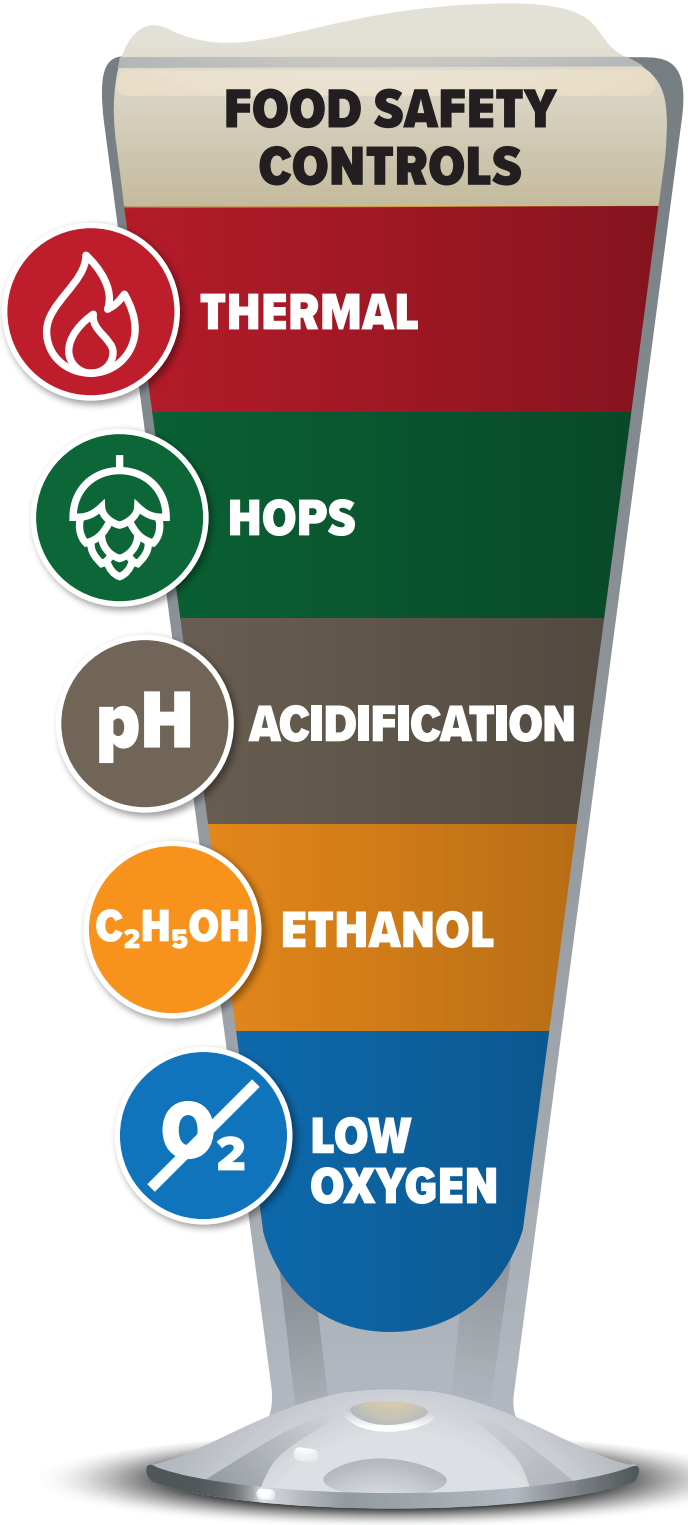
INHERENT MICROBIOLOGICAL FOOD SAFETY CONTROLS IN TRADITIONALLY BREWED BEER

Traditional brewing processes yield a set of inherent properties which have a long history of ensuring microbiological food safety even before modern scientific methods were developed, allowing civilization to thrive when potable water limited. This document will briefly describe the five main points of microbiological food safety control and how they work together to make beer food-safe: thermal processing, alpha acids, pH, ethanol, and low concentrations of oxygen. Each contributes to beer being safe for consumption, and together they form a set of "hurdles" which inhibit human pathogens, essentially stopping these microorganisms dead in their tracks. Modern research has shown that these hurdles can't function in isolation. Much like the factors that determine the efficacy of cleaning procedures, these food safety hurdles work in concert. This document aims to discuss the different food safety properties of beer and help illustrate the necessary considerations when innovating or changing these Safety Controls. If you would like a deeper dive on food safety at your brewery, see the Brewers Association Food Safety Planning Guide for Brewers.



1. THERMAL PROCESSING

Thermal processing is a technique traditionally used in brewing and many other types of food processing to eliminate pathogens. When heat is applied to a product at a high enough temperature for a sufficient duration, the proteins that comprise cells are denatured, which renders proteins essential for proper cell function useless. Brewing utilizes thermal processing in the boiling of wort to disrupt any microbes carried by incoming raw materials (e.g. malt, hops, and adjuncts). Pasteurization is another common form of thermal processing used in the brewing industry and may occur before or after packaging. Both methods work by heating the liquid up to an appropriate control point. The benefit to thermal processing is that unlike the other hurdles, it can function in isolation when applied to the final product. Unfortunately, thermal processing can sometimes change the flavor of the final product and should be taken into consideration.

2. HOPS ISO-ALPHA ACIDS

Alpha acids are chemical compounds which reside in lupulin, the resin portion of a hop cone. They are the portion of the hop cone which is largely responsible for bitterness in beer. While these compounds are not very soluble at room temperature, they become much more soluble in the boil step of brewing, where they become isomerized into

iso-alpha acids. In addition to bittering, these iso-alpha acids have been shown to have useful antimicrobial properties. They are considered to be fairly weak acids which act as ionophores to disrupt microbial cell functions. This results in a significant decrease to cellular metabolism and nutrient uptake which can lead to cell death. However, it is important to consider situations that influence the effectiveness of these antimicrobial properties. First, iso-alpha acids tend to only have an impact on Gram-positive bacteria. Several Gram-negative foodborne pathogens, including *Salmonella* and *E. coli*, can exhibit hop resistance. Second, the antimicrobial effects of iso-alpha acids are greater in an acidic environment, such as the pH of a typical beer; beers with an elevated pH can begin to lose this benefit.

3. ACIDIFICATION

Adding acids to foods, either directly or as a result of fermentation, is a centuries-old technique for preserving food. Acidic environments, i.e. low pH, inhibit the growth of microorganisms by disrupting essential hydrogen bonds in proteins, DNA, and RNA, and also by interfering with the cell's ability to produce ATP through cellular respiration. Very few foods have pH values low enough to completely inhibit the growth of microorganisms, especially yeasts and molds, which can tolerate lower pH conditions than most bacteria. When it comes to food safety and the inhibition of pathogens, most processes require a pH below 4.6 under the assumption other hurdles are present. For beer specifically, as long as other hurdles such as heat, alcohol, and hops remain in play, a pH control limit of 4.6 is generally acceptable. If those hurdles are removed, some pathogens can survive in environments with pH as low as 3.7 (see FDA's Bad Bug Book).

4. ETHANOL

Ethanol is a potent barrier to bacterial growth. Ethanol achieves this through the disruptive effect on cell membranes and walls, thereby affecting cellular regulatory and reproductive functions. That said, studies have shown that Gram-negative pathogens can survive in a 5% ABV beer for several days and for several weeks in alcohol-reduced beers (2.3-2.9% ABV), particularly at lower temperatures. With this time-delay, it's possible pathogens could survive through to beer dispense. Alcohol-free beer is an entirely different story where it has been shown that Gram-negative pathogens are capable of vigorous growth, especially at a slightly elevated pH. Gram-positive bacteria are largely inactivated by iso-alpha acids even in alcohol-free beer.

5. LOW OXYGEN CONCENTRATION

The low levels of oxygen in beer have long been referenced as one of the pillars of beer as a food-safe beverage. This makes intuitive sense: since humans are aerobic, human pathogens naturally would also be aerobic. Unfortunately, this isn't entirely true. Of the top five foodborne pathogens listed by the Centers for Disease Control and Prevention (CDC), none are strictly aerobic. Several commonly known foodborne pathogens are either facultative anaerobes or anaerobic, including *Listeria* and *E. coli*. These pathogens may be more vulnerable and slower-growing in an environment with parts-per-billion oxygen concentrations compared to parts-per-million levels, but their inhibition is still largely caused by other factors.

In summary, beer is a remarkable beverage whose historical development naturally combined numerous unseen forces and created a pathogen-free environment. However, as brewers innovate with new production techniques and create new categories and flavor profiles, some of these inherent safety controls may be reduced, changed or even removed. It is possible that by reducing or eliminating even one of these barriers, these intrinsic protections can be lessened or eliminated. The remaining controls must then make up for the altered safety control, otherwise the possibility of contamination that renders the product impure or harmful exists. Brewers have a responsibility to our customers, our partners, and our community to protect consumer health by ensuring that we follow food-safe practices.

REFERENCES

- Foodborne Germs and Illnesses
- FDA Bad Bug Book
- Growth and Survival of Foodborne Pathogens in Beer
- Thermal Processing of Food 101