly, that they could be killed *and* prevented from growing back under the right conditions.

The idea that you can heat food to sterilize it while keeping it sealed from further contamination is commonplace today, but was revolutionary at the time. The key ingredient here is time and temperature. Heat kills bacteria, and the higher the temperature, the shorter the time needed to eliminate pathogens. Canned food has always had a reputation for being overcooked and mushy because of this process. Modern day pasteurizers have solved this problem in several ways. You may have noticed more and more products, like tuna, are being sold in pouches instead of cans. These flat pouches increase the surface area of the product and reduce the time required to heat them all the way through. Another workaround currently popular is ultra-high temperature (UHT) pasteurization. In food science, this is referred to as the thermal death time, and the formula is contingent upon the organisms targeted, usually botulism. Botulism thrives in zero oxygen environments, and canned foods are ideal. This is why discarding dented and damaged cans is so important. Even a few *Clostridium botulinum* bacteria introduced into a can through a dent or microscopic puncture can quickly multiply into the millions. These bacteria produce botulism toxin, which cannot be destroyed by heat or "cooked out." Even if all the bacteria are dead, the toxin remains. Botulism toxin is *the most deadly poison known to man*. Botulism paralyzes the nerves that control our muscles, including the heart and lungs. Pasteurization has saved millions of lives over the last 150 years. Thanks, Louis!



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CULTURING AND FERMENTATION

What better way to stymie bacterial growth than to beat them at their own game? Culturing and fermentation are the processes of controlling the environment and cultivating certain micro-organisms and excluding others. Cheese, yogurt, soy sauce, beer, wine, and sour cream are all great examples of cultured foods. Yeast has been used for at least 10,000 years to produce alcohol through alcoholic fermentation. The yeast eats sugar and produces ethanol as a by-product. The resulting ethanol kills microbes so effectively that it is the principal ingredient in most hand sanitizers. The alcohol even kills the yeast that produced it when it reaches a concentration of 14 percent. To reach a higher alcohol content, distillation is necessary.

Dairy cultures, like cheese and yogurt, probably came about by accident when the right organisms made the unrefrigerated dairy products of our ancestors last longer *and* taste good. Like adding yeast to grape juice to make wine, it is important to add a culture of the beneficial bacteria into the mixture to get the desired product. Once added, they will protect the product from other harmful organisms by changing the pH, creating an acidic

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environment that isn't friendly towards enemy bacteria. This acidity is accompanied by a sour flavor. I guess that is why we call it sour cream.

Another interesting consequence to adding beneficial organisms is the potential effects they then have on our digestive systems. Science has only recently begun to recognize the importance of having the right bacteria in our guts, and a growing body of research suggest that this affects far more than just digestion, but overall physical and mental health as well.

PICKLING AND BRINING

Like cultured dairy, pickling protects food by manipulating the pH with the addition of an acid. In most cases, this is acetic acid, commonly known as vinegar, and accompanied by salt to help with flavor and as a protective effect. Pickling is often accompanied by pasteurization to kill any of the hardy microorganisms that might like an acidic environment (acidophiles), but mainly relies on the acid and salt in the pickling mixture. Often garlic and strong seasonings are added to compete with the strong vinegar flavor and aroma. Pickled cucumbers are incredibly common in North American cuisine, but just about every garden vegetable, root, egg, and even fish are pickled staples of some regional cuisine somewhere. Personally, I have always been suspicious of a giant jar of murky, sea-green liquid with cucumbers floating in it at my local gas station, but my friends (true believers) assure me that it is safe. Apparently, the only thing growing in there is flavor.

THE KEY TO PASTEURIZATION is time and temperature. Heat kills bacteria and the higher the temperature, the shorter the time needed to eliminate pathogens.

PICKLING protects food by manipulating the pH with the addition of an acid.

SUMMARY

In summary, we preserve foods by manipulating the conditions that pathogens need to grow and reproduce. We often hear the acronym FAT TOM in sanitation class to describe the six things that bacteria need to flourish (with *total* disregard for TOM's feelings). Bacteria need *Food*, the right *Acidity, Time* to reproduce, the right range of *Temperatures*, the right *Oxygen* level, and *Moisture* or water activity. If you look back on our traditional food preservation methods, you will see how each one is connected to FAT TOM.

Sorry, TOM. E

CE Questions: Food Protection Connection

This Level II article provides basic to advanced resources. The desired outcome is to facilitate application of knowledge into practice by drawing connections among ideas and using information in new situations.

Reading *Unspoiled: Humanity's Quest to Save Food for Later* and successfully completing these questions online has been approved for 1 hour of Sanitation continuing education for CDM, CFPPs. CE credit is available ONLINE ONLY. To earn 1 SAN CE hour, access the online CE quiz in the ANFP Marketplace. Visit **www.ANFPonline.org/market** and select "**CE Articles**" within the Publications Section. If you don't see your article title on the first page, then search the title, *"Unspoiled: Humanity's Quest to Save Food for Later."* Once on the article title page, purchase the article and complete the CE quiz.

1. What is FAT TOM?
   A. An acronym describing the conditions bacteria need to survive and reproduce
   B. The leader of the great sausage rebellion in Germany in 1807
   C. The inventor of the electric refrigerator
2. Pasteurization is the process of:
   A. Making food safe for room-temperature storage by heating and sealing items
   B. The process of moving cattle from indoor pens to large pastures
   C. Making non-dairy creamers taste more like milk
3. Clostridium botulinum is:
   A. Named for the Latin word "Sausage"
   B. A bacterium that produces the deadliest poison known to man
   C. Both A and B
4. A concentration gradient is:
   A. Named for the "uphill thinking" used to solve food safety problems in the 1800s
   B. When water or other solvents flow from an area of higher concentration to a lower concentration
   C. When water or other solvents flow from an area of lower concentration to a higher concentration
5. Refrigeration:
   A. Violates the laws of thermodynamics by destroying energy
   B. Creates more heat than cold
   C. Was invented in 1927
6. Most bacterial growth at temperatures below 40˚F:
   A. Is slowed dramatically
   B. Is unaffected
   C. Increases dramatically
7. Water activity is important to bacteria because:
   A. Of the dangerous foodborne bacteria associated with swimming in lakes
   B. Most bacteria need water to survive and reproduce
   C. Water slows bacterial growth up to 75 percent