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Foodservice Industry Germ Wareface

A look at microorganisms and how to control them

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Cleanliness is an important part of life. In the food service industry, cleanliness is a major concern. Recently E. coli contaminated hamburgers, "mad cow" disease, and salmonella infected chickens have all been in the national news. Protecting consumers from the risks of foodborne illness is one of the primary responsibilities of the food service industry. Unfortunately, sanitation is often one of the least emphasized.

As far back as biblical times, there were strict rules on cleanliness, dietary rules and handling of waste. Aristotle instructed Alexander the Great to have his armies boil their drinking water and bury their human waste. Nicolas Appert in France in 1810 developed a method for sterilizing food with heat and preserving it in closed containers. Today we call this canning.

In 1845 and 1846 two to three hundred thousand Irish people died in the potato blight as potatoes rotted in the field. What is especially tragic about this is that 10 years earlier a Frenchman, Isaac-Benedict Prevost, discovered that microorganisms caused disease. Prevost successfully used chemical disinfectants in field tests to show that he could prevent infection. By applying copper solutions to crops he kept them from becoming diseased. Unfortunately for Prevost and the Irish, people believed in "spontaneous generation" of disease where abnormalities in the plant "juices" caused disease. In England in 1827, Alcock recommended that chlorine be used to purify drinking water for the first time.

Louis Pasteur helped save the French wine industry by discovering that heating wine briefly to 120 - 140°F prevented bacterial fermentation, thus giving us the process known as pasteurization. Robert Koch, in 1881, demonstrated that bacteria did indeed cause disease. This led to the use of chemicals as disinfectants.

Alcohols have been used to kill germs, but in 1903 Harrington and Walker demonstrated that to be effective a 60 - 70% solution needed to be used and that no amount of alcohol could kill bacterial spores. In 1915, during W.W.I, 5000 ppm solutions of sodium hypochlorite (bleach) were used to disinfect wounds.

REGULATION

Federal Government regulation of antimicrobial products began with the regulation of pesticides in the Insecticide Act of 1910. Starting in 1947, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), which is the basic law used today, was passed. These early acts were designed to protect consumers from products that did not work. Based on these early laws, disinfectants and sanitizers were regulated along with crop pesticides because they all killed organisms. Starting in 1964, the government started to be able to deny registration of products. The Federal Environmental Pesticide Control Act of 1972 drastically transformed FIFRA from a labeling law, to a comprehensive regulatory statute controlling the manufacture, sale and distribution of pesticides.

Today any product that makes a claim of killing, disinfecting or sanitizing must be registered. Surface sanitizers like chlorine bleach, iodophors and quats are regulated along with crop pesticides and rat poisons.

COMMON INDUSTRY TERMS

Bacteria - Microorganisms, often composed of one cell, sometimes containing chlorophyll, in the form of straight or curved rods (bacilli), spheres (cocci) or spiral structures.

Bactericide - Capable of killing bacteria but not necessarily spores.

Bacteriostat - An agent, usually chemical, that prevents the growth of bacteria, but does not kill them or their spores.

Disinfectant - An agent that frees an inanimate body from infection by destroying microorganisms, but doesn't necessarily kill bacterial spores. Disinfectants kill 100% of certain microorganisms, but they are not used on people, only inanimate surfaces.

Fungi/Fungus - Sporebearing microorganisms that have a nucleus but don't have chlorophyll living as parasites on plants, animals or other fungi. Fungi reproduce sexually and asexually. Yeasts, mildew and mushrooms are all fungi.

Germ - This is a generic term for microorganisms, usually for pathenogenic organisms.

Germicide - An agent that destroys microorganisms, especially pathogenic microorganisms. Generally germicides kill some microorganisms but not spores.

Pathogenic - Capable of causing disease. Generally any microorganism capable of entering another body and causing disease.

Sanitizer - An agent that reduces the number of bacteria on an inanimate surface to safe levels as judged by public health requirements. A sanitizer generally is a chemical that kills 99.999% of specific test bacteria in 60 seconds.

Spore - A body, usually one cell (unicellular) found in plants and protozoa. Certain bacteria form thick walled spores that are difficult to kill. They are not reproductive. Some spores can withstand boiling in water for hours.

Sterilization - The act or process, physical or chemical, that destroys or eliminates all forms of life, especially microorganisms. Being sterile is an absolute expression. An object or body cannot be partially sterile.

Virus - An infectious agent composed entirely of protein and nucleic acids. Viruses can reproduce only in living cells and are so small that electron microscopes are needed to see them. They are parasites relying on living cells.

Some Common Microorganisms Associated with the Food Service Industry

Campylobacter jejuni (bacteria) is found in the intestinal tracts of animals. It can contaminate meat and poultry during processing if feces contacts other meat. The bacteria can also be found in unpasteurized milk and untreated water. It causes severe diarrhea, abdominal cramps, chills and headache. The disease can also cause nerve damage. Symptoms occur 2 to 11 days after contact and the disease lasts 1 to 2 weeks.

Clostridium botulinum (bacteria that causes botulism) is an organism that produces a potent neurotoxin that causes weakness, double vision, slurred speech, paralysis, and often death if ingested. Found in canned foods, it is killed through heating. The pH must be above 4.6 for the bacteria to grow. High acid foods (below pH 4.6) do not need steam for processing to kill botulinum spores.

Clostridium perfringens (bacteria) is found in meat, stews and gravies. This bacteria is spread when serving dishes don't keep food hot enough or food is chilled too slowly. Symptoms include watery diarrhea, nausea, and abdominal cramps. Symptoms occur 1 to 16 hours after contact and last 1 to 2 days.

Escherichia coli, also called E. coli (bacteria) is found in the intestines of cattle. Meat is contaminated during slaughter.The disease is spread through eating undercooked meat. The bacteria can also be found in unpasteurized milk, apple cider and human feces. Symptoms include watery diarrhea which turns bloody within 24 hours. Severe abdominal cramps, nausea, and occasional vomiting are common. The disease can result in kidney failure. Symptoms occur 1 to 8 days after contact. The disease lasts 5 to 8 days.

Salmonella enteritidis, choleraesuis, and typhimurium (bacteria) cause an average of 40,000 cases/yr. 2000-3000 result in death. Salmonella is the primary infectious bacteria associated with food. It is commonly found in meats, poultry, milk and eggs. It is spread on knives, cutting surfaces or by an infected person who practices poor hygiene. Salmonella causes severe diarrhea, watery stools, nausea, vomiting and fevers over 101°F. Symptoms occur 6 to 72 hours after ingestion. The disease lasts 1 to 14 days.

Salmonella typhimurium (bacteria) causes typhoid fever. The bacteria enters the body through contaminated food and water, invading the intestinal tract.

Shigella (bacteria) are related to salmonella which produce a similar infectious syndrome. They are usually transmitted by a fecal-oral route, or by feces contaminated water, rather than food.

Staphylococcus aureus (bacteria) produces toxins very resistant to heat. It is found in the nose and throat of healthy people and is passed to food through improper hygiene. It grows on meats, prepared salads, cream sauces, and cream filled pastries. When foods are temperature abused, the bacteria grow and produce toxins. Heating kills the bacteria, but not the toxins which cause severe vomiting, diarrhea, nausea, cramps and lightheadedness 1 - 6 hours after ingestion. The disease lasts 1 to 2 days. The disease may induce toxic shock syndrome.

Vibrio vulnificus (bacteria) is found in raw oysters, mussels, clams, whole scallops and potentially other uncooked seafood as well. The symptoms include chills, fever, skin lesions and may progress to bacteria in the blood (which is fatal 50% of the time). Symptoms start 1 hour to 1 week after contact and the disease may be fatal in 6 hours after onset of symptoms.

BACTERIA

Bacteria are the most commonly referred to type of microorganism in the Food Service Industry. As discussed later, sanitation and sanitization refer to reducing the number of bacteria present on a food contact surface. Bacteria usually have a single cell structure. They are so small that 50 billion would fit inside 1 cubic inch. Bacteria are a mix of 70-90% water, 1-10% mineral, proteins, and carbohydrates. They are self-sustaining as long as they have food and water. Bacteria live in body fluids, but don't actually enter a body cell like viruses. They move molecules of food and water through their outer membrane (called a cytoplasmic membrane) by a process called osmosis. This keeps the bacteria alive. While water and food are necessary for growth, oxygen may not be required. Bacteria that require oxygen are called aerobic bacteria, while bacteria not requiring oxygen are called anaerobic.

Bacteria are further classified as gram-positive or gram-negative based on a dye stain test developed by a scientist named Gram. This is important because gram-negative bacteria have a more complex structure with a tougher outer membrane than gram-positive bacteria. This makes gram-negative bacteria more difficult to kill with chemicals. Gram-positive bacteria are easily killed by chemicals in most cases.

Bacteria are pH sensitive with the pH range of 4 - 9 being the best for bacterial growth. Changing the pH of food can dramatically affect the rate of growth of bacteria.

Temperature sensitivity also applies. Most foodborne pathogens (bacteria causing disease) grow best at body temperature, but bacteria have been known to grow from 40°F to 167°F, depending on the strain. Hot food should be kept above 140°F and cold foods below 40°F to prevent most foodborne illness.

Bacteria do three basic things: they eat, excrete wastes, and reproduce. If bacteria only ate, they would not be as much of a problem. When they excrete wastes, they excrete substances that may be toxic to humans. The toxins can be more dangerous to humans than the bacteria itself. Often these toxins have odors which aids in the identification of spoiled food.

Every cell in a typical population of bacterial cells retains the potential for duplication. The growth of bacteria can occur at an exponential rate. This means that two bacteria become four. Four become eight. Eight become sixteen, and so forth. This is known as a logarithmic series. The rate of growth is measured by the generation or doubling time. The generation time is the time needed for the population to double. If reproduction occurs every 30 minutes, the generation time is 30 minutes.

Under favorable conditions, bacteria can double as fast as every 15 minutes. In only 20 population doublings there would be over 1 million bacteria. In 30 doublings there would be over 1 billion. This means each bacteria could generate billions of others in 8 hours. At this rate, overnight any contaminated food processing equipment would become a serious health hazard. Fortunately growth quickly slows as ideal conditions are difficult to maintain. Bacteria too far from food and water stop reproducing.

Bacteria can also generate spores. A spore is a special, much more complex, dormant form of a bacterial cell. When a bacterial cell forms a spore, it grows a hard outer shell that makes it impervious to most chemical attack. Some spores can be boiled for several hours and survive. Otherwise the spore can stay dormant indefinitely. Spores stored for 50 years have been easily activated.

DESTRUCTION OF MICROORGANISMS AND THE ENVIRONMENT

When people in the sanitation industry talk about germ kills, there are different levels of microorganism control. The highest level of germ kill is sterilization. This is the complete (100%) kill of all microorganisms including: bacteria, spores, fungi and viruses. This is usually accomplished over a period of hours. In a hospital, any instrument used in surgery or that enters the body will be sterilized. This is necessary as a precaution to prevent any organism from entering the body and causing disease.

In food plants, restaurants and other food processing facilities, sterilization and disinfection level microorganism control is impractical. Many bacteria that can get into the food cannot grow in that environment. The main concern is the reduction of bacteria that can cause disease (pathogens) to safe levels on food contact surfaces. The term for this is sanitizing. Sanitizing kills 99.999% of certain bacteria in 1 minute of contact time. Sanitation is a process of cleaning and sanitizing food contact surfaces to reduce microbial contamination to safe levels as judged by government agencies. Sanitation is best employed just prior to equipment use so that surviving organisms will not have time to multiply.

ENVIRONMENTAL FACTORS

Many environmental factors influence the growth of a microbial population (bacteria). Changes in moisture, temperature, oxygen, food and pH all affect the growth rate.

Temperature- Microorganism growth slows down and eventually stops if they are exposed to reduced temperatures. Some microorganisms can still grow at temperatures approaching 32°F. In the food industry, some organisms that can grow at normal refrigeration temperatures can cause serious problems. Freezing and then thawing has been shown to kill many microorganisms. Storage temperatures a few degrees above 39 - 40°F can permit the growth of pathogens such as clostridium botulinum (causes botulism), salmonellae and staphylococcus aureus, all of which cause foodborne illness. In 1986 the annual cost for salmonellosis (caused by salmonella) in the United States was $1.9 - $2.3 million dollars.

Temperature is one of the most important factors controlling the survival of microorganisms. Usually, as the temperature increases toward an ideal temperature which varies from organism to organism, growth and metabolic functions increase. Above this temperature activity decreases. For each organism, there are minimum and maximum temperatures below and above which growth will not occur. These temperatures are typically between the freezing and boiling point for water. No single organism can grow over the whole temperature range. The optimum temperature for using sanitizers is 70-100°F. At temperatures above this, although the chemicals will generally kill more quickly, chlorine and iodines become unstable. Low temperatures slow the germ kill thus reducing the effectiveness of a germicide.

The center of hot food can remain at >120°F for 24 hours, even when stored in a refrigerator, thus giving optimal growth conditions for some pathogens. Improper heating and cooling are a serious problems in the food service industry. As an example, food prepared in airline flight kitchens is often stored at temperatures conducive for the growth of pathogens for prolonged periods of time.

Outside contamination can lead to disease as well. One of the largest outbreaks of a disease called enteritis was due to the passing of yersinia enterocolitica (bacteria) on the outside of contaminated milk cartons (contaminated by the crates in which the milk was being hauled.

pH- Each organism has a pH range and a well defined optimum pH for growth. The typical pH range is from 5 -9, but microorganisms have been found at a pH of less than 2 and a pH greater than 10. In high acid foods, such as fruits, pickles and sauerkraut, spoilage organisms tend to be yeasts and molds (fungi) because they grow well at low pHs. Bacteria are usually inhibited from growing in high acid foods because they don’t handle the low pH. Chlorine sanitizers lose effectiveness rapidly at pH’s greater than 10. Iodophors and acid-anionic sanitizers are only effective at an acidic pH and both lose effectiveness at pHs greater than 5.

Oxygen- The earth’s atmosphere is about 20% oxygen. Aerobic microorganisms need oxygen to grow and generally can’t grow without it. Anaerobic organisms can grow without it and several of this type of organisms are destroyed by contact with oxygen.

Water- All organisms require water for life. Removing all moisture (drying or heating) may not kill organisms, but it keeps them from growing. Organisms use moisture to transfer food through the cell wall and transfer wastes out of the cell. The less water that is available, the slower the growth.

Food- Without food/nutrients, microorganisms cannot grow. Food or nutrients include some form of protein, minerals and sometimes carbohydrates or vitamins. The food or nutrient requirements for microorganisms varies from organism to organism. One of the easiest ways to help control organism growth is to deprive them of food. Since bacteria are so small, even minute traces of milk products on equipment provides a veritable feast for bacteria. Sanitizers such as chlorine and iodophors react with organic matter and become less effective, so removing food residues is important for effective germ kill.

Concentration- The use dilution for chemical germicides should be followed exactly. The use dilutions have been set up to give specific product concentrations. Using too little product will affect its germ killing ability. Using too much product will not give any better results and could leave potentially harmful residues on food surfaces.

Time- Each sanitizer and disinfectant sold by U S Chemical has minimum contact times to be assured of microorganism kill. For sanitizers, a 1 minute contact time is required in 3 tank sink operation, so a dishwasher should never just dip ware in the sanitizing solution. Contact times are just as important as the germicide concentration.

Water Hardness- Chlorinated products have no hard water tolerance and lose their effectiveness more quickly in hard water. This means that the operator will have to recharge the third sink more frequently. Acid-anionics and iodophors have excellent hard water tolerance and can be used in waters of up to 60 grains hardness. Quaternary ammonium compounds can be used in water up to 500 ppm hardness (30 grains per gallon) before the hardness affects the antimicrobial performance.

Detergent Residues- Contamination of chlorine or iodophor sanitizers with alkaline detergent residues rapidly decreases the sanitizer effectiveness. Quaternary ammonium compounds can be deactivated by pot and pan detergent residues on ware that has just been washed. Thus, it is important to rinse objects between washing and sanitizing to insure that the sanitizer is free to do its job and its effectiveness has not been reduced.

The most important factors in contamination of food with pathogens resulting in human infection are:

1. Improper cooling - 44%
2. Delays of 12 hours or more between preparation and consumption of food - 23%
3. Food handlers as carriers of pathogens - 18%
4. Mixing of uncooked and cooked food or ingredients - 16%
5. Inadequate processing - 16%
6. Improper hot holding - 14%
7. Inadequate reheating - 11%
8. Unsafe sources - 10%
9. Cross-contamination - 5%
10. Improper cleaning/sanitizing - 5%

In most cases, the food contamination occurs at the restaurant or food processing before consumption. Between 1978 and 1993 there were a minimum of 12,250 outbreaks of foodborne illness in Wisconsin alone. Outbreaks range from 1 case per incident to 600 cases from a single source. 62% of the outbreaks were caused by food prepared in a restaurant, deli, or by a caterer. 14% were caused by food prepared at home and 5% occurred in nursing homes. During 1994-1995 there were 20 restaurant associated outbreaks reported in Wisconsin.

PHYSICAL DESTRUCTION

Hot water held at 170°F for 5 minutes can be used on food processing equipment as an excellent sanitizer. Hot or boiling water is not used for sterilization because the low temperatures would require excessively long contact times. The principal advantages in using hot water as a sanitizer are its availability and its lack of destruction to the equipment. High temp dishmachines use hot water as a sanitizer for ware (plates, glasses and flatware). As a rule of thumb, lowering the temperature 10°F halves the germ kill rate.

CHEMICAL DESTRUCTION

There is no single chemical that is ideal for all microorganism control. All chemicals show some selectivity, meaning they work better on some types of microorganisms and poorer on others. The better the chemicals work across the spectrum of microorganisms, the more hazardous the chemicals are to use. In hard surface disinfection the main chemicals used are quaternary ammonium compounds (quats), iodophors and phenolics. The main sanitizer chemicals are quaternary ammonium compounds, iodophors, chlorine and acid-anionics.

The use of chemical germicides has helped develop strains of organisms that are increasingly resistant to germicides and antibiotics. Multiple antibiotic resistant bacteria have been isolated from drinking water. Disinfection and purification of water may also be increasing the occurrence of antibiotic resistant bacteria.

CLEANING

All authorities stress the importance of thorough cleaning and rinsing of surfaces prior to sanitization. Cleaning and rinsing reduce the levels of organisms on equipment surfaces, which reduces the amount of time a sanitizer needs to work. Unclean processing and packaging equipment provide an excellent environment for growth and reproduction of microorganisms.

Food soils are usually composed of sugars, fats, proteins and salts. Proteins and fats are the most difficult to remove. The type of soil influences the choice of cleaning chemicals used in cleaning. However, water is the primary solvent of cleaning. Because of this, the hardness of the water affects the cleaning ability of many products. Water hardness, caused by calcium and magnesium ions in the water supply, reduces the effectiveness of cleaners by binding with compounds in the cleaner. These metal ions may deposit on surfaces leaving limescale or white films. For this reason, most food plants will have a supply of softened water available for cleaning. Limescale and other mineral buildups must be avoided on food equipment. Limescale prevents a visual evaluation of equipment cleanliness, protects microorganisms from cleaning and sanitizing agents, and may contribute to corrosion of the metal surfaces.

Rinsing of equipment and work areas soon after use will help prevent drying of soil and will make the cleaning easier. Rinsing of soiled equipment will also flush away a large number of microorganisms. Depending on soil type, warm water (95 - 110°F) should be used to flush surfaces. If hot water is used as a rinse, soil protein may coagulate and make later soil removal difficult.

SANITATION AND SANITIZATION

Sanitation is regulated by government agencies. The following have regulations for some area of food handling: USDA, BATF, CDC, DOJ, EPA, FTC, FDA, Dept. of Commerce, and various state and local agencies. When we talk about sanitation or sanitization, we are generally referring to the food industry.

The ultimate purpose of using detergents and sanitizers in the food industry is the reduction of numbers of potential food pathogens to a level that minimizes the risk of foodborne illness. In addition to the public safety, the shelf life of food is extended as well. Sanitation of a surface does not mean sterilization. Bacterial spores, viruses, fungi and some resistant bacteria may survive. Some of these organisms are dangerous to the food industry because of the diseases that they can cause once in food if still alive.

A sanitizer is an antimicrobial that kills 99.999% of specific test bacteria under conditions prescribed in the official test. Effective cleaning of equipment is probably 90% of the overall sanitizing job in that cleaning removes many of the bacteria. The sanitizer is the remaining 10% of the job killing the bacteria that are left.

To be labeled as a sanitizer, the product must be tested against one or two organisms. For iodophors and chlorine, they must kill Salmonella typhi. For acid-anionics and quats they must kill Escherichia coli and Staphylococcus aureus. What this means in terms of real germ kill, is that if a sanitizer kills the test organism, it is expected to perform equally well against other bacteria that it is not tested against as long as the other bacteria have a resistance to the sanitizer equal to or less than that of the test bacteria.

Factors which influence the effectiveness of sanitizers are: concentration of sanitizer, time of exposure, number of organisms, pH, presence of organic matter, water hardness and temperature. The 3 most common classes of sanitizers used in the food industry are chlorine, iodine and quaternary ammonium compounds. A fourth lesser used group would be the acid-anionics.

Sanitizers do not claim to kill fungi, viruses, or even all bacteria. What sanitizers do is reduce the population of bacteria to levels that will not make people sick. This level is set by the government. Unlike disinfectants, which are tested against each organism that they claim to kill, 1 or 2 specific hard to kill bacteria have been chosen to test the ability of the sanitizer to kill bacteria in general. On a food contact surface there may be several different bacteria. Since we cannot possibly test a sanitizer against all of the tens of thousands of bacteria, only the most significant ones are used.

An important consideration arising from the use of sanitizers on food contact surfaces is the effect on people by ingestion of food contaminated by chemical sanitizers, since there is a potential for a chemical residue on sanitized surfaces. The concern of the FDA over the unsafe adulteration of food, especially of milk, led to a requirement to rinse sanitized surfaces with water before reuse. Since 1969 this has been reversed, because of the potential for microbial contamination of a surface by using potable (tap) water on a sanitized surface. Rinsing defeated the purpose of sanitizing, because sanitized surfaces would then be recontaminated by the organisms in the fresh water. FDA approved sanitizers do not require a potable water rinse after sanitizing, but only complete drainage of the sanitizing solution from surfaces before contact with food products.

In dishwashing in the kitchen, in a restaurant, nursing home, or other food service establishment, the owner makes a decision as to how he or she wants to comply with governmental law. If items are washed by hand, the 3 tank sink approach must be used. If items are to be washed automatically, an industrial dishwasher with its own operating rules must be used. The guidelines for dish sanitization are set forth by the National Sanitation Foundation (NSF). However, their guidelines are not legally binding, so states and the federal government have based laws on these recommendations and predictably, the laws vary from state to state.

MECHANICAL WAREWASHING

In general, if the kitchen uses an industrial dishwasher, the cycle will include a wash with mechanical warewash detergent, and a final rinse. In some dishmachines, called high temp dishmachines, there is a heater on the final rinse water so that it is between 180°F and 195°F. The 180°+ water contacts the dishes for a minimum of 10 seconds. If cooler water is used, the water must be at least 165°F and must contact the dishes for at least 30 seconds. In both of these cases, the kitchen is using hot water for germ kill.

If, on the other hand, the kitchen wants to use a chemical sanitizer, they must inject chlorine at a minimum concentration of 50 ppm. (one drop of water from an eyedropper in 30 gallons is 1 part per million (ppm)). This solution, which must be over 120°F, must contact the dishes for at least 9 seconds.

3 TANK SINK

If the kitchen decides to do items by hand in a 3 tank sink, they must use the 5 step procedure. Dishes (and other items) must be: prescrapped to remove gross food soil, washed in a suitable pot and pan detergent, rinsed with fresh water, sanitized in an approved sanitizer above the required minimum concentration for at least 1 minute, and allowed to air dry. Towel drying is not acceptable because of the risk of cross contamination of dishes. If a towel gets bacteria on it, the bacteria could then be transferred to each dish the towel touches. Dishes must be allowed to drain and air dry to remove the chemical sanitizer before reuse.

Minimum levels for each of the classes of chemical sanitizers are regulated by each state. In general: 50 ppm of chlorine, 12.5 ppm of iodine, 200 ppm of quaternary ammonium compound, or 200 ppm of acid-anionic (yielding a pH of 3.5 - 4.5), must be maintained to sanitize dishes based on a 1 minute contact time.

TYPES OF SANITIZERS

1. Chlorine

Chlorine compounds in water react with the water to produce hypochlorous acid which is an extremely powerful oxidizing (bleaching) agent and a germ killer as well. The hypochlorite ion itself has very little, if any, germ killing activity. In solutions of pH 4.0-5.0, practically all of the chlorine occurs as hypochlorous acid. Below a pH of 4.0, hypochlorous acid breaks down to release chlorine gas (very dangerous). As the pH is increased above 5.0, increasing amounts of hypochlorite occur.

However, at pHs below 5, corrosion becomes a serious problem. The best range to use chlorine bleach is between pHs of 6.0 - 7.5. Corrosion and irritancy are minimal, but the concentration of hypochlorous acid is sufficient for effective sanitizing. Hypochlorous acid is the active germ killing agent. Increasing pH decreases the germ killing activity of chlorine and a decrease in pH increases this activity. 100 ppm of chlorine at pH 8.2 would kill the same number of bacteria as 1000 ppm of chlorine at pH 11.3.

Chlorine is commercially available as sodium hypochlorite (bleach) and dry chlorine bleach, which is the salt form of isocyanuric acid. They are used in swimming pools, sewage treatment plants, household bleach and sanitizers for restaurants and food processing equipment. Hypochlorite solutions destroy a wide spectrum of bacteria very quickly. Hypochlorites can cause corrosion and pitting of stainless steel and other metals. Because of this they are rarely used as overnight equipment sanitizers. Salts of isocyanuric acid (dry chlorine) are used in a similar way to sodium hypochlorite. They are more stable in storage and use.

Dry isocyanurates are dosed at 100 ppm and maintained at 50 ppm to promote effective sanitization. Hypochlorites are effective sanitizers at a 50 ppm concentration. Hypochlorites are dosed at 100-200 ppm because of their unstable nature.

Hypochlorites are effective only on clean surfaces for sanitization. The U.S. Public Health Service recommends a minimum 50 ppm chlorine solution with a contact time of 1 minute minimum at 75°F or higher for sanitizing utensils and equipment. For spraying applications, 100 ppm is recommended. Compounds other than hypochlorites are allowed if they give activity equal or better than 50 ppm of hypochlorite at a pH of 10 at 75°F after 1 min.

In food processing plants, even the water used in processing may be treated for organisms. If standard tap water is used and it contains bacterial spores, after canning, it is possible for the spores to grow causing food poisoning. A botulism outbreak in canned tuna was attributed to Clostridium botulinum spores entering the cans during cooling. In poultry processing high levels of hypochlorite (200 ppm) are used in cooling tanks where dead chickens are held prior to final processing.

Chlorine based sanitizers are the most widely used because they are the cheapest and they have great killing power against a wide range of bacteria. Chlorine in an aqueous solution, even in minute amounts, exhibits fast bacterial action, but chlorine compounds have no residual effect on sanitized surfaces. Once a surface that has been sanitized with chlorine is dry, bacteria that contact the surface may reproduce.

Metals in the water or on ware can affect the chlorine stability. Iron, aluminum, copper, nickel and cobalt affect the stability of chlorine solutions. High alkalinity makes chlorine solutions more stable.

Concentration, pH, temperature and organic content affect the germ killing ability of chlorine. Kill times are reduced by 60-65% for each 20°F rise in temperature. Various types of bacteria, viruses and fungi exhibit different resistance to hypochlorites under diverse practical conditions. Chlorination of drinking water has practically eliminated various waterborne pathogens that cause cholera, dysentery and typhoid.

Hypochlorites kill bacteria, but their activity is greatly reduced in the presence of organic matter. Organic matter in chlorine solution consumes available chlorine and reduces its germ killing ability.

Chloroisocyanurates (powdered chlorine) kill at about the same speed and concentration as hypochlorites. However against Streptococcus faecalis, twice the concentration of the chloroisocyanurate was needed to kill at the same rate.

In the swimming pool industry, small amounts of chlorine are used to control microbial growth. Swimming pool waters are chlorinated from 0.6 ppm to 2 ppm. Spas and hot tubs are chlorinated to 1 to 3 ppm. Water used in making ice is often chlorinated to 2 ppm to reduce the bacteria added to beverages from ice. Food processing plants chlorinate water from 4 to 25 ppm depending on the type of plant.

Some foods, such as shellfish and other fish, are disinfected by rinsing in a 200 to 6000 ppm solution of hypochlorite. Fruits and vegetables are often washed in a 4 - 5 ppm solution to remove microorganisms.

Hypochlorites - Advantages

1. Cheapest sanitizer to use per dose
2. Fast germ kill
3. Kills a wide spectrum of microorganisms
4. Non-toxic at use dilution
5. Leaves no residual to contaminate food
6. Solutions are colorless

Hypochlorites - Disadvantages

1. Inactivated by organic residues
2. Corrosive to skin and ware
3. Effectiveness decreases as pH increases (detergent residues)
4. Degrades rubber and some plastics
5. Unstable in storage
6. Deactivated by iron and other metals in the water supply
7. Strong odor

2. Iodine

Iodine was discovered in 1812 by a French scientist. Its ability to kill microorganisms was discovered in 1874. Iodine is most effective below a pH of 6.0. Above 6.0, the effectiveness is reduced by the formation of iodate.

Iodine is an effective germ killing agent for a wide variety of microorganisms. Iodine and alcohol blends used in the medical field have characteristics that preclude their use in the food industry, namely the staining, toxicity and corrosiveness. When it was discovered that iodine could be complexed with surfactants to make iodophors, the door to use in food was opened, because now the iodine was more stable, stained less, and was not corrosive to many surfaces.

Iodophors are a combination of iodine and a detergent that slowly releases free iodine in water. When stabilized (buffered) with acids their effectiveness is not appreciably reduced by organic matter. They are active against most microorganisms. Iodophors carry the iodine and stabilize it so that it has a long shelf life.

Iodophors are stabilized with an acid, like phosphoric acid. This aids in the control of hard water (limescale) buildups. Iodophors are used at a pH of about 4.0 - 5.0. Some tests have shown that 1 part available iodine is equivalent to 3 to 6 parts available chlorine. 25 ppm of iodine at low pH is equivalent to 200 ppm of chlorine at pH of 7.0. Iodine is dosed at 25 ppm and maintained at 12.5 ppm as a sanitizer.

Iodophors have rapid germicidal activity in hard water and cold water. They are nontoxic at use dilution, nonirritating to skin, and have detergency in addition to germicidal activity. Solutions of iodophors of 10 ppm or above have an amber color. As the concentration falls, the color changes to yellow indicating that more sanitizer is needed.

Iodophors are more expensive than chlorine, are corrosive to galvanized iron, aluminum and copper, stain some plastics, forms purple complexes with starches and decompose to release iodine above 120°F. At temperatures above 120°F, iodine will become volatile and come out of solutions as a corrosive gas. Iodophors should never be used over 120°F.

Iodine, like chlorine, reacts not only with living microorganisms, but dead ones and proteins as well. In experiments, iodine was shown to react with proteins at least 3 times slower than chlorine. Thus in the presence of dissolved proteins, like in blood, iodine is much more efficient than chlorine, because iodine will not react with the protein, tying it up.

Iodophors - Advantages

1. Long shelf life
2. Contains some surfactant which aids in cleaning
3. Destroys yeast cells at a faster rate than hypochlorites
4. Acidic nature prevents lime/hard water film formation
5. Less sensitive to organic matter than hypochlorites
6. Water hardness doesn't affect germ kill
7. Broad spectrum germicide
8. Noncorrosive to ware and hands
9. Nontoxic (iodine is found naturally in milk)
10. Visual indication of product presence

Iodophors - Disadvantages

1. Cannot be used at temperatures above 120°F
2. Can stain surfaces and ware, especially in concentrated form
3. Effectiveness decreased with increasing pH, such as alkaline detergent carryover

3. Quaternary Ammonium Compounds, Quats

Quaternary ammonium compounds, called quats for short, have found use in the food industry for a variety of reasons. They are stable to heat over long periods of time, they leave a nonvolatile residue on surfaces rendering them bacteriostatic for some time after sanitization, they are effective over a wide pH range, but most effective at slightly alkaline pH, they are noncorrosive and nonirritating to skin at use dilution, they are odorless and tasteless at use dilution, and they are less affected by organic matter than hypochlorites.

Surfactants, those chemicals that are detergents and cause foaming, come in three basic types: cationics (having a positive charge), nonionics (having no charge), and anionics (having a negative charge). Just as you would never mix an acid and an alkaline together because they would neutralize each other, cationic and anionic surfactants mixed together neutralize each other. So in a cleaning product you can find nonionics with either cationics or anionics, but you will not see cationics and anionics together. Anionics are good detergents but poor bactericides. Nonionics are good detergents, but have little or no bactericidal properties. Cationics are good bactericides, but have poorer detergency than the others. So the choice of sanitizer involves some trade-offs with detergency when using surfactants.

Quats are cationics. Most industrial suds-type laundry products contain nonionic surfactants. Pot & pan detergents are usually anionics and nonionics. So a quat sanitizer mixed with an anionic would tend to neutralize each other. Because of this, pot & pan detergent residues on ware washed by hand will neutralize quat sanitizers. This makes acid-anionics a good choice in 3 tank sink operations.

Quats can exhibit a residual effect on sanitized surfaces by preventing bacteria from duplicating for up to several hours. This is called a residual bacteriostatic effect and is one of the biggest advantages of using quats.

Quats biggest disadvantage is their selective action for certain types of bacteria. They are not effective against certain gram-negative bacteria.

Quaternary Ammonium Compounds - Advantages

1. Noncorrosive at use dilution
2. Handles organic matter better than any other sanitizer
3. Residual bacteriostatic effect (up to several hours)
4. Temperature stable
5. Nonirritating to skin at use dilution
6. Nontoxic at use dilution
7. Odorless
8. Can perform light duty cleaning
9. Can handle up to 30 grains per gallon (500 ppm) of water hardness

Quaternary Ammonium Compounds - Disadvantages

1. Narrow spectrum of antibacterial activity. Will not kill spores.
2. Foaming can be a problem in CIP systems
3. Easily neutralized by pot & pan detergent and any anionic detergent residues
4. When used in glass washing, will kill the foam head on beer

4. Acid-Anionics

Acid-anionic sanitizers are a combination of anionic detergents that have antimicrobial properties and a strong acid, like phosphoric acid. The pH control offered by the acids enhances the antimicrobial action of the surfactant. There is a synergistic effect of acids and certain anionic surfactants. This means that together they kill more germs than both do when added separately.

Because there is a lot of free acid, these products are the most effective in hard water. Acid-anionics remain active in the presence of hard water of up to 60 grains hardness. Acid-anionics kill fast against both gram positive and gram negative bacteria.

Acid-anionics are used in the food and dairy processing industry. Acid-anionics have very slow sporicidal activity, so they are not much help in killing botulism spores. However trace amounts of organic material, such as milk, does not affect the antimicrobial properties of the acidanionics as it would chlorine and iodine.

Acid-Anionics - Advantages

1. Fast kill times
2. Kills a wide spectrum of microorganisms
3. Noncorrosive to stainless steel
4. Nonstaining
5. Removes and controls hard water/lime buildups
6. Good detergency in addition to sanitizing activity
7. No odor
8. Low toxicity

Acid-Anionics - Disadvantages

1. Effective at acid pH only
2. Generates foam
3. Little to no effect on spores

CONCLUSION

The battle against microorganism growth in the food service industry is ongoing. As people hire a caterer, eat in a restaurant or deli or buy food in a grocery store, the least of their worries should be whether or not the food will make them sick. It is our job to help prevent this from happening. The National Restaurant Association estimates that an average outbreak of foodborne illness at an establishment can cost in excess of $75,000. The lost profit and lost business from the publicity can be much higher; sometimes restaurants are forced to close. There are all kinds of ways that people cut corners in germ warfare. It is up to us to educate our customers and provide information to them as a technical resource in the ongoing war on germs.

The information presented herein is, to the best of our knowledge, true and accurate. It should not be assumed that the information is 100% complete, or that it will not change in the future due to conditions beyond our control. This brochure is not to supercede and Federal, state or local regulations which may be in force.