**Food Fermentation: The Scientific Magic Behind the Centuries Old Process**

**Introduction:**

 In a time before refrigeration or preservatives were widely available, a more primitive approach to preserving foods were utilized in order to keep food fresh and unspoiled. This approach is known today as fermentation, and it is used in more products than just alcoholic beverages. For example: sauerkraut, yogurts, cheeses, sourdough, salami, sausage, kimchi, soy sauce, coffee, tea, chocolate and the list goes on and on of other products that utilize the phenomenon that is fermentation. Fermentation is the microbial process of breaking down simple sugars and converting them to either alcohol or organic acids by the use of microorganisms (yeast or bacteria) under anaerobic (without oxygen) conditions.

 With the simplicity of buying pre packaged frozen foods at the grocery store the art that is food fermentation has somewhat taken a back seat the past 50 years. However, in recent years with the new belief that fermented foods carry with them a plethora of health benefits, a resurgence of the craft that is fermentation has begun. So, everyday more and more people are seeking out kombucha, kimchi, sauerkraut, or whatever else appeals to the consumer, because of the belief that these foods/beverages will contribute to a better overall gut health (by improving gut flora). Whereas, Eastern countries like China, Germany, India, and several other undeveloped countries have always advocated for fermented foods mostly out of necessity rather than novelty, due to their longer shelf life and increased duration of safety. We owe this prolonged safety to the microscopic bacteria known widely as anaerobic bacteria, and this is simply a blanket term to describe all bacteria that perform at their best without the presence of oxygen.

**Practical and Historical Reasons For Fermented Foods and Beverages:**

Fermented foods and beverages date back to 7000 B.C. or possibly further with some of the first discovered examples stemming from China which included fermented rice wine (sake) [1]. The processes for several of these foods has been known for quite a long time, but the science and the actual microbiological ongoings of it all is more of a recent discovery (within 200 years or so). This proves that when in struggle, people will find a way to make it work for them. In the early days before controlled refrigeration, and in the times before artificial preservatives, fermentation was a way of prolonging the shelf life of certain foods from anywhere between 4 weeks to a year or longer. This works because lactic acid producing bacteria are also, by nature, anti fungal [2]. This is the ‘magical’ property that fermentation bestows upon its products. This was important for the times when crops were bad and food stores were necessary for survival. So this incredible property allowed for the survival of a group of people and allowed for the survival of a time old practice.

 Today, however, fermentation is not as crucial for survival as it was 200 plus years ago because of our technology (refrigeration, preservatives, etc…) . Today, fermentation is more used for perceived health benefits, flavor, and overall general nutrition. Recent discoveries have found that microbial activity can lead to a more efficient uptake (absorption) of nutrients naturally present in the foods that have been fermented. Which could also lead to a healthier individual through the increased absorption of antioxidants into the body, thus utilizing a higher percentage of the nutrients [3], so essentially getting “more bang for your buck” when it comes to choosing what to buy at the grocery store.

**Anaerobic Microbes:**

 Anaerobic microbes are present on just about everything, and they are the unsung heroes of the fermented food/beverage world. There are several (insert hundreds) that are naturally occurring on fruits and vegetables but only a few thrive and become the characteristic microbe in that particular food/beverage. The majority of the time the following will be responsible for the fermented food: *Lactobacillus, Enterococcus, Pediococcus, Acetobacter,* and *Saccharomyces*. Individually, or as a team, these bacterias create the fermented foods that are present on your table.

**Fermented Vegetables:**

 We all know that pickles begin their life as cucumbers, and sauerkraut has its start as cabbage, but what we may not know is how it got from point A to point B.

 Sauerkraut, for example, is made/created using fresh, salted, shredded cabbage. Shredded is an important concept because it creates more surface area on the cabbage which gives more room for the Lactic bacteria to take control and do work. The next step, the cabbage is allowed to sit in a vat (large barrel), this is the process known as bulk aging, and the *Lactobacillus mesenteroides,* which is naturally present on the leaf, takes hold and it begins what is known as a ‘primary fermentation’ and this begins the souring process, which basically just lowers the pH of the cabbage. Because of this acidifying, the *Lactobacillus mesenteroides* quickly dies off due to its inability to survive in such a low pH — meanwhile *Lactobacillus brevis* and *Lactobacillus plantarum* take over to complete the fermentation process. While these bacteria have taken over (*L. brevis and L. plantarum*) this phase is known as the gaseous phase. This phase is where the lactic acid producing bacteria metabolize (eat) sugars and this process creates ethanol (alcohol) , carbon dioxide (CO2), acetic acid (vinegar), and lactic acid. After a period of about two weeks, the cabbage is ready to be consumed as sauerkraut [4].

 Pickles on the other hand, are an entirely different beast than say sauerkraut. Pickles rely on an already fermented beverage (vinegar) to do the microbial breakdown of its makeup. The cucumbers are brined which simply means put in an extremely salty solution along with vinegar and together these two liquids ferment the cucumbers, thus creating pickles.

**Fermented Dairy:**

 Cheese is another form of fermented food, often times overlooked as being fermented, but rest assured its fermented. The majority of all cheeses are produced using Lactic Acid bacteria, which makes sense because milk is a lactose product. The lactic acid forming bacteria is actually the main contributor to the sensory (smell, or aromatic qualities) of the cheese.

 Kefir is a slightly alcoholic milk beverage that is extremely popular in Russia, and it is an anaerobically fermented sheep, goat, or cows milk that is slightly sour and acidic. *Lactobacillus acidophilus* is generally the anaerobic microbe responsible for fermenting (metabolizing) the lactose (milk sugar) out of the liquid thus creating a tart, nutritional milk beverage with a longer shelf life due to the presence of alcohol (ethanol).

 Yogurt or yoghurt is a creamy milk food that is a result from the lactic fermentation of milk. Originally widely popular in India and the Middle East, probably due to their huge amount of dairy producing animals (cows, goats, etc…) that inhabit in those areas. The process includes: heating the milk up to 45 degrees celsius, which as a result denatures (breaks down/destroys) the milk proteins present in the milk, creating a long form of unconformed milk proteins and then several anaerobic microbes (*Lactobacillus dellbruecki* subspecies *bulgaricus, Streptococcus thermopilus)* are pitched (added to the liquid). This unique cocktail of bacteria will work on the liquid, by breaking down and metabolizing the various sugars present and the final result will be yogurt.

**Fermented Bread:**

 Bread may very well be one of the most famous fermented foods in the world, second only to beer and wine. But not everybody is aware that bread is in fact, a fermented food, especially sourdough. The process that occurs is when the dough is prepared and yeast (*Saccharomyces cerevisiae*) is added to the dough and the mixture is allowed to leaven (to ferment and to rise). This process is what is responsible for giving sourdough its ‘tangy’ character and also helps to preserve the bread for a longer shelf life. When the yeast is added and the dough is rising, the yeast are metabolizing the simple sugars within the dough, which results in the creation of gas (CO2), which gives it the appearance of ‘rising’. This release of carbon dioxide also results in the holes you find within the loaf of sourdough.

**Fermented Meats**

 Salami, pastrami, and sausage are just a few examples of the huge amount of fermented meats in the world. Meats are a very popular choice for fermented foods because of their relatively short shelf life if left natural and unprocessed. The microbial fermentation for meats is quite a bit different from all of the other foods mentioned thus far. Because meat, lacks a lot of natural sugars itself, dextrose (corn sugar) is often times added to give the lactic acid forming bacteria some food to eat in order to lower the pH of the meat, which also inhibits other microbes from spoiling the meat so quickly and easily. After the meat is fermented for about a day, it is then covered in a casing and allowed to hang, this process is known as ‘curing’. This step allows the moisture to be evaporated out of the meat, leaving it with almost an airtight layer surrounding the inner layers of the meat and the casing.

 **Fermentation Gone Wrong:**

 Fermentation is not always as easy as putting some cabbage in a large container and letting it sit for a couple of weeks, hoping to get healthy, edible cabbage. Many times, you have to have control of all of the variables in order to ensure a sound, safe product.

 The discovery of vinegar stemmed from a wine fermentation where the vat was left open and not under anaerobic conditions for fermentation and a strain of Acetobacter (a producer of acetic acid) crept into the vessel, ultimately reducing the could be good wine to vinegar. But this was a good accident, other accidents do not always end as well. Pickles, for example, if not sealed or canned properly can be a great environment for the infamous *Clostridium botulinum*, or otherwise known as Botulism, to creep in and not only ruin the batch, but also possibly seriously injure or kill the individual eating the pickle.

**Conclusion**

 The fermentation of foods and beverages were originally discovered as a means of preserving, but now they are simply a means of nutrition and enjoyment to the consumer. Fermentation is the microbial activity of a yeast/bacteria/fungus metabolizing simple sugars and converting the sugars to gases, acids, or alcohol inside of a particular closed system, or anaerobic and thus lowering its pH and ultimately preserving the food/beverage because of these reactions. Most food fermentations are produced by a lactic acid producer, the most famous one being *Lactobacillus,* followed by *Pediococcus* together these two genus’s make up a great majority of all of the food fermentations.

 There are countless amounts of fermented foods and beverages that we all enjoy each and every day. Many of them we take for granted, so the next time you eat a pickle, or some sauerkraut, thank the little guys that provided you with the safe, nutritious meal.

**References:**

1.Marsh, Alan J., Colin Hill, R. Paul Ross, and Paul D. Cotter. "Fermented Beverages with Health-promoting Potential: Past and Future Perspectives." *Trends in Food Science & Technology* 38.2 (2014): 113-24. Web.

2.Hugenholtz, Jeroen. "Traditional Biotechnology for New Foods and Beverages." *Current Opinion in Biotechnology* 24.2 (2013): 155-59. Web.

3.Granato, Daniel, Domingos Savio Nunes, and Francisco J. Barba. "An Integrated Strategy between Food Chemistry, Biology, Nutrition, Pharmacology, and Statistics in the Development of Functional Foods: A Proposal." *Trends in Food and Science Technology* (n.d.): n. pag. Print.

4. Wood, Brian J. B. *Microbiology of Fermented Foods*. London: Elsevier, 1998. Print.