

UNDERSTANDING CHLORINE

Chlorine is one of the most ubiquitous, and at times one of the lesser understood, compounds in the processing plant. Here's help on understanding its applications and effectiveness. ■ by Julie Northcutt and Scott Russell

Chlorine is the most commonly used disinfectant in poultry processing. It has been routinely used in rinse water, chiller water and as a sanitizing agent during cleanup and sanitation. However, with the initiation of HACCP-based inspection and the new microbiological standards for salmonella and *Escherichia coli* (*E. coli*), the application, effectiveness and impact of chlorine have been thrust into the limelight. The purpose of this article is to address the usage, application, advantages and disadvantages of chlorine as a disinfectant.

When the USDA-FSIS HACCP regulation standards for salmonella were developed, the USDA based the standards on the average prevalence of salmonella on raw poultry in the U.S. According to an FSIS survey, the average percentage of carcasses with salmonella was determined to be approximately 20 percent. The standard was set such that processing plants are not allowed to exceed a level of 24 percent (12 out of 51) based on a moving-sum window. This new regulation means that nearly half of the plants in the country may fail to meet the standard on any given day. However, one failure does not constitute a process deficiency.

In addition to salmonella testing, the regulation requires that processing plants test one carcass out of every



Measuring chlorine levels in water

22,000 birds processed to determine *E. coli* levels. Carcasses with $\geq 1,000$ colony forming units (CFU) of *E. coli*/mL of rinse fluid are considered unacceptable (results in a failure), while *E. coli* levels between 100 and 1,000 CFU/mL are considered questionable (three questionables in a window of 13 tests equal a failure). If *E. coli* levels are ≥ 100 CFU/mL, the carcasses are considered to be acceptable. Research indicates that *E. coli* levels are not only based on proper control of procedures in the plant, but they are also affected by disease and health conditions in the field, such as air sacculitis, residual yolk sac and infectious process. Because all plants are required to continuously perform better than the FSIS-established average for salmonella (three consecutive failures results in a loss of USDA inspection) and because *E. coli* levels may be out of the realm of control of the processing plant, some companies are having difficulty meeting the microbiological requirements as stated in the regulation.

For this reason, many poultry processors have increased chlorine usage, changed chlorine application systems or have added chlorinated rinses to all possible locations throughout the processing line.

Methods of Chlorine Application

In the poultry industry, methods of applying chlorine vary from company to company and are frequently dependent upon plant logistics, as well as the plant's ability to effectively manage the particular chlorine system that it chooses. While no one method of applying chlorine has been proven to be better than another, one of the most common methods of chlorine application in poultry processing is sodium hypochlorite. Liquid sodium hypochlorite is commercially available at solution concentrations ranging from 10 percent to 15 percent active sodium hypochlorite. Typically, the liquid is delivered from a storage drum or tank



Measuring chlorine (ppm) in air

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to the desired location in the plant by a metering pump. The sodium hypochlorite is then mixed with water to obtain the target concentration of chlorine. Another method of applying chlorine that is increasing in popularity involves the use of tablets containing 65 percent to 70 percent calcium hypochlorite. The tablets are stored in the plant in a polyethylene tank, where they are dissolved in a water stream as the water passes through the tank on its way to another storage vessel. From the second storage vessel, liquid calcium hypochlorite is delivered to the desired plant locations using a metering pump. The least common method of applying chlorine in the poultry industry is by direct injection of chlorine gas into the fresh water line. This method of applying chlorine is used less frequently because of the potential hazards associated with chlorine gas. Chlorine is a yellow-green gas that has the typical unpleasant odor normally associated with bleach. It is usually measured in units of parts per million (ppm) which refers to the amount of active chlorine by weight that is present in a million parts of solution or air. Exposure to high levels of chlorine gas (1 ppm within any 15-minute period) is extremely irritating to the eyes, skin and respiratory tract of humans. It is important to note that chlorine gas will be liberated regardless of the method of chlorine application (liquid, tablets or chlorine gas) used in the processing plant; however, a chlorine odor will be detected at levels well below that which would be considered hazardous. According to the United States Department of Labor, Occupational Safety and Health Administration (OSHA), the Time Weight Average (permissible constant daily exposure) of chlorine gas is 0.5 ppm for an eight-hour period. The human odor threshold, or level that is detectable by smell is between 0.02 and 0.2 ppm volatile chlorine gas. Some individuals are slightly more sensitive to chlorine than others. However, noticing a chlorine odor does not necessarily indicate that the situation is unhealthy.

Optimizing Chlorine Effectiveness

Regardless of the method of chlorine application, its effectiveness against

disease-causing bacteria depends upon the product's ability to dissociate and form hypochlorous acid (HOCl). Thus, many factors can determine the effectiveness of chlorine by altering, or reducing hypochlorous acid levels. The following list identifies some of the major factors which influence the effectiveness of hypochlorous acid against bacteria:

- pH of the chlorinated water
- chlorine concentration
- water temperature
- amount of organic matter present
- exposure time (contact period)
- growth stage and type of bacteria present on the carcasses

Many processors have increased chlorine usage, changed chlorine application systems or have added chlorinated rinses to all possible locations throughout the processing line.

Variation in any of these factors can cause erratic chlorine levels in the water and air in the plant. For example, formation of hypochlorous acid will be greatest (and chlorine gas production will be at a minimum) when the pH of the chlorinated solution is between 6.5 and 7.5. The concentration of chlorine added to water will also significantly influence the active chlorine in solution. In the plant, chlorine may either react with bacteria, or it may react with other organic material. Typical organic material found in chiller water includes soil, fat, blood, ingesta and some soluble muscle proteins. When chlorine comes in contact with organic material, it binds with the organic material and begins oxidizing it. Because of this, chlorine is usually subdivided into two categories—total residual chlorine (TRC) and free available chlorine (FAC). TRC consists of all of the chlo-

rine in the water including that which has reacted with organic material. The target level for TRC should be 20 to 25 ppm in the chiller overflow. When the chlorine is bound to organic material, it is no longer available to react with bacteria, and it loses its disinfectant properties. If the added chlorine exceeds that which may be bound by bacteria and other organic material, it is referred to as FAC. The absence of adequate FAC in the chiller overflow could explain a situation where a plant has trouble meeting the USDA microbiological standards. The target level of FAC in the chiller overflow is approximately 0.5 to 1 ppm.

Water temperature and chlorine exposure time are additional factors that can significantly influence the efficacy of chlorine on bacteria. In general, chlorine activity against bacteria increases when either the water temperature or the chlorine exposure time are increased. However, at higher water temperatures, more chlorine gas will evolve, making the chlorine demand greater. Moreover, processing plants have very little flexibility when it comes to chlorine exposure in the chiller. Additional chlorinated spray rinses throughout processing will increase carcass chlorine exposure, thereby reducing contamination.

Most species of bacteria on freshly slaughtered poultry are actively growing vegetative cells that do not produce spores (dormant and resistant forms of the cell). These types of bacteria are more susceptible to the effects of chlorine than spore-forming species. Of the few spore-forming species of bacteria that are present on carcasses, their spores can revert back to produce vegetative cells as soon as the threat (in this case, chlorine) to their survival is removed. This means that while chlorine significantly minimizes the number of bacteria present on carcasses, it does not completely eliminate bacteria on raw poultry. Moreover, chlorine kills bacteria on contact and has very little residual effect. This means that bacteria maybe trapped in feather follicles on the skin of the carcass, or in fat globules on the carcass skin are not likely to be killed by chlorine.

Chlorine has remained popular in the poultry industry because of its efficacy, availability and low cost. However, be-

cause the bactericidal effects of chlorine depend upon a chemical reaction, water in the plant must be continuously monitored for proper levels of chlorination. Processing plants may maximize the effectiveness of chlorine on reducing carcass bacteria during processing by understanding the chem-

istry of chlorine and the factors which affect hypochlorous acid formation. Optimization of the factors listed in this article in combination with a reduction in the bacterial contamination of the live birds coming into the plant will assist processors in meeting the USDA microbiological standards for

poultry. ■

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