

Use of Chlorine in the Food Industry

Chlorine compounds are widely used in the food industry to kill bacteria and disinfect. Examples include treating pasteurizer cooling water, washing fruit and vegetables and disinfecting food contact surfaces.

Chlorine is usually combined with inorganic compounds, such as sodium or calcium, to produce hypochlorites, which are effective disinfectants. Chlorine mixed with sodium is a liquid bleach¹ known as sodium hypochlorite NaOCl. Chlorine mixed with calcium is usually in granular or tablet form and is called calcium hypochlorite - Ca(OCl)₂. Chlorine may also be available as chlorine dioxide (ClO₂). However, hypochlorites are the most active of the chlorine compounds. Table 1 lists these and other common chlorine sanitizer compounds.

Table 1. Common chlorine sanitizer compounds

Chemical	Synonyms
sodium hypochlorite ~5% active chlorine	hypochlorous acid, sodium oxychloride, bleach
sodium hypochlorite ~10-15% active chlorine	hypochlorous acid, sodium oxychloride
calcium hypochlorite	hypochlorous acid, calcium oxychloride
sodium dichloroisocyanurate	Dichloro-s-triazine-2,4,6-trione; sodium salt
chlorine dioxide	chlorine oxide, chlorine peroxide
sodium chlorite	none

Factors affecting chlorine efficacy

Certain factors can affect the sanitizing power of chlorine compounds. They include the presence of organic material, pH, temperature, concentration, and contact time. When using chlorine as a sanitizer, note the following:

1. **Presence of organic material.** Organic material such as food residues decreases the effect of chlorine. For proper disinfection, use chlorine on cleaned surfaces only. Make sure you remove all organic material residue including fat and protein, before you apply chlorine as a sanitizer.
2. **The pH of a chlorine solution.** The level affects the antimicrobial activity. Use chlorine solutions with a pH range of 6.5 to 7.0 for optimum antimicrobial activity. At pH values near 4.0, hypochlorite solutions are most effective, but very unstable. At high pH values, the efficacy of chlorine is reduced. If you are using a highly alkaline cleaner to remove protein and fat residues, rinse the surfaces thoroughly before applying chlorine solution because high pH residues will reduce the chlorine activity.
3. **Temperature.** Generally, chlorine antimicrobial activity increases with warmer temperatures. However, at high temperatures, chlorine compounds may release chlorine gas which is toxic. The potential of corrosion also increases as temperatures go up.

4. **Concentration.** Higher concentration of chlorine increases the effectiveness of killing micro organisms. However, high concentrations of chlorine are not recommended because they can cause corrosion, explosions, and adversely affect the health of workers. A chlorine concentration of 50 to 200 parts per million (ppm) is recommended to disinfect food contact surfaces including utensils, equipment, and tables.
5. **Contact time.** The bactericidal activity increases with longer exposure time. If the chlorine solution you are using does not exceed 200 ppm, no rinsing of the surface is required. If using a solution stronger than 200 ppm, rinse the surface with clean water after a few minutes of application. Do not let the chlorine solution stay in contact with equipment for more than 30 minutes or it could corrode.

Storage of chlorine

Aqueous chlorine solutions such as commercial household bleaches are not stable. This means that chlorine may dissipate rapidly, reducing its content and effectiveness. So, chlorine powders should be used to sanitize in food processing plants, not bottled bleach.

Preparing a chlorine solution

Hypochlorite liquid solutions commonly used in the food industry can be diluted with water until they reach the right concentration desired.

Example

To prepare 100 litres of a 50 ppm solution from a 12.5 per cent sodium hypochlorite (NaOCl), the following calculations are needed:

Final chlorine solution volume = 100 litres = **100,000 millilitres (ml)**, because a litre = one thousand millilitres

Final chlorine solution concentration desired = **50 ppm**

Initial chlorine solution concentration = 12.5% solution = 125,000/1,000,000 which can also be expressed as **125,000 parts per million (ppm)** because 1 ppm = 1 ml in 1,000,000 ml

Initial chlorine solution volume = **Z**

Initial chlorine solution concentration	x	Initial chlorine solution volume	=	Final chlorine solution volume	x	Final chlorine solution concentration desired
125,000 ppm	x	Z	=	100,000 ml	x	50 ppm
		Z	=	40 ml		

To prepare 100 litres of a 50 ppm solution of sodium hypochlorite, dilute 40 ml of a 12.5% sodium hypochlorite solution with water.

Monitoring your chlorine solution

Once you prepare your chlorine solution, use a test kit to monitor free available chlorine and in some cases, total residual chlorine (TRC) concentrations. Free available chlorine refers to the amount of chlorine available to react with bacteria. TRC is the amount of

chlorine in the water, which includes chlorine available and chlorine bound with organic materials.

Free and total residual chlorine test kits are commercially available including test strips, color cubes, titration-based test kits, colorimeters and colour discs.

Nitrates and Nitrites in Meat Products

Nitrates and nitrites are used widely in the meat industry to cure. They are usually mixed with meat binders and cure ingredients and are added to dry sausages, semi-dry sausages, preserved meat and preserved meat by-products such as ham and salami. They can be added in the form of sodium and potassium salts (eg: sodium nitrate, sodium nitrite, potassium nitrate and potassium nitrite).

Use

Nitrates and nitrites are used to:

- control the growth of spores
 - provide cured meat flavour and colour
 - extend the shelf life of meat products

Control the growth of spores

Nitrates/nitrites control the growth of spores, particularly from *Clostridium botulinum*. These spores are a real concern in the food industry, because they can survive normal heat processing. Under the right conditions, they can produce vegetative cells, which can create a lethal toxin.

Influence on colour

Nitrites cause a colour reaction in the meat and add an appealing pink colour to cooked products. Meat products without nitrates/nitrites are brown or gray coloured.

Nitrates undergo a chemical reaction and are converted to nitrites. Then, nitrites react with the protein of the meat (myoglobin), and are converted to nitrosomyoglobin (bright red). When cooked, nitrosomyoglobin is converted to nitrosohemochrome (pink pigment). This bright pink colour is normally associated with cured meat such as wieners, bologna and ham.

Why are nitrates/nitrites regulated in South Africa?

The use of nitrates or nitrites is restricted because high levels can be hazardous to humans. Excess nitrates can react with amino acids in proteins during processing and form carcinogenic nitrosamines. Processors should have their systems checked during formulation to ensure the right levels are used.

How much nitrate/nitrite can be used?

In South Africa the levels of nitrites/nitrate levels are regulated in terms of Regulation R965 of 1977, as amended, promulgated in terms of the Foodstuffs, Cosmetics and Disinfectants Act, Act 54 of 1972.

How to comply with regulations?

To comply with the regulations regarding the nitrate/nitrite levels in your products, you need to know the precise concentration of nitrates/nitrites in your recipes. Your supplier should be able to tell you what they are in your cure mix or meat binder. Use this information to calculate the amount of nitrates/nitrites in your formulation, based on your recipe.

You can also test your raw products for the total concentration of nitrates/nitrites at an external laboratory. To comply with the regulations, the sum of nitrates and nitrites should not exceed the maximum level

WHAT IS HACCP?

HACCP stands for **H**azard **A**nalysis and **C**ritical **C**ontrol **P**oint

HACCP is an internationally recognized, science-based, food safety system that is used to help ensure the manufacture of safe food products. HACCP is designed to prevent, reduce or eliminate potential biological, chemical and physical food safety hazards, including those caused by cross-contamination. During the development of a HACCP system, potential hazards are identified and control measures are implemented at specific points in the manufacturing process.

HACCP:

- Provides a more systematic approach to ensuring food safety than traditional inspection procedures
- Places more responsibility for ensuring food safety on the food manufacturer than traditional inspection programs
- Is based on science, rather than simply past experience or subjective judgement
- Focuses on preventing problems before they occur, rather than trying to detect failures through end-product testing.

HACCP is internationally recognized as the primary means for enhancing food safety throughout the food chain, and is increasingly being used around the world. A HACCP system is the responsibility of the company. The food manufacturer has the most control over the product and thus can have the greatest impact on the safety of the food produced. The actual development, implementation and maintenance is up to the manufacturer.

A. The Codex Alimentarius Commission and HACCP

HACCP methodology has been standardized internationally by the Codex Alimentarius Commission. The information provided by Codex is used around the world in the development of HACCP programs (e.g., SANS 10330); however, each approach developed may be somewhat different.

B. The Components of a HACCP System

There are two components of an effective HACCP system:

1. **Prerequisite Programs**—Designed to control hazards related to *personnel* and the food manufacturing *environment*, creating conditions that are favourable to the production of safe food products.
2. **HACCP Plans**—Designed to control hazards directly related to the *food* being processed or the manufacturing *process*.

HACCP System = Prerequisite Programs + HACCP Plan(s)

i. Prerequisite Programs

Prerequisite programs are designed to ensure a suitable and safe environment for food manufacturing that does not present sources of contamination. To control and prevent hazards within the manufacturing environment:

- Appropriate personal practices are managed
- Shipping, receiving and storage practices are managed
- Equipment and structures are maintained
- Water supply safety is maintained
- Sanitation and pest control activities are performed
- Appropriate employee training is provided

Prerequisite programs encompass universal criteria that must be controlled regardless of the product being manufactured. However, there may be elements of the prerequisite programs that focus on characteristics inherent to the product or manufacturing process. For instance, the sanitation program must include procedures that are specific for the equipment that is used within the facility. Prerequisite programs are implemented prior to the HACCP plan(s) because they control a large number of general hazards that then do not need to be controlled in a HACCP plan, thereby making the system more efficient and easier to maintain. Prerequisite programs lay the foundation for effective HACCP plans.

ii. HACCP Plans

A HACCP plan is designed to control hazards directly related to the product, ingredients or manufacturing process that are not controlled by the prerequisite programs. HACCP plans are developed through a process of hazard analysis to determine hazards significant to food safety. Control measures are then put into place to prevent, reduce or eliminate these hazards. The control measures are monitored for effectiveness. If a hazard is not adequately controlled (the control measure fails), actions are taken to correct the failure.

WHY IMPLEMENT HACCP?

New food production and processing practices, emerging food-borne pathogens, and changing eating habits and demographics have contributed to a higher awareness of food-borne illness in recent years. Increasingly, prevention has become the focus. HACCP systems control food safety hazards through prevention, elimination and reduction.

To address food safety concerns, market forces are driving HACCP implementation throughout the food continuum, particularly the processing sector. When a food illness outbreak occurs, many points in the food continuum suffer, including the retail sector. In response, many retailers and grocers have begun to insist that their suppliers have effective food safety systems, including HACCP, implemented in their facilities. This

action drives the adoption of HACCP by many processors to retain their current market and customer base or, in fact, expand it.

A. Common Benefits of HACCP

Although the adoption of HACCP systems worldwide is due primarily to the added food safety protection provided to the consumer, a number of other benefits to the food industry, including your company, can be realized by implementing a successful HACCP system.

i. Increased Focus and Ownership of Food Safety

Food safety is the responsibility of everyone in the food supply chain. Through the process of developing and implementing a HACCP system, your company's employees will become more aware of food safety and their roles in maintaining and contributing to food safety. This increased awareness leads to increased ownership and pride in the production of a safe product.

ii. Increased Buyer and Consumer Confidence

There is an increasing trend for buyers to request HACCP from their suppliers. Food processors who have implemented a HACCP system provide buyers and consumers with a greater degree of confidence that the facility is producing a safe food product.

iii. Maintaining or Increasing Market Access

Market forces continue to drive food safety awareness and HACCP implementation throughout the food processing sector. As food safety systems, particularly HACCP, become more common, market access is limited for processors who do not implement them. In many cases buyer demands require HACCP implementation to maintain market share and/or gain access to previously inaccessible markets. HACCP implementation may also permit re-entry into a market that had been lost. Considering the economic implications, HACCP implementation may be a necessary cost of business.

iv. Business Liability Protection

Implementation of a HACCP system can provide your facility with some degree of increased business liability protection and may lead to reduced insurance premiums. This will be an important factor once the Consumer Protection Bill has been passed by Parliament

v. Reduced Operational Costs

The process of developing and implementing a HACCP system requires that the entire manufacturing process be reviewed and analyzed, and written procedures developed. This process often reveals areas where operational costs can be streamlined. For example, developing a sanitation program may identify that excessive chemical concentrations are being used. Reducing chemicals to the correct concentration may decrease sanitation costs.

vi. Efficient Oversight

Similarly, HACCP implementation can provide your company with ongoing efficient oversight. It can be cost effective to implement HACCP in spite of the associated costs. Activities that are performed on a regular basis, such as product and process monitoring, employee training and review of procedures, allow your company to maintain control over the facility and product. You may find there are certain areas of the process that can be made more efficient and productive.

vii. Improved Product Quality and Consistency

The implementation of a HACCP system may indirectly enhance product quality. Procedures that minimize the presence and growth of pathogenic micro-organisms can also minimize the presence and growth of spoilage micro-organisms, leading to an

increased product shelf life. In addition, the attention given to standardized procedures will improve product consistency.

viii. Reduced Wastage

The preventative nature of HACCP allows a company to control costs by minimizing the amount of product requiring rework or rejection, and focusing resources on areas that have been identified as critical in the manufacture of a safe food product. You will find that many problems are addressed before they escalate and before products are dispatched from your facility; you will not simply be waiting for the results of end-product testing. With the regular monitoring inherent in a HACCP system, you will become aware of problems earlier, and your costs of wastage will be reduced.