Cleaning and Disinfection

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PREFACE

The agro-food sector is of major importance in many economies worldwide. In many countries the food and drink industry is a leading industrial sector. Food is a serious component of everybody daily life activities and it is recognized the contribution of safe food to a healthy life. For this reason, food safety and the protection of end consumer health is of increasing concern not only for the consumers but also for governments, professional associations and all organizations involved in the food chain from the primary production to retailers and other food businesses that put food products at the disposal of the population. Food safety is used as a scientific discipline describing the handling, preparation, and storage of food in ways that prevent food-borne illness. This includes a number of routines that should be followed to avoid potential hazards. Food safety considerations include among others, the origins of food, the practices related with food labeling, food hygiene, food additives, control of hazards and good manufacturing practices. The prevention of the multiple type of hazards with very distinctive origins requires a comprehensive and integrated approach to food safety in order to address food safety risks in every day more complex and globalized food chains. All actors in a food chain have a responsibility to ensure the safety of food products at the stages of intervention, irrespective of the nature of the activities they carry out. This book is one of a collection that aims to facilitate to the users the understanding of relevant issues related with food safety.

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DEDICATION

To,

Our beloved teams at MonoJo Biotech and the Jordan University of Science and Technology (JUST) and everyone who contributed towards the success of this series of e-books.

This series of e-books has been prepared for the FOODQA Project which was cofunded by EU through Erasmus+.

The series of e-books has been composed with passion and is available for public access to provide a high quality reference on the best practices in food quality and safety that can be used by the food industry, relevant governmental bodies, students, professors, and academics.

Our heartfelt gratitude goes towards our Jordanian and European partners who dedicated their precious time and effort towards the success of this entire project.

We dedicate this work to our beloved country, Jordan, and its people and to our European partner countries.

- Prof. Fahmi Abu Al-Rub, Dr. Penelope Shihab, and Dr. Safwan Abu Al-Rub

Chapter 1

INTRODUCTION

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Chapter Objectives

- Introduction to cleaning and disinfection in food industry
- Definition of terms and importance of cleaning and sanitation in the food industry
- Importance of water in the food industry sanitation
- Soil characteristics

A new approach to food safety has been set by adopting the European Food Law – Regulation (EC) 178/2002 of the European Parliament and of the Council on general principles and the requirements of food regulations establishing the European Food Safety Authority (EFSA). Following the adoption of the European Food Law, 2004 a whole series of regulations were passed that further regulate the area of hygiene and official controls related to production, processing and distribution of food, which are popularly referred to as the “hygiene package”. They are the same in the EU came into force on 1 January 2006 and laid down the foundations of the food safety system in entire food chain “from Farm to Fork”.

It is necessary to emphasize that according to the provisions of the Food Act, food business entities primarily responsible for food in all phases of production, processing and distribution under supervision according to law. The basic provision of the Food Act that most influences the control system Food safety is the obligation to introduce self-control systems based on the principles of the system Hazard analysis and critical control points (“HACCP”) for all facilities in food business, except for the primary level Production, and the obligation to apply good hygiene practices for all facilities including the primary production.

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The Ordinance on Food Hygiene prescribes hygiene requirements that all subjects must meet who operate with food regardless of whether the products are food of animal or non-animal origin. In the case of the production of food of animal origin, food business operators shall meet special hygiene rules of Food of animal origin prescribed by the Ordinance on the hygiene of food of animal origin. In addition, food business entities are obliged to comply with the provisions of the Ordinance Microbiological criteria for foodstuffs under which the provisions of Commission Regulation (EC) No. 2073/2005.

DEFINITION OF TERMS AND IMPORTANCE OF SANITATION IN THE FOOD INDUSTRY

Food handlers have legal obligation to keep food premises clean same as all food equipment, contact area, and if it necessary used, disinfected. Hazard must be controlled. Food handlers shall ensure appropriate standards cleaning and disinfection during all times and throughout all the stages of processing and distribution of food.

The legal obligation of all government, including European Union and wider is concern to make sure that the food we eat is same high standard for all its citizens, whether the food is home-grown or comes from another country, inside or outside the EU.

Food handlers must be aware of the specific risks associated with their operations and how they can control risk. Those who are responsible for managing the cleaning and disinfection process in the food processing often do not fully understand the reasons for the high hygienic standards or scientific principles and effective cleaning technology. This is necessary to meet the legal and technical standards and ensure control food hazards. All workers in the food industry must have the necessary skills for effective cleaning programs, including cleaning the grounds, principles of disinfection, equipment and methods, application and monitoring of hygiene.

In food processing operations, soils and deposits originate from the ingredients used in the preparation of the product.

Accumulated soils on food equipment and in the food environment can support the growth of pathogenic microorganisms that can contaminate foods and potentially harm consumers. Food contact surfaces must be constantly cleaned and disinfected to minimize potential contamination.

Cleaning in the food industry is not an easy task. However, it is a critical step within food production since it is crucial to maintain and guarantee food safety. To ensure a safe hygienic product and manufacturing environment food handlers and workers must understand why they clean and how detergents and disinfectants work.

Food safety management systems often put HACCP in the center to control the hazard of food, that can identify the specific risk associated with adverse impacts consumers. This requires a program of basic controls that deal with the general hazards, many of which can identified as Good Manufacturing Practice (GMP), Good Hygiene Practices (GHP), Prerequisite Programs (PRP) and a Control Point (CP), etc...

They represent the basic requirement for good practice necessary to provide a safe environment for food production. Among the most important of them is cleaning and sanitizing plant and equipment for the production of food without physical, allergic, chemical and microbiological hazards. In addition, it is important that employees understand the reasons why "everything must be clean." Only order to workers is not enough to maintain high standards - they need to understand the reasons why and how they do it only way to ensure a safe, healthy, high quality product and mutual trust between manufacturers and customers.

All these standards ensure that risks of food poisoning and contamination are minimized, comply with local and international legislation, meet the specific requirements of customers and food safety standards and act in accordance

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with the law, as allow for maximum productivity, promote safe working conditions and ensure that customers have highly safeness in food product.

Visual appearance of a food factory is an indicator of the company's standards and culture. This has a strong impact on the perception of auditors or customers and can affect the overall outcome of auditing and securing new jobs. For this reason, visual imagine of the company is as important as detailed HACCP plans. Cleaning is expensive and is often perceived as a necessity, that does not directly add value to the product. Cleaning and non-cleaning costs are not often associated with market evaluation of the company.

The typical cost elements of a cleaning programme include Labor and supervision, water supply, treatment and purchase, water heating, cleaning equipment, chemicals, corrosion, monitoring, effluent and etc.

Labor is usually the biggest factor accounting for over 60% of the total cleaning budget whether resourced under contract or in-house. While this may save money in the short term, over time, high price of labor will lead to a number of indirect costs including a reduction in shelf life, increase in product complaints, recalls, regulatory restriction and a loss of business. The viability of the business will ultimately be impacted. The next most significant costs are water and chemicals which depending on the source and supplier.

Definition of Terms

Cleaning

Complete removal of food soil using appropriate detergent chemicals under recommended conditions from devices, work surfaces, workstations, and environment and so on.

Disinfection

A process of destroying microorganisms, but usually not a bacterial spore, until their number are reduced to a safe level or reduces them to an acceptable level with respect to the defined purpose (a level that will not affect the safety or the food spoilage). Disinfection can approximately mean killing all active (vegetative) microbes but not the spores.

Disinfectants

A chemical used to disinfect. These are usually chemical in nature and used in conjunction with detergents used to destroy, slow down growth and replication or removal of most microorganisms on surfaces, in or Facilities, appliances, accessories and equipment. Such products can call germicides, bactericides or biocides.

Sanitation

A chemical agent used for cleaning and disinfecting surfaces and equipment usually contains both detergents and disinfectants. To sanitize is to reduce the number of microbes to a safe acceptable level. It never recommended mixing cleaning chemicals on their own discretion.

Working concentration

Amount of water used to dissolve the chemical concentrate before than the same can used. It is necessary to follow the manufacturer's instructions.

Contact time

Time-consuming for the effective action of chemical agents on the surface.

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IMPORTANCE OF WATER IN FOOD INDUSTRY

Clean water is a liquid without color, taste and smell. Under standard conditions of pressure, freezing of water at 0°C, the transition from liquid to a gas is carried out at 100°C. The water reaches its maximum density at 4°C, which is reduced when the temperature drops caused by anomalies known as hydrogen bonding. Oxygen atom in a molecule of water is electronegative, and one end of the molecule has a partial negative charge and the other a positive partial charge, responsible hydrogen bonds. The polarity of molecules greatly determines other water properties, including the most important dissolution of different types of substances.

Water pH ranges generally from pH 5 to 8.5. This range is of no serious consequence to most detergents and sanitizers. However, highly alkaline or highly acidic water may require additional buffering agents.

The industry uses water in the process of production and sanitation. It is estimated that around 15% of water consumption in the world is the industry.

Water can also contain significant numbers of microorganisms. Water used for cleaning and sanitizing must be potable and pathogen-free. Treatments and sanitization of water may be required prior to use in cleaning regimes. Water impurities that affect cleaning functions are presented in **Table 1**.

Solutions for cleaning and sanitizing containing approximately about 95–99% of water. Water has the role to carry the detergent or the sanitizer to the surface and carry soils or contamination from the surface.

Impurities in the water can drastically affect the performance of the detergent or sanitizer. Water hardness is the most important chemical properties and directly affect the effectiveness of cleaning and disinfection. Other impurities can affect the surface of contact with the food, the properties of soil deposits or the formation of the film.

Water alkalinity represents the quantitative ability of an aqueous medium to react with hydrogen ions. Alkalinity determines the amount of ion in water that neutralizes hydrogen ions. In alkaline waters, alkali forms the following ions: carbonates, hydrogen carbonates, hydroxides, silicates, borates, phosphates, and hydrogensulfides.

Water hardness is the concentration of polyvalent metal cations in a solution that reacts in saturation with anions. Water hardness determines the chemical quality of water. One of the mandatory procedure in sanitation is to determine the water hardness used in sanitation. Different compounds dissolved in water have different solubility properties that can be changed by changing pH or temperature. Chlorides and nitrates are salts that are well soluble in water and do not usually precipitate while bicarbonates are tends to deposition.

Water Hardness is Expressed in Different Units

- French grade - $CaCO_3$ / liter.
- English grade - $CaCO_3$ / UK gallon.
- American degree - $CaCO_3$ / USA gallo.
- German grade - CaO / liter.

Water hardness to German degrees (° nj): (1° nj = 10 mg CaO / L).

- Soft water < 9° nj.
- Moderately claiming 9-18° nj.
- Hard Water: 18-26° nj.

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- Very hard water > 26° nj.

Increasing the concentration of calcium may be due to process contamination e.g. skim milk 120 mg Ca / 100g, fresh cheese > mg Ca / 100g, squid 144 mg Ca / 100g, ...). The content of iron and magnesium should be taken into account in sanitation of meat and vegetable processing plants. Blood (hemoglobin) contains iron and chlorophyll magnesium. Sequencing agents help detergents in removing dried blood and deposits formed after blanching of vegetables. Sequestration is the phenomenon of binding of metal ions to water-soluble complexes that prevent deposition. In some cases, the cleaning process is carried out first with acidic, then alkaline, e.g. in the case of cleaning surfaces contaminated with blood.

Water pH can affect the efficiency of sanitation. Some sequestrants have better action at higher pH. The pH below 4, indicates potentially corrosive action of the solution. Corrosion in pH range from 4 to 10 mostly depends on oxygen diffusion. Water used in sanitation is very importance because it serves as a carrier for sanitation and as a rinse aid. According to the quality, it must comply with the standards of drinking water.

The presence of minerals that make water hardness reduces the efficiency of sanitizers, and during sanitation, deposition of calx on the devices can occur. If more than 200 ppm of calcium is present in the water, it recommended adding an agent for water softening that prevents the deposition of the calx. In areas where sanitation carried out, it is important to provide installations with sufficient water, especially hot water.

SOIL CHARACTERISTICS

Food soil is generally defined as unwanted matter on food contact surfaces. Soil is visible or invisible. The main source of soil is from the food product being handled. Also, minerals from water residue and residues from cleaning compounds make to films left on surfaces. Microbiological biofilms also make to soil formation on surfaces.

Because soils have variable composition, no one detergent is capable of removing all types. Many complex films contain combinations of food components, surface oil or dust, insoluble cleaner components, and insoluble hard-water salts. These films vary in their solubility properties depending upon on heat effect, age, dryness, time, etc.

It is important that workers involved in cleaning process have an understanding of the nature of the soil to be removed before selecting a detergent or cleaning regime. The rule is that acid cleaners dissolve alkaline soils or minerals and alkaline cleaners dissolve acid soils and food wastes. Incorrect use of detergents can actually "set" soils, making them more difficult to remove. For example, acid cleaners can precipitate protein. Many films and biofilms require more sophisticated cleaners that are improve with oxidizing agents such as chlorinated detergents for removal.

Soils May be Classified as the Following

- Soluble in Water (Sugars, Some Starches, Most Salts).
- Soluble in Acid (Calx and most mineral deposits).
- Soluble in Alkali (Protein, Fat emulsions).
- Soluble in Water, Alkali or Acid.

The physical condition of the soil deposits also affects its solubility. Freshly precipitated soil in a cool or cold solution is usually more easily dissolved than an old, dried, or baked-on deposit, or a complex film. Food soils are complex in that they contain mixtures of several components. A common soil classification and removal characteristics are presented in **Table 2**.

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Surface Deposit	Solubility	Ease of Removal	Heat-Induced Reactions
Sugar	Water soluble	Easy	Carmelization
Fat	Alkali soluble	Difficult	Polymerization
Protein	Alkali soluble	Very Difficult	Denaturation
Starch	Water soluble, Alkali soluble	Easy to Moderately Easy	Interactions with other constituents
Monovalent Salts	Water soluble; Acid soluble	Easy to Difficult	Generally not significant
+Polyvalent Salts	Acid soluble	Difficult	Interaction with other constituents

Table 2: Characteristics of Food Soils (Allan Pfuntner, M.A., REHS).

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Chapter 2

CLEANING

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Chapter Objectives

- Presents the basic principles of cleaning in food industry
- Presents the most important in cleaning agents in food industry
- Give brief classification of cleaning agent with review on alkalian and acids cleaning agents
- Presents factor affecting cleaning agents and selections of cleaning agents

Cleaning is the complete removal of food soil using appropriate detergent chemicals under recommended conditions. It is important that personnel involved have a working understanding of the nature of the different types of food soil and the chemistry of its removal.

Cleaning Methods Equipment can be categorized regarding cleaning method as follows:

- **Mechanical Cleaning:** Often referred to as Clean-in-Place (CIP). Requires no disassembly or partial disassembly.
- **Clean-out-of-Place (COP):** Can be partially disassembled and cleaned in specialized COP pressure tanks.
- **Manual Cleaning:** Requires total disassembly for cleaning and inspection.

This will be described in more detail in further text.

When selecting the optimal cleaning agent, it should be considered:

- The type of material to be cleaned and possible damage to the material (e.g. corrosion),
- The type of impurities that is removed (fats, minerals, proteins, sugars, ...)
- Procedure or devices to be used (manual cleaning, CIP system, COP system, ...),

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- The frequency of sanitation,
- Temperature, pH and hardness of water,
- The impact of resources on the environment,
- Price and cost effectiveness
- That is readily available, water-soluble and easy to apply.

Generally, the "higher" temperature at which the cleaning is performed will have a better effect, but it has certain limit with respect to the type of contamination. Increasing temperatures for 10 ° C accelerates various reactions. The maximum temperature to be applied depends on the stability of the cleaned material and the type of impurities to be removed. When setting the cleaning regulations, it is necessary to prescribe the temperature limit, considering the cost of energy, type of pollution, washing agent, time of operation, washing effects etc. In some cases, high temperatures may have opposite effect or even reduce the washing effect. For example, high temperature for proteins and sugars change their properties and even more stick to surface, making it difficult to remove them.

Restrictions on the timing of sanitary agents are because of possibility of damage to materials because of corrosion and the time available within the manufacturing process between shifts or lot.

Mechanical action also improves the cleansing effect, especially if larger amounts of contamination are present and very hard impurities as caramelized sugar, sealed dirt, denatured proteins, etc. Limitations of mechanical action are reflected in the construction of the production line and the device.

CLEANING AGENTS

Cleaning agents, factor affecting cleaning agents and selection of cleaning agents.

Cleaning is the complete removal of food soil using appropriate detergent chemicals under recommended conditions. It is important that personnel involved have a working understanding of the nature of the different types of food soil and the chemistry of its removal.

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Dirt, food waste and other debris can be a potential source of microbiological and physical hazards and will attract pests that can contaminate the production environment. Effective cleaning on a regular basis is essential to remove dirt and debris from the food premises. Effective disinfection of clean food contact surfaces is necessary to reduce bacteria to an acceptable level. Poorly executed cleaning program and storage and use of cleaning materials may give rise to chemical hazards. Procedures needed to prevent or minimize the risk of such hazards causing illness or injury to consumers.

Equipment for food processing or preparation upon use covered with the remains of food Formulations (carbohydrates, fats, proteins, salts ...). Pests contain microorganisms and represent seriously hazard. Sanitation of equipment for production of food products and the working environment consists of two steps:

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1. Cleaning.
2. Disinfection.

Cleansing removes various impurities. Disinfection means the process of destruction, inhibition or removal of undesirable and harmful microorganisms. Disinfection does not have to be removed by everyone Microorganisms, especially not slow (unlike the sterilization process). Pollutants in the food industry are complex mixtures of organic and inorganic substances. It's great It is important to know the composition of the pollutants in order to properly select the cleaning agents and systems. It is often Cleaning should be done in at least two steps, using various cleaning agents as needed various organic and inorganic impurities have been removed. It is difficult to remove from cracks, openings and other uneven surfaces and hard-to-reach places Impurities, which should be considered in the construction of the drive.

Removal of impurities carried out in three steps:

1. Separating impurities from the surface (reducing surface tension, facilitating soaking Impurities, decrease the bond strength between the substrate and impurities),
2. Dispersion of impurities in the cleaning agent and
3. Preventing re-accepting dispersed impurities for the surface being cleaned.

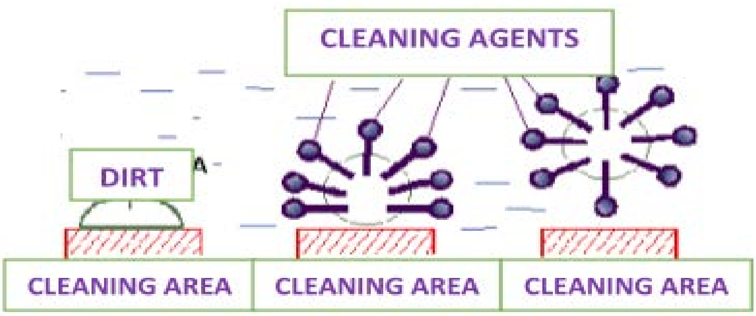

Figure 1: Schematic action of cleaning agents and removal of impurities from cleaning area.

It is important to know that for each type of impurity using the appropriate cleaning agents.

Type of contamination	Cleaning agents
Inorganic impurities	Acid cleaning agents
Organic impurities Fats based on petroleum Fat contamination	Alkaline cleaning agents The diluents
Salts	Acid cleaning agents
Sugars	Alkaline cleaning agents
Fats	Alkaline cleaning agents Phosphate based emulgators
Proteins	Alkaline cleaning agents and some acids

Table 1: Type and some properties of contamination.

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There are various chemical detergents with regard to:

- Different areas of application (surface that encounters food, floors, walls, production plant, warehouse, etc.)
- The construction and material from which the surface to be cleaned is made (tiles, aluminum, plastic, steel ...),
- Quantity and type of impurities (fat, proteins, starch, etc.)
- Frequency of washing.

Chemical cleaning agents are in most cases used in the form of liquids, rarely as gases or solids. Cleaning and disinfecting agents do not penetrate well into cracks, openings and mineral impurities, and in those places are not efficient enough that should be considered. At the same time cleaning and disinfection can be applied with a suitable means only in cases where there is little pollution. If cleaning is combined with different means, care should be taken as to whether the means should be mixed. Sanitation equipment to produce food products and the working environment consists of cleaning and disinfection. Cleaning removes various impurities, and disinfection destroys, inhibits or eliminates undesirable and harmful microorganisms. To disinfectants could operate effectively, the surface to be treated must be completely clean. The dirt can protect microorganisms from the effects of disinfectants or diminish their effectiveness of action. Impurities are food microorganisms and if left behind will enable their growth and development.

Basic Classification of Disinfection Procedures

1. Physical (Heat, Radiation, etc).
2. Mechanical (Washing, Filtering, etc).
3. Chemical (Using Disinfectants).

The effectiveness of disinfectants depends on

- Amount of microorganisms.
- Age of colony and type of microorganism.
- Exposure time.
- Temperature.
- Concentration of disinfectant.
- pH.

TYPES OF CLEANING AGENTS

Classification of cleaning agents:

- According to physical form (liquid, powdery and gaseous).
- According to pH (alkaline, acidic and neutral).
- According to purpose (for cleaning, disinfection, cleaning and disinfection).

Most sanitation products used in the food industry are mixtures of different compounds. Manufacturers combine different compounds to obtain sanitizer having a broad spectrum of action with respect to other impurities, pH, temperature, hardness of water, type of microorganism, type of material being treated, etc.

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ALKALINE AND ACID CLEANING AGENTS

Alkaline cleaning agents have a pH between 7 and 14 and different performance characteristics:

- **Emulsifiers:** Disperse fatty acids, oils and proteins in the water and thus allow their removal by water.
- **Saponificatiors:** Reduce surface tension and soothe soaking (Hydration) of pollutants and their removal from the surface.
- Prevent the deposition of calcification.

The higher pH betters (easier) the removal of organic impurities. Surfactants impregnate impurities and thus facilitate the penetration of these agents, especially when treating rough surfaces. The most used alkaline agents are NaOH and KOH. In **Table 5**. are the alkaline agents used in sanitation?

Salts of alkali agents are added with detergents to enhance their properties. Thus, silicate to inhibit aluminum corrosion, trisodium phosphate forms a buffer system in combination with mono- and disodium phosphate, polyphosphates act as sequestrants and dispersing agents, etc. Although many alkaline agents have good cleaning properties, none have multifunctional properties and are combined by other means. KOH is recommended for cleaning where it prevails

Fat detergents (slaughterhouses and meat processing plants), NaOH where protein contamination is dominated, especially denatured proteins (milk industry) and other sealed contaminants. NaOH and KOH are relatively difficult to wash and adjuvants (oxidants) are added thereto. Chlorine compounds and hydrogen peroxide improve the effect of alkaline sanitation.

Agents	pH 1% solution
NaOH	13.1
KOH	13.0
Sodium metasilicate	12.6
Trisodium phosphate	12.1
Sodium carbonate	11.3
Tetra sodium pyrophosphate	10.1
Sodium tripolyphosphate	8.9
Sodium bicarbonate	8.2
Sodium sulphate	7.3

Table 2: Alkaline agents used in sanitation in the food industry.

Since organisms cannot survive in high pH mediums, high alkaline agents have bactericidal activity.

Precautions: Alkaline, chlorine-based and enzyme-containing agents must be kept separate from acidic substances.

Strong Alkaline Cleaning Agents

Strong alkaline agents have a great power of dissolving and removing impurities. However, they are very corrosive to many materials, especially for aluminum. Care should be taken when handling, and workers who use the means must undergo training for proper handling. They cause burns on the skin and cause dandruff. Longer skin contact causes permanent damage and lung inhalation damages the lungs. Strong alkaline agents destroy microorganisms (disinfectants), dissolve proteins and act as dispersants and emulsifiers. Silicate additions reduce their corrosion. They also improve the penetration power in impurities, thereby enhancing the decomposition and rinsing of impurities.

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Strong alkaline agents are used to clean up heavy contaminants (impurities heavily attached to the substrate) that occur in ovens and dryers (sealed impurities). They are not suitable for removing mineral impurities and are not used for manual cleaning because they are harmful to humans. The most used highly alkaline means is sodium hydroxide.

Medium Strong Alkaline Cleaning Agents

Medium strong alkaline agents have a moderate power of decomposition of impurities. They are gentle or not corrosive at all. They are often used in CIP and high-pressure cleaning systems. They are good for removing fat, oils and proteins. Sodium carbonate is an inexpensive medium very alkaline agent that has a wide application in removal of protein and fatty contamination. The addition of sulfate reduces the corrosive effect of medium strong alkaline agents on tin and tinplate.

Weak Alkaline Cleaning Agents

Weak alkalinity agents' alkaline agents such as sodium bicarbonate are used for manual cleaning of minor impurities. In addition, they can be used to soften the water.

Acid Cleaning Agents

Acidic agents have a pH lower than 7. Acidic agents with organic impurities form hydrophobic substances and are therefore not recommended for their removal. They are used to remove inorganic contaminants and deposits (stone, dairy, beer, etc.). Among acidic substances, nitric and phosphoric acid (in combination or separately) are most used in sanitation in the food industry.

Concentrated inorganic acids crush the skin and need to be very careful when handling. Nitrates and fluorides are particularly dangerous; their vapors irritate the mucous membrane, and in high concentrations can be deadly. Note: alkaline, chlorine-based and enzyme-containing agents must be grouped and kept separate from acidic agents. Never mix chlorine-based cleaning agents with acidic agents because chlorine is a deadly gas. It is also not recommended mixing the acidic agents.

Very Acidic Cleaning Agents

Strong acid cleaning agents have a great potential for dissolving and removing impurities and destroying microorganisms (disinfectants). However, they are very corrosive to many materials. They are used to remove larger impurities and remove scale. They are particularly effective in removing mineral deposits. The most used strong acid agents are hydrochloric acid (HCl), perchloric acid ($HClO_4$), nitric acid (HNO_3), fluoride (HF) and sulfuric acid (H_2SO_4).

Medium Strong Acid Cleaning Agents

Medium strong acid cleaning agents make organic acids: acetic, tartaric, sulfamic and gluconic acids. They are good for softening water, easy to wash and are not harmful to the skin. Medium strong inorganic acids (H_2SO_3, H_3PO_4) are excellent in removing mineral impurities, however they can cause corrosion and damage the skin and should be careful when handling. Medium strong acidic agents are corrosive to concrete, most metals and fabric. By heating these agents, they evaporate by corrosion of lung-defatting gases. They are used to remove scale and dirt from evaporators, steam boilers and other food processing equipment.

Weak Acid Cleaning Agents

In the mild acidic agents, we include hydroxy acetic, acetic, lactic, citric, tartaric and gluconic acids. They are tender or non-corrosive, and they tend to corrode the skin and eyes. Corrosion inhibitors are often used. Organic acids are suitable for manual cleaning and as a water softener.

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Surfactants

The basic properties of surfactants are: "soaking" impurities and emulsifying, depending on the type, prevent formation or formation of foam, some of which have properties of disinfectant and gel formation. Their role is particularly important when cleaning porous surfaces because they allow the penetration of other impurities in the dirt-free impurities.

One of the major problems during cleaning is the removal of grease and hydrophobic impurities that do not dissolve in water. Sodium and potassium soaps, one of the oldest surfactants, have certain deficiencies: they are sensitive to polyvalent metals in water (poor solubility in hard water), and their effectiveness depends on the fat structure. Therefore, there are synthesized surfactants without any of the drawbacks and which are intensively used today to remove impurities.

Surfactants are Divided into Four Categories

Cationic: They have a positive charge. They reduce the surface tension of water and thus enhance the soaking and suspending of impurities and their separation from the surface. This group includes quaternary ammonium compounds having antimicrobial properties.

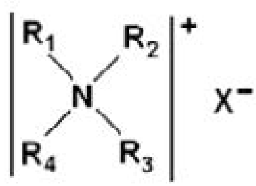
Anionic: They have a negative charge, the pH is neutral, compatible with acid and alkaline use, and is incompatible with cationic sanitation. Anionic surfactants are alkylbenzene sulfonates and linear alkylbenzene sulfonates. They have foam-forming properties and are the basic components of foam cleaning agents. They do not cause skin irritation and are used as a means for manual cleaning and hand washing.

Nonionic: Excellent Excellent in the removal of grease and oil. Compatible with anionic and cationic sanitation devices. They prevent foam formation and have excellent soaking properties (rough surface cleaning). Nonionic surfactants: ethylene oxide polymers, ethylene oxide polymers and propylene oxide. During the polymerization (production) of nonionic surfactants, various lipophilic molecules (fatty alcohols, acids, amines, amides, alkyl mono- and polyaromatic compounds, glucosides and silicone derivatives) are also incorporated.

Amphoteric: Molecules contain a positive and negative charge, have acidic and base properties and act as cations in acidic medium, ie. as anions in alkaline. They are therefore compatible with anionic, cationic and non-ionic means. Means that are dominated by the positive charge have biocidal properties and are used in combination with cationic agents to improve disinfectant activity. Means in which the negative charge dominates have good moistening and cleaning properties. Amphoteric surfactants form foam and do not irritate the skin (additives in personal hygiene and manual sanitation of households and plants). Amphoteric surfactants belong to: alkyl benzene, alkyl sulfobetain, imidazole compounds and alkyl polyamyglycine.

Quaternary Ammonium Compounds (QAC)

QAC are cationic agents or surfactants. The general structure of the QAC is:



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Where R1, R2, R3 and R4 are covalently bound organic groups (alkyl, methyl, benzyl or ethyl benzyl). X^- is halogen, most preferably chlorine or bromine.

Various substituents result in the formation of quaternary compounds of various properties. They are not compatible with anionic detergents or other compounds that are in solution in the form of anions. They are active and stable in broad temperature and pH ranges (6 - 10).

Depending on the composition (type) the QAC is divided into emulsifiers, softeners, antistatic agents, disinfectants and corrosion inhibitors.

QAC act on membranes of microorganisms and belong to a group of low-active disinfectants. These compounds are effective against Gram positive (staphylococci, streptococci), fungi and most gram-negative microorganisms (coli, salmonella and pseudomonas). Some microorganisms of the genus Pseudomonas are resistant to these compounds, but this problem is solved by the addition of EDTA.

Alkaline solutions dramatically improve their performance. The most used QAC having disinfectant properties are alkyl dimethyl benzyl ammonium chloride, dodecyl methyl ammonium chloride, chetyl pyridine, guanin and paliguanids. KAS form bacteriostatic film on solid surfaces and does not react with organic compounds. The main advantage of this agent is:

- Effective at relatively low concentrations even if impurities are present.
- Have no odor and color.
- Are not corrosive to metals.
- Stable at high temperatures.
- Do not irritate skin.
- Wash easily and leave no stains.
- Relatively non-toxic (Ecologically acceptable) if applied according to given instructions.

Apply to

- Sanitation of the facility (disinfection with foam or gel).
- CIP sanitation (non-foaming agents, alkyl polyamides and Polyhexanide).
- Heat exchangers, cooling towers, tunnel pasteurizers and swimming pools.
- Control and removal of mold.
- Combined with ethyl and isopropyl alcohols in “dry” disinfection of open surfaces.
- Disinfection of smaller parts of equipment and accessories by immersion in solution (COP system).
- Disinfection in veterinary medicine (poultry farm, cows, etc.).
- Personal hygiene goods.
- Manual sanitation in combination with non-ionic surfactants.

Negative properties of QAC: Are not compatible with soaps, anionic detergents and other anionic agents and cause foam formation in mechanical operations. QAC are used as sanitation solutions in the food industry, hospital sanitation and skin antiseptics. They can be combined with nonionic soaking agents and other enhancers as a special

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purpose sanitary remedy. If used to treat surfaces that encounter food, they must be in accordance with the rules and regulations.

OTHER CLEANING AGENTS

Soaps and Detergents

Soaps and detergents reduce the surface tension of the water and thus enhance the soaking and suspending of impurities and their separation from the surface and washing with water. They emulsify fats and oils and allow them to rinse with water. Detergents are effective for removing fats because they keep the fats dissolved and at reduced water temperature. They often contain various additives (chlorides, silicates and phosphates) that improve their effectiveness. The pH of most soaps and detergents ranges between 8 and 9.5, and some hand soaps are slightly acidic (pH about 6) and are used to remove strong impurities from the skin. They dry the skin, but they are not harmful.

Sequestrants

Sequesters are chemical substances that form water-soluble complexes with metal ions. By coupling these substances inactivate metal ions and thus prevent their binding with anions (carbonates, sulphates or phosphates) with which poorly soluble compounds are formed. Sequestration efficiency is influenced by concentration, pH, temperature and ionic strength. Sequesters are added to many cleaning agents to enhance their effectiveness or to prevent the negative effects of the metal ions and anionic deposits that originate from Hardness of water or impurities from the process.

Phosphates and Polyphosphates

Phosphates and polyphosphates are used as water softening agents and substances to prevent the formation of deposits. They are the first discovered agents to prevent deposition of lime. Today, they are often used in combination with more advanced sequestrants that undo the negative properties of polyphosphates. The negative properties of these substances are possible hydrolysis and formation and deposition of calcium phosphate. There are various forms of phosphates used as sequestrate: Sodium hexametaphosphate (SHMP), pyrophosphates, phosphoric acid and Sodium triphosphate (STP). Among the above-mentioned forms, the best Features possess STP.

Phosphonates are organic phosphorous compounds belonging to the recent generation of sequestrants that have been used since the seventies of the last century.

Positive phosphonates properties are

- Effective at very low concentrations, 0nly a few ppm is enough for action.
- They are soluble in any medium and can be used in alkaline, neutral and acidic environments.
- Stable at high temperatures regardless of pH.
- Inhibitors corrosion, Phosphonates, alone or in combination with zinc, nitrogen derivatives and
- Molybdenum inhibits corrosion of copper and its alloys, aluminum and steel.
- Low phosphorus concentrations, Relatively low concentration of phosphorus (<20% in the substance itself) and low concentration in application (ppm) results in practically harm to the environment
- Stable in contact with chlorine.
- Peroxide stabilizer, Phosphonates addition prevents peroxide degradation caused by the catalytic action of impurities containing metals.

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- Environmentally safe, Phosphonates show low toxicity to water organisms. They are relatively fast decomposed.

The most commonly used Phosphates for cleaning in the food industry are: *Amino Trim ethylene Phosphonic Acid* (ATMP), hydroxyl ethyl diene phosphoric acid, phosphonobutane tricarboxylic acid.

Hydroxy Acids

Among the hydroxy acids, the following components are used as a cleaning agent component in the food industry: glucose, heptonic and glucoheptonic, borogluconate, boroheptonate, tartaric, citrate and hydroxy acetic acid. Hydroxy acids behave as bi-functional agents, depending on the ph. Relatively ineffective at pH below 11, and the higher the pH, the better the efficiency. The medium is effective for calcium but is superior to heavy metals.

The Diluents

Diluents are alcohol or ether-based cleaning agents. Removal of impurities from petroleum products, such as lubricating oils. Strong diluents do not mix with water but create emulsions.

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Chapter 3

DISINFECTION

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Chapter Objectives

- Presents the basic principles of disinfection in food industry
- Presents the most important disinfection agents in food industry
- Give methods of disinfections and requirements for disinfection agents
- Presents basic steps in cleaning and disinfection procedure in food industry

Disinfectants are applied to the surface of food equipment should have broad antimicrobial spectrum in order to kill non-spore-forming spoilage and pathogenic microorganisms and consequently reduce total bacterial load.

DISINFECTION AGENTS

The main types of disinfectants used in food industry are:

Hypochlorites

Hypochlorites are strong oxidizers that have wide antimicrobial spectrum against different types of microorganisms that can damage the outer membrane of vegetative microbial cells. However, higher concentrations of hypochlorites with longer contact times at elevated temperatures is required for elimination of spore forming bacteria.

Even hypochlorites are easy to use and dissolved well in hard water within pH between 5 to 7, they can bind with organic compounds and form disinfection by products (DBPs) which considered as toxic material to human like trihalomethanes.

Chlorine Dioxide

Chlorine dioxide is an oxidizing agent that reacts with fatty acids and proteins of the bacterial cell membrane that

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leads to disruption of protein synthesis and increase membrane permeability.

Generally, lower concentration of chlorine dioxide compared to hypochlorite is required to eliminate microorganisms from the surface of food processing equipment .i. e, 5-ppm with a contact time for 1 minute effectively sanitize food contact surfaces while disinfection will be attained when 100 ppm is applied for 10 minutes. Additionally, chlorine dioxide is less reactive with organic restudies making it more environmentally friendly.

Iodophors

Iodophors are a group of disinfectant composed of iodine and surfactant that act as carriers for the iodine which increases its solubility in water. These disinfectants exert antimicrobial activity against both Gram -ve and Gram +ve bacteria and actinomycetes. Spore forming bacteria and viruses can be killed when higher concentration and longer contact times are used.

Iodophors can be used under slightly acidic pH conditions. The effective concentration of Iodophors for sanitization is 25 ppm for 1 minute. Unfortunately, iodine compounds easily stain many surfaces, particularly plastics leaving a typical brown coloring.

Peroxyacetic acid

Peroxyacetic acid is effective a disinfectant with a wide range of antimicrobial activity against both Gram -ve and Gram +ve bacteria, yeast and molds as well as spore- forming bacteria and viruses at room and cold temperatures through disruption of chemical bonds within the cell membrane. peroxyacetic acid has a greater oxidizing capacity at an acid pH. Its effectiveness is reduced in the presence of organic compounds and as the pH approaches neutrality. Peroxyacetic acid is applied at concentrations ranging from about 100 ppm to 200 ppm for disinfection of sterilize stainless steel and glass containers, tubes and piping, tank trucks and aseptic packaging of fruit juices and milk.

Quaternary Ammonium Compounds

Quaternary ammonium compounds (QAC) are positively charged cations that react with negatively charge phospholipids of microbial cell wall that blocks the uptake of nutrients into the microbial cell and prevents the discharge of waste. QACs are effective against a wide range of vegetative form of bacteria. In general, Gram -ve are more resistant than Gram +ve bacteria to QAC. QACs may be applied at concentrations range from 100 to 400 ppm. In addition, QAC can act as detergents when present in high concentration because the compounds possess both hydrophilic and lipophilic chemical groups.

QAC are non-staining, odorless, noncorrosive and relatively nontoxic to human. Although, QAC act well over a wide range of temperature and pH, their activity is greater at warmer temperatures and in alkaline conditions.

REQUIREMENTS FOR DISINFECTION AGENTS

Disinfectants used in food industry should be:

a) Not toxic for human.

b) Soluble in water.

c) Not irritant or corrosive.

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d) Remain stable under processing conditions.

e) Provide a good cost-benefit ratio.

The effectiveness of disinfectants can be affected by various factors such as:

Temperature: Increasing the temperature accompanied by increasing the effectiveness of disinfectants through accelerating the speed of reaction of the disinfectants with microorganisms.

pH: Disinfection is usually carried out with neutral pH even though an acid pH improves the effectiveness of the disinfectants with oxidizing properties.

Concentration and Contact Time: Higher concentration and longer contact time enhance the bactericidal activity of microorganisms.

BASIC STEPS IN CLEANING AND DISINFECTION

Cleaning and disinfection are considered as two discrete steps in the cleaning procedure. Cleaning is the complete removal of visible dirt and organic substances such as protein and fat from surfaces of food processing equipment and materials through the use of chemical and physical means. Disinfection can be defined as reducing the number of microorganisms to a safe level through the use of chemical or physical means. Therefore, effective cleaning is essential for proper disinfection of food processing equipment and contact surfaces in order for reducing the contamination of food with pathogenic microorganisms.

The cleaning and disinfection steps for effective elimination of microorganism in food processing plants consist of the following:

Remove Visible Dirt and Organic Substances

The accumulated solid dirt and organic substances on the surface of food equipment are removed either by hand or use of brushes, brooms, scrapers or squeegees. A warm rinse is recommended to complete this step with cold or hot water (<50˚C to avoid denaturation of the proteins or precipitation of the magnesium and calcium salts present in the water). Proper Remove visible dirt and organic substances enhance the action of detergent in the subsequent steps and permits the use of reduced amount aggressive detergent.

Cleaning with Water and Detergents

Water is widely used for cleaning, capable of removing even the finest residues of foodstuffs after processing. The specification of water that will be used in cleaning of food facilities should be similar to drinking water specification; colorless and clear with a low concentration of mineral salts. Otherwise, hard water can restrict the action of detergents used in cleaning thus reducing their efficiency.

Detergents are added to water to lower the surface tension of the water that helps in detaching dirt and organic substances from the surface of food equipment. Although, detergents are not obligatory to have disinfecting activities, a partial reduction in the total number of microorganisms can be achieved which may enhance the efficiency of disinfectants

Intermediate Rinsing with Water

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Dirt and grease upon application of detergents on the surface of food equipment will be removed by rinsing with warm water. In some instance, rinsing with water followed by rinsing with an acid solution to neutralize the alkaline residues and remove any inorganic salts that may be present.

Disinfection

This step is vital to produce food products free from pathogenic and spoilage microorganisms through their elimination or reducing their number to acceptable level. Disinfection process requires the use of chemical substances with an oxidizing effect. These disinfectants are only effective on surfaces that have been thoroughly cleaned once applied according to manufacturer's recommendations interms of concentration and contact time.

Final Rinsing with Water

A final rinse step is required after application of disinfect for complete removal of the residues of chemical disinfectants from the surface food equipment and contacts surfaces. Rinsing with hot water (<80˚) under certain conditions can be used where a high level of hygiene is required.

Types of Detergents

Inorganic alkaline detergents

Highly Alkaline Detergents (or heavy-duty detergents) use caustic soda (sodium hydroxide) or caustic potash (potassium hydroxide) have an excellent dissolution and saponification properties that is used to remove fats, grease and proteins residues. They are widely used in Clean Place systems or bottle-washing applications. However, they are considered as aggressive detergents that limits their application in food industry.

Acids detergents

Acid detergents includes:

a) Organic acids such as such as Citric, Gluconic and Hydroxyacetic.

b) Inorganic acids such as Hydrochloric, Nitric and Phosphoric.

Acid detergents are usually used in conjunction with alkaline detergents in a two-step sequential cleaning systems such as clean in place. In addition, the formation of stone films such as milk stone can be prevented through the use of inorganic acid such as nitric acid.

Water Conditioners

Water conditioners are substances added to detergents to prevent the build-up of mineral scales such as calcium and magnesium salts. These chemicals include:

Organic compounds

Nitrilotriacetic acid (NTA) and ethylendi-aminotetracetic acid (EDTA) are the main compounds that belongs to this type of detergents. These detergents are widely used in food industry because of their high solubility in liquid detergents.

Inorganic compounds

Sodium polyphosphates, sodium tripolyphosphate and tetrasodium pyrophosphate are example of these detergents.

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Surfactants

Surfactants, also called surface active agents, are organic chemicals used to reduce the surface tension of water that enable the cleaning solution to wet a surface and promote emulsifying of grease residues and keep them dispersed and suspended thus preventing their re-settlement on the surface of food processing equipment.

Surfactant agents can be divided into different types according to their ionic (electrical charge) properties in water to:

Anionic surfactants

They are ionized in water to negatively charge compounds. Alkylsulphates, alkylbenzen-sulfonates and ethoxylate sulphates and alcohol ethoxysulfates are among the main anionic surfactants that are widely used in the food industry.

Cationic surfactants

These surfcantants ionized to positively charged molecules upon dissociation in water. Quaternary ammonium compounds are the major cationic surfactants that are widely used in the food industry. Also they pocesse antibacterial activtty that allow them to combine the cleaning and property.

Non ionic surfactants

These surfactants do not dissociate in water to charge molecules. Polymers of ethylene oxide are examples of this group of surfactants. They are not affected by water hardness with good foaming power and solubility in water.

Amphotheric surfactants

These surfactants tend to form negatively charged, positively charged or nonionic molecules upon dissociation in water depending to the pH value of the system. Imidazolines and betaines are among the major amphoteric surfactants used in food industry. In addition, they have a good disinfectant property against both Gram positive and Gram negative that permit the combination of the detergent with the disinfectant characteristics.

Usually, detergents that are available commercially are mixtures of several compounds mentioned above to meet the requirements of food industry. For example, a surfactant that have physical activity on dirt mixed with a detergent possess chemical activity to encounter water hardness. The efficiency of the detergent that will be used in food industry in measured based on the standard of achieved hygiene, time consumed and the costs required in order to attain that standard.

Solid residues removal

Solid residues can be defined as any unwanted material which remains on the surface, whether or not it comes into contact with the foodstuffs. In general, dirt can be to segregated into the following:

Greasy residues

Can be removed by alkaline detergents with saponification or emulsification characteristics.

Protein residues

Can be removed by strong alkaline detergents that possess proteolytic activity with the addition of humectants to increase its solubility.

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Carbohydrate-base residues

Can be removed by the application of water, while starch residues can be removed with mild detergents.

Inorganic compound-base residues

Can be removed by using acid detergents.

Grease and lubricating oils residues

Can be removed by using water after being emulsified with suitable detergents.

Other insoluble residues

Can be removed by using a surfactant detergent.

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Chapter 4

CLEANING AND DISINFECTION EQUIPMENT

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Chapter Objectives

- In this chapter we present the basic Cleaning and Disinfection equipment for food industry
- How to select the most suitable equipment for Cleaning and Disinfection of food premises

INTRODUCTION

Choosing a Cleaning and Disinfection System Depends on

- Type of equipment (Materials, Construction, Technical design).
- Part of the facility being treated (Floors, Walls,....).
- Cleaning and disinfecting agent (Gaseous, Liquid, Foam).
- Price.

Universal cleaner and disinfectant and universal equipment practically does not exist. Different surfaces and different types of soiling require different treatments. Mechanical cleaning works reduce cleaning time and increases efficiency, especially when removing large dirt. Good cleaning systems are significantly more expensive, but reduce the need for labor-saving resources and energy.

Most sanitation systems and cleaning and disinfecting agents work well at temperatures below 55°C. Lower temperature means less energy costs and a lower risk of burns at work, and easier removal of protein contamination. Use of appropriate amounts of sanitation agents in appropriate concentrations reduces costs and less pollutes the environment.

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Sanitation can be performed manually or automatically with special devices. It is necessary to provide workers with all the tools and equipment as efficient sanitation with consumption of less time, energy and resources. It is also necessary to provide adequate storage of equipment and sanitation facilities (separate from raw material and finished products).

CLEANING AND DISINFECTING EQUIPMENT AND EQUIPMENT SELECTION

Mechanical Abrasives Agents

They are used for manual cleaning, and make them a broom, steel wool, brushes, spatulas and others. It is not recommended to use on surfaces that come into contact with foodstuffs as little bits of help may remain on the surfaces and so get into the food product. Also, it is not recommended to use broom because they transmit molds and bacteria. If the rags are used for any purpose, they must be boiled and disinfected before use.

Water Hoses

They are used to clean cracks and valves with direct jets. They can have different extensions such as "sprays" that spray liquids in the form of flakes and thus cover large areas in a very short time. Reagent sprays are used for cleaning around and under the equipment. The brush at the end of the hose allows simultaneous spraying of fluid and brushing.

There must be a jet closure system in the water hose to reduce the water consumption, reduce spatter and facilitate the change of the extensions. After cleaning the hoses must be removed from the production area, disinfected and hung on the hooks (above the floor). This is particularly important in the control of *Listeria monocytogenes.*

Steam "Cannons"

Steam cannons mix steam with water and / or cleaning agents and consume much energy and should be careful when handling. It can cause condensation of water on walls, ceilings and equipment, which enhances the growth of mold and allows growth of *L. monocytogenes*. Generally speaking, this is not a good way to clean because it causes steam cloud and thus condensation and does not disinfect the cleaned surface. An alternative is using high pressure pumps that work just as well as steam cannon but with lower temperature on the cleaned surface.

Washing With Hot Water

This can be called a cleaning method rather than a type of equipment. Wide use because only a bowl or sink, hose and hot water are needed. Although it is cheap and easy to install, washing with hot water is not a good way to clean. Namely, without high pressure water does not come in all areas, and it requires a lot of workforce, high energy costs and steam condensation.

High-Pressure Systems (Portable and Central)

High pressure water pumps can be portable or stationary depending on volume and needs. They can also have mixing tanks for cleaning agents and disinfectants. Central high pressure pumps can supply water through the entire operation, with excerpts where staff cleans the equipment and space.

Taps, accessories and hoses must maintain water pressure, and all equipment must be corrosion-resistant. Portable High Pressure Cleaning Systems consist of: high pressure air or water pumps, tanks for sanitation agents, hoses for supply.

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The mobile unit provides adding the correct amount of cleaner in the reservoir according to water pressure, and high pressure spray disperses the cleaning agents. Requires more manpower than central mounted units and higher maintenance costs.

The principle on which this system is based is the same as for portable and consists of: centrally located tanks with sanitation agents, hot / cold water, pumps, dosage devices. From centrally-located unit, the piping system provide the delivery to all parts of the plant. Central systems are flexible, efficient and easy to use.

For high-pressure systems, chemical agents work better because they are better disperse in water. Acidic, alkaline and neutral sanitizing agents can be used in these systems. If not used properly, the system may disseminate dirt in all directions. Therefore, prior to use of this system, the surface is washed with a low pressure jet.

Foam Cleaning Systems (Portable and Central)

Agents and systems for sanitation with foams first started to be used in meat processing plants, and shortly thereafter spread to almost all types of food industry. The reason for this is simple and quick application, efficiency and relatively small workforce needs.

To form a foam, the cleaning agent is mixed with air and water. The foam stays longer on the surface and is better visible and it is easy to determine which surfaces are treated and it is less likely to skip surfaces or clean the same surface twice.

Foam cleaning is especially suitable for cleaning vertical surfaces because the foam is better fixed to the surface and act longer. It is used to clean the exterior and interior surfaces of transport vehicles, ceilings, walls, tubes, conveyor belts and packaging. The efficiency and the price correspond to the portable units for high pressure cleaning.

The principles of work central and portable cleaning system are the same. The technical design is the same as in high-pressure central and portable systems.

Combined Cleaning With High Pressure and Foam

This system is a particularly effective way of sanitizing facility. They are more flexible than other systems because foam can be used for large and vertical surfaces, and for less space and hard-to-reach areas can be used high pressure cleaning. These systems are more expensive than the foam and high pressure sanitation system.

Portable Systems for Cleaning with Gel

The gel is particularly suitable for cleaning the packaging system because the gel is attached to the moving parts and helps to remove the accumulation of dirt. It is also suitable for cleaning vertical surfaces. This equipment costs approximately as much as the portable cleaning system with foam or high pressure equipment.

Cleaning in Place (Cip)

CIP systems are practically used only for sanitation of closed facility (pipelines, barrels, heat exchangers, centrifuges and liquid homogenizers, etc.). Almost all the dairy industry and beverage manufacturing industries use this system. In other branches, very little is used because it is expensive and is not suitable for cleaning some food processing equipment.

To make CIP sanitation successful, the cleaning agent must be in contact with the surface for at least five minutes, and sometimes longer. In order to preserve water, energy, sanitation solution and water are recirculated several times throughout the system.

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The CIP system consists of:

- Suitable containers - hot / cold water tanks, sanitation agents etc.
- Dosing pumps.
- Delivery and return pumps for transporting medium to the cleaning place. Mensural, regulating and controlling devices (for flow, pH, temperature etc).

CIP sanitation in most cases consists of the following phases

1. Prewashing and rinsing with water.
2. Alkaline washing.
3. Wash with water.
4. Acid wash.
5. Wash with water.
6. Disinfection.
7. Wash with water.

Usually alkali wash is preceded by acid, however, there are cases where acid washing precedes alkaline (washing nano or ultrafiltration plant where equipment is contaminated with contamination mainly containing starch and whey). The reason for this is the possibility of precipitating phosphate or starch's gelatinization in contact with the lysine. If cleaning is carried out at high temperatures or by means of disinfectant, no disinfection steps are required.

The benefits of CIP are

Less workforce required, efficient sanitation, controlled and computerized process control precisely the sanitation process and the dosage of the agents, lower consumption of cleaning agents and water. By automatic measurement and re-use of water, sanitation reduced the amount of waste, efficiently use of equipment, automated systems run as soon as the production process stops, so the equipment is ready for reuse, greater security, and workers do not have to enter and disassemble parts of equipment.

Disadvantages of the CIP system

High initial investment and costly servicing, inflexibility, cleaning is possible only in the areas where the system is set up, while the mobile cleaning units cover multiple areas. CIP systems are difficult to remove the strong sticking dirt.

Cleaning out of Place (COP)

When using the COP system, workers must dismantle the equipment and transfer it from the production area to the sanitation area. This system cleans smaller parts of equipment, dishes and smaller packaging in a recirculation machine so called COP unit. The COP system consists of a recirculation pump for sanitation and flushing solutions, and a special part for washing, which is used for soaking in washing solution. Sanitation generally takes 30 to 40 minutes. The COP system usually includes a two-part sink with motor-driven brushes.

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Advantage of the COP system

Used for washing a wide range of smaller equipment and utensils, it requires less work force and is better in maintaining hygiene than manual washing. It is relatively inexpensive when it comes to procurement and maintenance, but for smaller capacity plants it may be expensive and unsuitable because it requires work force.

Implementation of cleaning and disinfection system COP.

Disinfection with hot water (Three-part sink).

1. Remove large impurities.
2. Wash in detergent solution - above 40°C (or according to detergent instructions).
3. Wash in clean water.
4. Disinfection in hot water - above 75°C (shortest 30 seconds).
5. Air drying.

Disinfection with chemical agents (Three-part sink):

1. Remove large impurities.
2. Wash in detergent solution - above 40°C (or according to detergent instructions).
3. Wash in clean water.
4. Disinfection in the disinfection solution (according to the manufacturer's instructions).
5. Air drying.

Disinfection Equipment

Disinfection equipment includes manual sprays, units mounted on the walls and sprinklers mounted on processing equipment. For Automated Cleaning Systems (CIP, COP) disinfection equipment is part of the system itself. Central cleaning systems with foam and high-pressure cleaning also contain disinfection lines.

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Chapter 5

SANITATION METHODOLOGY AND DOCUMENTATION

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Chapter Objectives

- Present the concept and principles of sanitation in food industry
- Present the methodology and documentation of sanitation in food industry
- Present the chemical sanitation, air drying and heat sanitation

THE SANITATION PROCESS

A sanitary processing environment is essential to food safety, and ensuring a sanitary plant means implementing cleaning standards as well as sanitation standards. The aim of sanitizations is to reduce or eliminate the disease causing organisms to safe levels. After cleaning and removing of the dirt and soils the sanitizers will be work effectively.

Sanitization procedures in modern food facilities vary greatly. Such procedures depend on the product, process and equipment used. Sanitation of food-contact surfaces is usually done in the following order:

Cleaning

By scrape all loose debris and food particles from surface; The first step in the cleaning and sanitation is the physical removal of gross solids and large particles. This could include the use of brooms and scrapers or simply physical lifting and disposing of items. The more food residues removed ahead of time, the cleaner the wash water will stay. This is often followed by flushing or rinsing of the surfaces to remove as much of the solids and particles prior to cleaning as possible. warm water, of 105° to 115°F is recommended to be used for rinsing. "If the water is too hot, it can cause the soils to become more adherent. Two types of cleaning practices are used:

Wet cleaning

The main cleaning method used in most food processing facilities is wet cleaning. This involves using a liquid (most often water) and some form of agitation (scrubbing or scraping) to remove soil. Tools such as brushes, high pressure pumps, air or steam are used in wet cleaning.

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Generally, wet cleaning is recommended to get rid of sticky residues containing allergens.

Dry cleaning

Not all operations can be wet cleaned. In bakeries, flourmills, dry blending facilities and similar operations, microorganisms are of less concern than moulds, insects, rodents and foreign objects. In these facilities, clean-up crews use brooms, brushes, shovels and vacuum systems to remove waste and spills.

Unlike wet cleaning, dry cleaning does not use a step-by-step procedure. In dry cleaning, the method is to start high and work down.

Use dry cleaning only when there are no sticky, glutinous allergen residues. Remember that allergens can easily become airborne, especially in facilities with a common air supply. Dry cleaning in such facilities could draw allergens into the air supply system and contaminate non-allergenic products. Use a vacuum cleaner to do most of the cleaning.

Sanitizing

Once the surfaces are verified as "clean," the sanitizing steps are begun. Sanitizing is done using heat, radiation, or chemicals. Heat and chemicals are commonly used as a method for sanitizing in a restaurant while radiation is rarely used. The item to be sanitized must first be washed properly before it can be properly sanitized. Some chemical sanitizers, such as chlorine and iodine, react with food and soil and so will be less effective on a surface that has not been properly cleaned.

Chemical sanitizing

Chemicals that are approved sanitizers are chlorine, iodine, and quaternary ammonium. Different factors influence the effectiveness of chemical sanitizers. The three factors that must be considered are:

Concentration

The presence of too little sanitizer will result in an inadequate reduction of harmful microorganisms and too much can be toxic.

Temperature

Generally chemical sanitizers work best in water that is between 55°F (13°C) and 120° F (49°C).

Contact time

In order for the sanitizer to kill harmful microorganisms, the cleaned item must be in contact with the sanitizer (either heat or approved chemical) for the recommended length of time.

The most common of these are chlorine-based, sodium hypochloride, commonly known as bleach. Other common sanitizers include "quats," or quaternary ammonium compounds; PAA—peroxyacetic acid; chlorine dioxide, similar to hydrogen peroxide; and iodine, in certain applications. "Each has different characteristics, advantages, and disadvantages that make it appropriate for different uses. Some may be more corrosive, others more effective in hard water, and others more easily inactivated by organic soil. Selection should, thus, be based on the materials to be treated and available time, e.g., whether or not the sanitizer is to be left overnight. Adding to that the sanitizer label should be consulted for selection of most applicable product. There will be registration information showing what it

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has been tested on and what bacteria it is effective against. In general detergents, sanitizers should be applied at the concentration and contact time recommended by the manufacturer.

Air drying

Utensils or other equipment must be air dried after sanitizing. Sanitizers come in two forms: leave on and rinse off. Most food processors currently use leave-on sanitizers due to the “glove-like protection” they provide. These can be left on the surfaces for several hours and still maintain their effectiveness. As with detergents, rinse-off sanitizers should be completely rinsed from surfaces prior to operational start-up, and label directions should be followed for dry time for leave-on sanitizers.

HANDLING AND STORAGE OF SANITATION AGENTS

Occupational Health and Safety and Chemical Hazards

A major issue facing all facilities is the potential for reactions between cleaning products. Some highly reactive chemicals, like bleach, will produce toxic fumes when in contact with other cleaners. This often happens when an acid cleaner is mixed with a base or caustic cleaner.

When using, storing or mixing chemicals, you should always look at the chemical’s Material Safety Data Sheet (MSDS). If you have doubts about how to use chemicals, or need information on possible chemical reactions, ask the chemical supplier.

Before using bleach of any concentration, rinse the area. Drain or clean equipment completely of all residual soils, cleaners and chemicals. Never use bleach in a confined space. Always make sure there is adequate ventilation.

Separate chemicals from food, equipment, utensils, linens, and single-use items. If chemicals are stored directly above or next to any of these items, they could spill onto the item and contaminate it.

Only buy chemicals approved for use in a restaurant or food establishment. Store chemicals in their original container away from food storage and food preparation areas. If a chemical is transferred to a new container, label the container with the chemical name, manufacturer’s name and address, and potential hazards of the chemical.

Material Safety Data Sheets (MSDS) are one way that chemical manufacturers provide hazard information to users, such as foodservice workers.

Information on a typical MSDS Includes:

1. **Contact information**

   Manufacturer name, address, emergency telephone number, telephone number for information, and the date the MSDS was prepared.

2. **Hazard ingredients and identity information**

   Hazardous components in the product.

3. **Physical and chemical characteristics**

   Boiling point, vapor pressure, vapor density, solubility in water, specific gravity, melting point, evaporation rate, and appearance and odor.

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4. **Fire and explosion hazard data**

   Flash point, how to extinguish, special fire fighting procedures, unusual fire and explosion hazards.

5. **Reactivity data**

   Stability, incompatibility with other products and substances, hazardous decomposition or byproducts.

6. **Health hazard data**

   Signs and symptoms of exposure, medical conditions generally aggravated by exposure, emergency and first aid procedures, health hazards (acute or chronic).

7. **Precautions for safe handling and use**

   Precautions for safe handling and use, such as steps to be taken in case the chemical is spilled; how to dispose; precautions to be taken in handling and storing; and any other precautions, such as respiratory protection, ventilation, protective gloves, eye protection, other protective clothing or equipment.

8. Control measures

The Occupational Safety and Health Agency (OSHA) of the US Department of Labor requires that restaurants have a hazard communication program. Material Safety Data Sheets (MSDS) are the foundation of the program. The MSDS must be available for all hazardous chemicals used in your restaurant and so keep them in a binder or in a central file in the establishment. The following information should also be available:

- A list of the hazardous chemicals located in each work area.
- A description of how employees will be informed about the hazards in using chemicals; and emergency procedures for spills, leaks or other accidents.

For containers of hazardous chemicals must

- Be properly labeled, tagged, or marked with the name of the contents.
- Display appropriate hazard warnings. The hazard warning can be any message, words, pictures or symbols that convey the hazards of the chemical(s) on the container. The label must be legible, in English (and in other languages as needed), and prominently displayed.
- Show the names and addresses of the manufacturers or other responsible parties.

Worker training must also be a part of your hazard communication program. Program records must be available upon request by workers and other designated government officials.

HEAT SANITIZING

There are three methods of using heat to sanitize surfaces: steam, hot water, and hot air. Hot water is the most common method used in restaurants. If hot water is used, it must be at least 171F (77°C). If a high-temperature where washing machine is used to sanitize cleaned dishes, the final sanitizing rinse must be at least 180 F (82°C). For stationary rack, single temperature machines, it must be at least 165 F (74°C). Cleaned items must be exposed to these temperatures for at least 30 seconds.

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DOCUMENTING A SANITATION PROGRAM

Sanitation program documents are important for three reasons:

- They demonstrate due diligence.
- They allow a third party audit the facility on behalf of customers and.
- Documentation of the sanitation program is a regulatory requirement.

The current trade environment demands that manufacturers prove due diligence in all activities. Documentation encourages employees to perform all key activities.

For any food safety program to be auditable, the manufacturer must document what they do. It's important that they prove their activities are following the stated methods. This is shown through documentation.

The sanitation program is key to food safety production. Because of this, auditors will likely check the sanitation program in their assessments.

Everything in the program should be documented. This includes:

- Training.
- Dilution rates.
- Pre-op inspection findings.

The facility should be able to show that the sanitation program supports all other prerequisite programs.

Three formats commonly used to document sanitation program requirements are:

- Sanitation Standard Operating Procedures (SSOPs).
- Matrix or schedules.
- A combination of matrix and SSOPs.

Sanitation Standard Operating Procedures (SSOPs)

Sanitation Standard Operating Procedures (SSOPs) are usually written in an essay or report form. Write out each cleaning procedure so that a new or untrained employee will be able to follow the instructions.

A typical SSOP will include a description of the activity to be done. It will also include:

- Information about the chemical(s) to be used – including concentration and procedures for using them, and any personal protective equipment (PPE) needed.
- Detailed step-by-step process instructions – including a list of sanitation equipment to be used, and instructions on taking equipment apart.

Be sure to document

- Sanitation process to be used (COP or CIP).
- Cleaning and sanitizing instructions.
- Temperature of water.

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- Water pressure needed.
- Reassembly instructions.
- Frequency that this activity must be performed.
- Document name of where completion of the activity is recorded.
- Job title of the person(s) responsible for the activity.
- Job title of the supervisor or person who will monitor and supervise the SSOP.
- Job titles of personnel to sign off and date the document after the SSOP is accepted or altered.
- Pre-op inspection or verification instructions.

Sanitation Matrix

Like the sanitation program, the sanitation matrix addresses a processing facility's unique needs.

The required information should be completely contained within the matrix. It should also be easy to understand. There are various ways to develop a sanitation matrix. Some recommended columns to include are:

- Room, area, equipment.
- List of tools and equipment needed.
- Frequency (Daily, Monthly, Yearly or as needed).
- The person responsible (and designated alternate).
- Chemicals used.
- Appropriate chemical instructions (Including mixing instructions, Concentration, Temperature and Contact times).
- Cleaning method to be used (Manual, Automatic, Foam, etc).
- Specific sanitation procedures.
- Disassembly instructions where required and.
- Sign-off record, or associated record.

It's important to make sure that the matrix is completed by relating it to:

- Training.
- Verification.
- Deviation SSOPs.

Monitoring the Sanitation Program

As with any prerequisite program, develop a method to monitor how the sanitation program is working.

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These procedures can include:

- Checking the concentrations of the cleaners and sanitizers while min use.
- Checking the temperature of the water during cleaning at a regular frequency and.
- Observing sanitation employees during cleaning to make sure that SSOPs are followed correctly.

DEVELOPING VERIFICATION AND VALIDATION PROCEDURES

Environmental swabbing (swabbing equipment and surfaces in food production areas) or testing is the most common way to check a sanitation program.

These procedures are not developed to determine if the product should be released. Instead, they are developed to monitor whether current system controls are working.

Generally, these tests are done on both food-contact and non-food contact surfaces. They are part of daily pre-operational activities. These procedures need to be documented within the sanitation program.

Strategic Sampling

Pre-operational swabbing will help identify trouble spots. These swabs provide baseline information that a facility uses to decide whether its control of microbes is getting better or worse.

Many facilities develop their verification procedures around trouble spots. Locations to sample in the facility will depend on:

- The layout of the facility.
- The kind of product being manufactured and.
- The type of processing line the product is being run on.

On production line equipment take samples from the following two areas:

- **Food-contact surfaces:** Where product comes directly into contact with the surface and.
- **Non-food contact surfaces:** where contaminants could move from and come into contact with food-contact areas. Don't just look at equipment and surfaces. All environmental sampling systems should include some form of air sampling. Microorganisms exist in the air as passengers on dust particles. They're also found in condensation droplets and exist as individual organisms.

In-plant sampling sites should include hot spots (Check air as well as equipment/surfaces). They should also include unusual locations such as posters or signs. The sampling should change to new locations from time-to-time.

Sampling Methods

Various methods are available for environmental testing. These include:

- Rapid microbial testing techniques.
- Standard microbiological testing and.
- Allergen residue testing.

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ATP Testing Methods

- ATP (Adenosine Triphosphate) testing is usually done with specific ATP equipment.
- In general, ATP takes little time or work to prepare. The testing units require appropriate training to use properly.
- ATP tests provide instant feedback on how the cleaning program is working. They are considered to be 'real-time' because the results are available in a minute or two and not days later as with microbial testing.
- ATP testing does not require a laboratory at the facility or sending samples to a third party lab.
- ATP swabs are often used to assess microbes and allergens. This process is sometimes unable to provide the exact amount or level of organic material or allergens present on a surface. However, it helps fine tune and correct the program.
- In addition to ATP testing, it's important to occasionally do a full microbiological analyses or allergen assessment of a facility environments.

Microbiological Testing Methods

- There are a variety of rapid microbial testing methods available. These may not be as fast as ATP testing, but they can assess the cleanliness of the facility.
- Results of microbial testing can serve as useful guidelines. However, interpreting results based on absolute numbers can be misleading.
- Sometimes this is even counterproductive. Certain conditions (such as fatty films) can make these bacterial counts inaccurate.

Allergen Testing Methods

- There are few approved methods to test for the presence of allergen proteins.
- Manufacturers may use allergen specific swabbing kits such as ELISA (Enzyme Linked Immunosorbent Assay), which detect allergenic proteins.
- A concern with allergen protein test kits is that they don't recognize denatured proteins. These proteins may cause a reaction in sensitive individuals.

DNA Testing Method

- Polymerase Chain Reaction (PCR) is one of the newer methods of allergen and microbial testing. PCR tests for the DNA associated with the material of interest.
- The main disadvantage of this method is that it doesn't test for proteins. Instead it tests for DNA. This means that a positive allergen PCR test may result in a negative ELISA or ATP result.
- Further, a positive microbiological test may end up scanning as negative. This is because of the extreme sensitivity of this testing.
- The PCR method can find dead and damaged cells as well as living microbes. As a result, most manufacturers have decided not to use PCR testing at this time.

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Food Premises Sanitation Plan Template

This plan outlines the regular cleaning and sanitation program you deem sufficient to ensure the safe and sanitary operation of your food premise.
All operators of food service establishments in Prince Edward Island are required to have a sanitation plan.

Name of Food Premise: ______________________

Civic Address: ______________________

License holder: ______________ Date: ______________

GENERAL CLEANING AND SANITIZING

Location	Frequency	Product used for Cleaning	Product used for Sanitizing	Mixing Directions for Sanitizer
kitchen (food contact surface areas, eg. counter tops)				
kitchen (non-food contact surface areas, eg. floors, walls)				
customer area				
washrooms				
grease trap				

Describe how you clean and sanitize the areas noted above: ______________________

____

____

EQUIPMENT (Check equipment used)

Walk in cooler	walk in freezer	fridge	freezer
stove	convection oven	grill	griddle
wok	vent hood	salad bar	ice cream machine
milk shake machine	slicer	other	

Describe how you clean and sanitize the equipment noted above: ______________________

____

____

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Chapter 6

PLANNING OF CLEANING AND DISINFECTION IN THE FOOD INDUSTRY

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Chapter Objectives

- Describe the objectives and the structure of a Cleaning and Disinfection Plan
- Evaluate best practices and explain the content of cleaning procedures
- Provide useful hints for cleaning and disinfection in the food industry

CLEANING AND DISINFECTION: ACTIVITIES AND OBJECTIVES

Cleaning and disinfection are critical steps in food production, because they are essential to ensure food safety. In general, the process of cleaning and disinfection includes a series of planned activities that are specially designed to achieve specific objectives.

These activities can be rather expensive and therefore they tend to be considered a necessary evil. Instead, only if workers are aware of the importance of keeping food plants clean, it will be possible to achieve high standards of food safety in the manufacturing environment.

Consequently, the first step in the development of a cleaning strategy is formation of workers' motivation. In particular, it is crucial to communicate the following reasons for cleaning and disinfecting food production areas:

- Control microbial contamination.
- Avoid cross-contamination by chemicals and allergens.
- Reduce soil and increase the efficiency of disinfection.
- Increase safety for workers, by removing food wastes from floors and food pathogens from equipment.
- Remove undesired odours from the manufacturing environment.
- Boost added value in production, by decreasing food wastes.
- Improve worker satisfaction.

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A Cleaning and Disinfection Plan (CDP) usually involves the following five unit operations: pre-rinse, wash, post-cleaning rinse, disinfection, and final rinse. This basic structure can be applied to different cleaning operations, e.g. hands, Cleaning-In-Place (CIP), Cleaning-Out of-Place (COP), etc.

The effectiveness of a CDP depends on different factors, such as:

- Type of soil.
- Type of detergent.
- Type of disinfectant.
- Cleaning water chemistry.
- Cleaning water temperature.
- Exposure times.
- Frequency of cleaning and disinfection operations.

Broadly speaking, nonconformities in a CDP can depend on "common causes" or "special causes". Common causes are normal variations of process parameters within the assigned tolerance values, e.g. detergent amount or water temperature. Special causes refer to unstable processes, where out-of-tolerance conditions are not easily predictable, e.g. extraordinary high microbial counts or drain obstruction.

As a matter of fact, the success of a CDP relies on the possibility to revise plant design according to food safety objectives, and decrease the probability of out-of-tolerance conditions.

BEST PRACTICES IN CLEANING AND DISINFECTION

The development of a CDP is a complex activity that requires synergistic efforts of different professionals: quality system experts, microbiologists, engineers, production managers, suppliers, etc.

In particular, before structuring a CDP, the following issues should be addressed:

- Cleaning and disinfection must be part of good hygiene practices aimed at preventing rather than solving nonconformities.
- The CDP should include all processes in the whole manufacturing plant.
- Cleaning and disinfection operations need to be regular and effective.
- The choice of detergents and disinfectants, as well as the methods used, should be chosen according to the materials, the processes, and the products that are present in every section of the manufacturing plant.

The first step in the development of a CDP is the definition of the cleaning objective, that is the expected aim of the operation, e.g. cleaning or disinfection or sterilization.

Cleaning objectives can vary according to risk assessment data, but also depending on the level of safety required in a specific production environment, e.g. storage vs. clean rooms.

The cleaning objective should also consider the intended use of the finished product, e.g. ready-to heat foods vs. ready-to-eat foods.

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Moreover, each cleaning objective shall be linked to the other elements of the CDP to achieve food safety objectives.

The second step in the construction of a CDP is the elaboration of the procedures that will be applied to achieve the desired cleaning objectives. For every unit operation of the cleaning process, e.g. pre-rinse or final rinse, the procedure shall describe all necessary operations. At the same time, all the operations performed for cleaning and disinfection shall be described by the CDP (Say What You Do & Do What You Say).

Each procedure shall contain the following elements:

- Purpose.
- Scope (Application).
- Revision history.
- Related documents.
- Instructions.
- Verification and records.
- Corrective actions.

In the section on instructions, the following information should be included:

- Products needed.
- Tools needed.
- Frequency of cleaning.
- Preparation for the task (e.g. Review product labels, etc).
- Special directions for the task (e.g. Personal protective equipment, etc).
- Application method.
- Detailed instructions for all operations.
- Product concentration.
- Water temperature.
- Exposure time.
- Chemicals management and safety procedures.

Finally, the third step in the CDP process is the validation of the plan. Validation should provide objective evidence that cleaning and disinfection procedures conform to cleaning objectives, quality requirements, and legal constraints. Validation will be discussed in the following chapter.

PRACTICAL HINTS

The staff involved in the elaboration of the CDP can take advantage of crucial information that is closely related to the choice of the optimal chemicals and the management of the cleaning process.

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First of all, it is very useful to list all the construction materials in each section of the manufacturing plant, including windows, doors, equipment, and conveyor belts. In fact, not all materials are compatible with all detergents and disinfectants: some plastic materials, light metals, rubber, and teflon cutting boards can be damaged by unsuitable chemicals (e.g. concentrated acids for light metals, iodine for teflon and rubber, etc.).

Second, it is very important to evaluate if cleaning and disinfection operations will be carried out by specialized external staff or by internal workers. In the latter case, continuous training and internal audits will be part of the CDP.

Third, special sections of the CDP will be dedicated to production areas with extraordinary cleaning requirements, e.g. equipment with CIP systems, clean rooms, etc.

Fourth, detergents and disinfectants will be chosen after careful evaluation of the technical documentation and the material safety data sheets.

Finally, during the elaboration of cleaning strategies, it should be taken into account that general rules on cleaning and disinfection can have exceptions. In general, increases in water temperature and product concentration boost the effectiveness of cleaning and disinfection. However, some disinfectants (e.g. peracetic acid) become unstable at high temperatures, while pure ethanol is not a good disinfectant because protein denaturation requires water.

By and large, the development of a CDP is a difficult task that is crucial for both food safety and production costs. All workers should always keep in mind that failures in cleaning and disinfection can cause life-threatening diseases and jeopardize the future of their company.

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Chapter 7

EVALUATING THE EFFECTIVENESS OF CLEANING AND DISINFECTION

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Chapter Objectives

- Define the objectives of cleaning validation
- Describe the methods used for validation studies
- List the documents needed
- Explain the sampling methods used

VALIDATION OF CLEANING PROCESSES: OBJECTIVES

The process of cleaning and disinfection is based on a set of assumptions that need to be verified and validated periodically, to show that they are suitable and significant to establish the set points of the process.

In fact, an effective Cleaning and Disinfection Plan (CDP) should obtain predictable results, providing objective evidence that the process steadily conforms to requirements. Therefore, the first objective of validation is to demonstrate that the cleaning process is steady and under control.

Another goal of validation is the critical analysis of the methods and materials chosen in the CDP. Actually, every production process, including cleaning and disinfection, involves common causes and special causes of variation, analyzed in the previous chapter. For this reason, it is of paramount importance to verify that the cleaning process is able to prevent nonconformities in real manufacturing conditions.

Finally, validation also intends to assess the trends of food safety data. As a matter of fact, the data gathered in cleaning validation ought to be compared with other information obtained on food safety (e.g. nonconformities, audits, HACCP data, customer complaints, etc.) to ascertain the impact of the CDP on the company investments for food safety.

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METHODS FOR VALIDATION

Validation of cleaning processes requires two separate steps

- Data collection.
- Statistical analysis.

Typically, the majority of data used for validation are results of microbiological analyses. Depending on the cleaning objective, different microorganisms can be used as targets.

For instance, during the washing step in the dairy industry, preventing biofilm formation is a fundamental cleaning objective, and therefore the validation process should verify that biofilm formation is not taking place and will not occur. In this case, *Pseudomonas* spp. (Rossi et al. 2017) or *Pseudomonas fluorescens* group (Rossi et al. 2016) can be suitable targets.

On the other hand, inactivation of pathogens is a critical step in disinfection, which has to be verified. In this respect, *Salmonella* spp. and *Escherichia coli* (or EHEC, Enterohemorrhagic *E. coli*) are frequently used in scientific literature on disinfectants validation (Laury et al. 2009).

However, physical and chemical data can also be interesting for validation of cleaning and disinfection. In general, not only are some antimicrobials able to exert microbiostatic or microbiocide effects, but they can also stabilize physical or chemical characteristics, when they are used for microbial decontamination of foods. For example, chitosan was able to stabilize pH of modified atmosphere packaged pork at 4°C up to day 13, when used as an antimicrobial for surface treatments (Paparella et al. 2016).

Moreover, it has been suggested that allergens should also be included in cleaning validation (Jackson et al. 2008), because allergen removal through cleaning is considered one of the critical control points for effective allergen control in the food industry.

As far as statistical analysis is concerned, a wide range of statistical tools can be used (Keener et al. 2005): control charts, capability studies, sampling plans, experimental design, failure mode and effect analysis. Among these, control charts and sampling plans are commonly used in the food industry, while experimental design is more frequently applied in scientific literature (Khwanmuang et al. 2017).

To perform statistical analysis, it is essential to keep good quality records for all the operations included in the CDP. In detail, cleaning records should contain all the data that confirm that the objectives of the process were obtained. For instance, when the cleaning procedure states specific time and temperature conditions, the records will consider both time and temperature. Moreover, if a maximum residual level is established for a disinfectant, it will be necessary to collect records that give objective evidence of this condition.

In addition to daily records, cleaning documentation should include information on the history of the CDP. In particular, it should contain data regarding risk assessment, changes in the staff involved, changes in materials and methods, and modifications in the characteristics of both process and product.

In the quality audits on the cleaning process, one of the weak points is often the documentation of the changes in the CDP. For quality auditors, it is undoubtedly important to analyse records providing objective evidence that all changes in the CDP were made on a scientific basis.

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VALIDATION IN THE CLEANING PROCEDURES

As a general rule, all the materials and methods used to validate a CDP shall be included in the cleaning procedures.

FDA (2014) listed the following procedures (SOPs, Standard Operating Procedures) that are considered necessary for cleaning validation in the pharmaceutical industry:

- General procedures on cleaning validation that should indicate who is responsible for performing and approving validation, the acceptance criteria, and the revalidation times.
- Written validation protocols for specific studies to be performed on equipment or manufacturing systems, including sampling procedures, analytical methods and their sensitivity.
- Records providing objective evidence that validation was actually performed according to general procedures and validation protocols.
- A final validation report, approved by management, which states the validity of the cleaning process and indicate that residues have been decreased to an acceptable level.

In the cleaning procedures, validation should have an impact on the related processes of the quality management system. Evidently, nonconformities in validation do not remain confined in the specific production area or equipment but they can extend to the whole manufacturing process and generate serious damage in the HACCP system, e.g. invalidating critical limits and/or requiring corrective actions.

SAMPLING IN CLEANING VALIDATION

As previously stated, most of the testing performed in validation consists of microbiological analyses. We have already discussed about the microbial targets that can be used for validation, which can be microbiota, food spoilage organisms or pathogens, depending on the cleaning objective.

Here we will provide information on the sampling methods that can be different according to both cleaning objectives and company organization. Independently from the method chosen, the final goal of sampling and validation should be to demonstrate that the cleaning process consistently works as expected and produces results that consistently fulfil the assigned specifications.

In general, three methods of sampling can be applied for the microbiological validation of the CDP

- Surface sampling of defined sampling areas, where the result is expressed as Log CFU/cm^2.
- Rinse sampling, where a larger surface area can be analysed, with results expressed as Log CFU/mL.
- Indirect sampling, e.g. conductivity and bioluminescence, which can be useful for routine testing after validation of the cleaning process.

A wide range of tools and materials is available for microbiological testing in validation studies. Ismail et al. (2013) classified these methods into two categories:

- Non-destructive recovery methods, and namely swabbing methods, scrubbing methods, and printing methods;
- Destructive recovery methods that are rinsing and immersion methods, sonication, scraping and grinding procedures.

Details on materials and methods can be obtained from Ismail et al. (2013) for sampling methods and Griffith (2016) for indirect methods.

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Chapter 8

EXAMPLES OF SANITATION IN FOOD INDUSTRY

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Chapter Objectives

Describe the methods used for disinfecting clean rooms in the food industry

SANITATION OF CLEAN ROOMS IN THE FOOD INDUSTRY

Clean rooms are confined environments, appropriately controlled, where perishable materials are produced and packed to provide protection from fine atmospheric mass concentrations (particulate matter below 2.5 µm, PM 2.5) (Dockery et al. 1993).

Originally used in the computer and pharmaceutical industries, clean rooms are increasingly common in the food industry, in particular for extended shelf-life (ESL) fresh foods, such as sliced meat products, fresh cheese, ice cream, and bakery, often packed under modified atmosphere. Foods are usually packed inside the clean rooms under special hygiene requirements, such as air filtration, overpressure, and extraordinary cleaning procedures.

Despite the diffusion of clean rooms in the food industry, scarce information is available on the microorganisms that can be isolated from these confined environments. The first documented studies on clean rooms in space missions (La Duc et al. 2009) were focused on contaminants that might endanger extra-terrestrial life detection experiments. Sandle (2011) reviewed over 9000 isolates from different grades of cleanrooms in the pharmaceutical industry, mainly composed of microorganisms associated with human skin (Gram positive cocci) but also coming from the environment (Gram positive rods) and water (Gram negative rods).

In the food industry, where clean rooms host packaging machines and other equipment (e.g. Slicing machines, Graders, etc.), the clean room environment should also contain microorganisms associated with foods.

In a clean room in the food industry, the following key issues ought to be addressed in the cleaning procedures:

- Cleaning and disinfection of walls, floors, and ceilings.
- Cleaning and disinfection of food contact surfaces.
- Surface decontamination of food products before and after the removal of packaging.

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In all cases, validation and rotation of disinfectants is performed and compared with the results obtained from routine microbiological testing.

Particular attention has to be paid to disinfection of food contact surfaces, where high-level disinfectants are used. In this connection, new products and technologies for disinfection are derived from the hospital environment (Boyce 2016), such as new hydrogen peroxide disinfectants, peracetic acid-hydrogen peroxide combinations, cold atmospheric pressure plasma, electrolysed water, and polymeric guanidine.

For decontamination of food products inside the cleaning rooms, two major problems have to be considered

- Disinfection takes place during production, while workers are inside the clean room.
- Surface decontamination shall meet the requirements established by hygiene regulations.

Consequently, in most of the cases, decontamination is performed on the external side of the packaging, by using hydrogen peroxide based disinfectants or peracetic acid. Then, packaging is drawn away from the clean room immediately after its removal from foods. However, the food surface can still be contaminated by microorganisms that may spread inside the clean room, and for this reason it would be advisable to decontaminate food surfaces also after the removal of packaging.

Most of antimicrobials cannot be legally applied to food surfaces, because food decontamination is allowed only at certain conditions, e.g. in The European Union (EU), lactic acid for decontamination of beef carcasses.

In some countries, specific antimicrobials cannot be used as additives but they can be applied to food surfaces provided that they are considered a processing aid. According to EU Regulation 1333/2008 on food additives, the term "processing aid" defines any substance that:

- Is not consumed as a food by itself.
- Is intentionally used in the processing of raw materials, foods or their ingredients, to fulfil a certain technological purpose during treatment or processing and.
- May result in the unintentional but technically unavoidable presence in the final product of residues of the substance or its derivatives provided they do not present any health risk and do not have any technological effect on the final product.

On this basis, Italy and Spain recently allowed a hydrogen peroxide based disinfectant (Aquative 3S) for surface treatment of cephalopods. This may open up new perspectives for the application of antimicrobials on the surface of food products inside the clean room, to reduce microbial risks.

In this regard, Paparella et al. (2006) proposed the application of essential oils as antimicrobials for surface decontamination in clean rooms. In fact, volatility of essential oils is a significant advantage in clean rooms, where any residue should be carefully avoided. Moreover, the antimicrobial activity could be enhanced with increasing vapour pressure.

In the future, the application of novel materials and innovative technologies (e.g. nanomaterials, nanofluid flow, active packaging, etc.) will contribute to improve control of microbial risks in the clean room environment.

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Keywords (Index)

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-F-

Food and Drug Administration

-G-

Good Hygiene Practices

Good Manufacturing Practice

-H-

Hazard Analysis and Critical Control Points

-M-

Material Safety Data Sheets

-N-

Nitrilotriacetic Acid

-O-

Occupational Safety and Health Agency

-P-

Peroxyacetic Acid

Polymerase Chain Reaction

Negative logarithm of the hydrogen ion concentration

Parts Per Million

Prerequisite Programs

-Q-

Quaternary Ammonium Compounds

-S-

Sanitation Standard Operating Procedures

-X-

Halogen

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Glossary

Acid: A substance with a pH of less than 7.0.

Acids, strong: Substances that release high concentrations of hydrogen ions in a solution giving a low pH; examples are muriatic and sulfuric acids.

Acids, weak: Substances with a moderately low pH; examples are organic acids, such as acetic and hydroxyacetic acids.

Alkali: A substance with a pH of more than 7.0.

Alkalies, strong: Substances that release high concentrations of hydroxyl ions in a solution giving a high pH; examples are sodium hydroxide and potassium hydroxide.

Alkalies, weak: Substances that release moderate to low concentrations of hydroxyl ions in a solution giving a moderately high

pH; examples are sodium bicarbonate and sodium tetraphosphate.

Allergen: A substance that causes the human immune system to trigger and work against itself.

Antimicrobial: A substance that prevents the proliferation of microorganisms.

Antiseptic: A chemical substance used to interfere with or inhibit the growth of certain microorganisms.

Bacteria: Single-celled microorganisms that decompose matter, resulting in product spoilage and/or foodborne illness.

Bactericide: A chemical substance that will kill certain bacterial cells.

Bacteriostat: An agent that inhibits the growth of bacteria but does not necessarily kill them.

Biofilms: A microbial consortium adhering to a surface, frequently but not in every case embedded in extra-cellular polymeric substances.

Buffer: A material that moderates the intensity of an acid or alkali in solution without reducing the quantity of acidity or alkalinity.

Celsius: Temperature scale related to the Fahrenheit scale by the formula 5/9 (°Fahrenheit - 32°) = °Celsius (centigrade).

CIP (cleaning-in-place): Automated wet cleaning system of a line and/or individual equipment in a closed circuit without dismantling. CIP efficiency depends on 5T's : time, temperature, titration, turbulence and technology. CIP can be done in a dry area, the aim being that the design precludes any water passing into the environment.

Clean: Free of visible soil.

Cleaning: The physical removal of soil from a surface.

Cleanroom: Room in which the concentration of airborne particles is controlled, and which is constructed and used in a manner to minimize the introduction, generation, and retention of particles inside the room, and in which other relevant parameters e.g. temperature, humidity, and pressure, are controlled as necessary.

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Contaminant: Any biological or chemical agent, foreign matter or other substance not intentionally added to food, which may compromise food safety or suitability.

Contaminate: To add foreign and unwanted matter to an object or environment.

Control point: Any step or procedure by which biological, physical, or chemical factors can be controlled.

COP (cleaning-out-of-place): Manual cleaning of dismantled equipment. The main part of the installation may remain fixed in a position but parts may be removed to another point for cleaning. (see also Wet cleaning)

Critical control point: A step or procedure at which control can be applied and a food safety hazard prevented, eliminated, or reduced to an acceptable level.

Cross-contamination: The transfer of microorganisms from one food to another through a nonfood surface, such as equipment, utensils, or human hands.

Dispersion: Deflocculation: The action of breaking up aggregates into individual parts.

Detergent: A chemical cleanser similar to soaps but of a different chemical nature.

Disinfect: To remove potentially pathogenic microorganisms from an object or from the environment.

Disinfectant: A chemical used to destroy the growing forms but not necessarily the spores, of potentially pathogenic microorganisms.

Disinfection: The reduction, by means of chemical agents and/or physical methods, of the number of micro-organisms, but not usually bacterial spores, in the environment, to a level that does not compromise food safety or suitability.

Dry cleaning: Cleaning which does not involve any use of water, a technique which can be used as a preventive measure to reduce risks of microbial development in equipment and in the environment. It also reduces risk of contamination with e.g. residues of aged or modified product. Mostly done manually using brushes and/or vacuum cleaners.

Food hygiene: All conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain.

Food safety: Assurance that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use

Hazard: A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect.

Germicide: A chemical that kills certain microbial cells.

Hazard analysis: The process of collecting and evaluating information on hazards and conditions leading to their presence to decide which are significant for food safety and therefore should be addressed in the HACCP plan. Hazard analysis is a crucial step in the implementation of an HACCP plan. Must not be confused with risk analysis.

Host: A plant or animal harbouring another as a parasite or as an infectious agent.

Hygiene: Practices necessary for establishing and maintaining good health.

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Manual cleaning: Removal of soil when the equipment is partially or totally disassembled.

Mechanical cleaning: Shall denote cleaning, solely by circulation and/or flowing chemical detergent solutions and water rinses onto and over the surfaces to be cleaned, by mechanical means.

Membrane: A thin, flexible sheet of material forming a porous partition which may allow the slow transfer of a liquid through it, such as cell-wall of a micro-organism.

Microbes: Microbes are a large group of life forms which can only be seen with the aid of a microscope. Microbes are subdivided into bacteria, fungi (which includes moulds and yeasts) and viruses

Micro organisms (pathogenic): Micro-organisms that can cause disease/illness in humans and animals. Distinguish from indicator micro-organisms, whose presence indicate a failure of a GHP. The number present is assumed to be related to the probability of contamination of a product with a pathogen.

Monitoring: The act of conducting a planned sequence of observations or measurements of control parameters to assess whether a CCP is under control.

Nonionic: Lacking an electrical charge through a balance of negatively and positively charged compounds.

Pathogen: A microorganism capable of producing disease when it enters the human or animal body.

pH: A logarithmic measurement on a scale from 0 to 14, of acidity and alkalinity due to hydrogen and hydroxyl ion concentration.

Pollution: The accumulation of foreign, unwanted matter that becomes a nuisance or a danger to the health of the environment.

Potable: Suitable or safe for drinking.

Precipitate: A deposit of an insoluble substance resulting from chemical or physical changes in a solution.

Risk: A function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard(s) in food. Risk is 'the potential for the occurrence of unacceptable food safety deviations' but may be extended to cover quality deviations. In Codex terminology 'risk' pertains to public health issues. It relates to safety and not to quality related matters.

Risk Assessment: Risk assessment is the scientific part of the risk analysis process in which the hazards and risk factors are identified and the risk is calculated.

Sanitary: Free of disease-causing microorganisms and other harmful substances.

Sanitation: The creation and maintenance of conditions favorable to good health.

Sanitize: Treatment by heat or chemicals to reduce the number of microorganisms present.

Soap: A compound of fatty acids and alkalies that has cleaning properties.

Soil: Any remaining, undesirable material in the equipment or process environment. It may or may not contain micro-organisms.

Solutions: Water and/or those homogeneous mixtures of cleaning agents and/or disinfectants and water used for flushing, cleaning, rinsing and disinfection

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Spoilage: Food spoilage is the process where food fit for human consumption becomes unfit due to changes brought about either by microbes, pests or chemicals within the food. Microbes and pests can spoil food rapidly whilst chemical changes within food usually take a lot longer

Spore: An inactive, resistant, resting, or reproductive body that can produce another vegetative individual under favorable conditions.

Sterilization: A process aimed at removing or killing all forms of micro-organisms, including bacterial spores from food or equipment.

Validation: Validation, in general, intends to establish documented evidence, that a specific process will consistently meet its predetermined objectives. More specifically, validation indicates obtaining evidence that the food hygiene control measures selected to control a specific hazard(s) in a specific food(s) are capable of controlling a defined hazard to the level specified.

Verification: The application of methods, procedures, tests and other evaluations, in addition to monitoring to determine compliance with for example a HACCP plan.

Wet cleaning: Can refer to cleaning of processing equipment or environment. The main aim of wet cleaning is to remove soil that may or may not contain micro-organisms.

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Abbreviations

ATMP: Amino Trimethylene Phosphonic Acid
ATP: Adenosine Triphosphate
C: Contact time
CDP: Cleaning and Disinfection Plan
CFU: Colony-forming unit
CIP: Clean in Place
COP: Clean Out of Place
CP: Control Point
DBP: Disinfection by products
DNA: Deoxyribonucleic acid
EC: European commission
EDTA: Ethylenediaminetetraacetic acid
EFSA: European Food Safety Authority
EHEC: Escherichia coli
ELISA: Enzyme Linked Immunosorbent Assay
ESL: extended shelf life
EU: European Union
FDA: Food and Drug Administration
GHP: Good Hygiene Practices
GMP: Good Manufacturing Practice
HACCP: Hazard Analysis and Critical Control Points
MSDS: Material Safety Data Sheets
NTA: Nitrilotriacetic acid
OSHA: Occupational Safety and Health Agency
PAA: Peroxyacetic acid
PCR: Polymerase Chain Reaction
pH: Negative logarithm of the hydrogen ion concentration
ppm: parts per million
PRP: Prerequisite Programs
QAC: Quaternary Ammonium Compounds
SSOP: Sanitation Standard Operating Procedures
X^-: Halogen

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