Section 1-2:
Control of Operation

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Section Overview

Effective food safety management requires an excellent understanding of food hazards, factors which control these hazards, and controlling operations in your food establishment in a manner that will minimize the risk of hazards in finished food products.

This section covers the requirements for effective control of your facility's operations. The following topics will be discussed:

- Control of Food Hazards
- Key Aspects of Food Hygiene Control Systems
- Incoming Material Requirements
- Packaging
- Water
- Management and Supervision
- Documentation and Records
- Recall Procedures

Learning Objectives

At the conclusion of this section, the learner will be able to:

- define a food safety hazard and list the major classes of hazards that are associated with food products,
- describe in general terms the approach to identifying and controlling food safety hazards in a specific food product,
- list and discuss common practices and technologies which can be used to effectively manage hazards in food products,
- list and discuss appropriate times and temperatures for preparing and holding foods to minimize the risk of foodborne illness,
- list and describe processes that can be used to control biological hazards such as microbial pathogens in food products,
- explain why it is important to prevent cross contamination in a food facility and describe methods to minimize the potential for cross contamination,
- understand the importance of incoming material requirements and describe the essential elements of a specification for incoming ingredients or raw materials,
- list characteristics of food packaging materials that are important for maintaining food safety,
- describe the requirements for water used in food facilities and as an ingredient in food or ice, and
- summarize requirements for management and supervision, documentation and records, and recall procedures.

Control of Food Hazards

As a food safety manager you must understand the nature of hazards that can be present in food and measures you can take to effectively control these hazards in food products.

The Codex General Principles of Food Hygiene defines a food hazard as **"a biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect."**

The major classes of food hazards that are present in food include:

- biological hazards such as pathogenic bacteria, parasites or viruses,
- chemical hazards such as naturally occurring toxins or residues from intentional or incidental food additives, and
- physical hazards such as metal, glass, wood or other unexpected foreign materials.

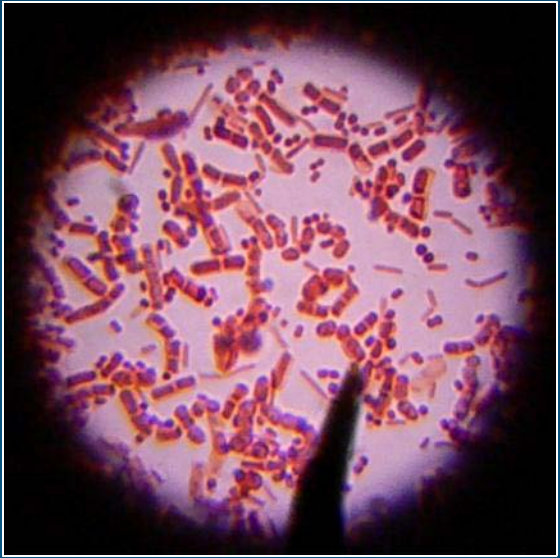
It is important to note that not all contaminants that might be present in food are necessarily hazardous. Factors which determine whether or not a contaminant is a significant hazard are 1) the severity of its health effects, and 2) the likelihood of its occurrence. These concepts will be discussed in greater detail in Module 3: Hazard Analysis and Critical Control Points.

Food Safety Systems

Food business operators should establish systems which are able to control food hazards in their products. These systems should be able to:

- identify any steps in their operations which are critical to the safety of food,
- Implement effective procedures to control food hazards at those critical steps,
- Monitor control procedures to ensure their continuing effectiveness, and
- review control procedures periodically, and whenever the operations change.

In the global food system, the most generally accepted system for managing food safety is the Hazard Analysis and Critical Control Points (HACCP) system.



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Key Aspects of Food Hygiene Control

There are numerous practices and technologies which can be used to effectively manage hazards in food products. The specific methods used in a particular setting will depend upon many factors including those specific to the food or its ingredients, the facility itself and processing steps used, and storage and distribution conditions, among other factors. This section will briefly discuss common methods to ensure effective food hygiene, including:

- time and temperature control
- specific processing steps
- microbiological and other food specifications, and
- prevention of cross contamination

Time and Temperature Control

Inadequate control of food temperature is a very common factor contributing to foodborne illnesses and also is permissive for quality defects such as food spoilage.

As appropriate, time and temperature controls should be in place for cooking, cooling, processing, storage and transportation of food products. Systems must be in place to ensure that temperature is controlled effectively when it is critical for ensuring food safety. Such systems should also specify tolerable limits for time and temperature variations.

Procedures for checking the accuracy of temperature recording devices must be established and followed where temperature is critical for food safety. Calibration procedures must be followed when routine checks of temperature measuring or recording devices indicate they are no longer accurate.

Graphic: International Association for Food Protection

Time and Temperature Control

Temperature control systems should also take into account a number of other factors. For instance:

- the nature of the food (e.g. water activity, pH, levels and types of microorganisms present),
- the intended shelf-life of the product,
- the methods used for processing and packaging the food, and
- how the food product is intended to be used (i.e. is the food ready to eat or does it require some type of further processing or cooking).

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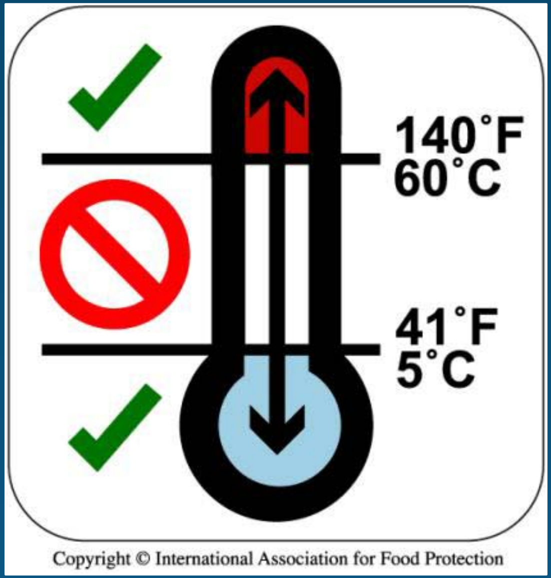
Food Hygiene Control

Time and Temperature Control

Pathogenic bacteria which are commonly associated with foodborne illness can proliferate quickly when they are present in foods held at temperatures favorable to their growth. The temperature range wherein these pathogens grow most quickly is often referred to as the temperature **"Danger Zone."** This Danger Zone is often considered to be 5-60° Celsius (41-140° Fahrenheit), although other temperature ranges are sometimes used.

When foods are held within the temperature Danger Zone, if other environmental conditions are favorable (e.g. nutrient sources, pH, water activity, etc.), bacteria have the potential to grow. Therefore, it is important to minimize the time that perishable food spends in this temperature range.



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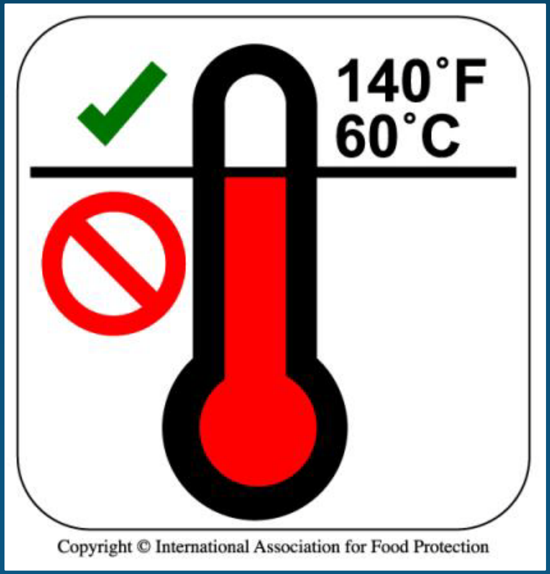
Food Hygiene Control

Hot Holding Temperature

Maintaining a high holding temperature for foods in service is an effective way to prevent the growth of bacteria. The most commonly recommended minimum hot holding temperature is 60° C (140° F), although some jurisdictions may allow other hot holding temperatures (e.g. a minimum of 135° F is allowed by the US Food and Drug Administration's 2009 Model Food Code).

Hot holding temperature should not be confused with appropriate temperatures for cooking or other thermal processing technologies. Cooking temperatures are determined based on a number of factors including the nature of the food, the nature of the microbial hazards being controlled, quality factors, and other variables. Usually, recommended safe cooking temperatures (internal temperatures in the food) will be higher than recommended hot holding temperatures.

It should also be noted that holding foods at hot temperatures for extended periods of time generally will result in decreased product quality.



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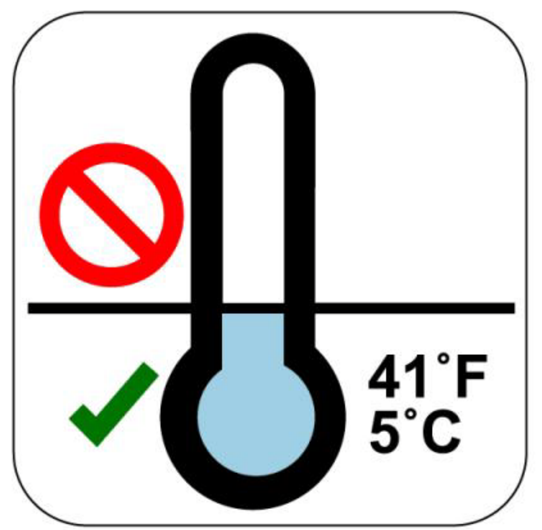
Cold Holding Temperature

Refrigeration of perishable foods is another effective way to prevent the growth of bacteria. The most commonly recommended refrigeration temperature is 5° C (41° F) or colder, although some jurisdictions may allow other refrigeration temperatures. Occasionally, recommended refrigeration temperatures are also product specific.

It is very important to understand that refrigeration does not completely stop the growth of bacteria. Some species of pathogenic bacteria such as *Listeria monocytogenes* and *Yersinia enterocolitica* are able to grow at refrigeration temperatures. Although neither of these pathogens grows very quickly at refrigeration temperatures, they may be able to proliferate to levels that can cause illness during refrigerated storage.

For this reason, it is essential that maximum time limits be followed for foods held in refrigerated storage. Storage times in refrigeration will depend upon a number of factors and should be determined based upon the characteristics of the food, packaging materials, post-processing handling practices, and other factors.



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Frozen Storage

Freezing of perishable foods effectively stops growth of bacteria. Common frozen storage temperatures are approximately -20° C (-4° F), although other temperatures may be used depending upon the type of food, quality considerations and other factors.

Freezing stops the growth of bacteria and, in fact, will kill significant numbers of bacteria. However, freezing is not a reliable way to quantitatively kill bacterial pathogens. Bacteria which survive freezing can readily resume growth once the foods have thawed and reached a temperature permissive for growth.

Maximum time limits should be established for foods held in frozen storage. These times generally will be based on quality considerations rather than food safety factors. This is particularly true for foods stored in permeable or semi-permeable packaging in "frost free" freezers, as storage in these units can result in significant dehydration and "freezer burn" of the food product.

Photo: Southern Foodways Alliance / Flickr

Specific Process Steps

Numerous food processing or handling procedures are used to control hazards such as microbial pathogens. These procedures control pathogens either by direct killing or inhibition of proliferation. Examples include:

- Chilling
- Thermal processing
- Irradiation
- Drying
- Chemical preservation
- Vacuum or modified atmosphere packaging

It should be noted that this list represents only some examples of the major food processing techniques. Processing steps may be used individually or in combination to control food hazards. The selection of appropriate process steps will depend upon a number of factors including product type, hazard profile and expected concentrations, packaging and handling practices, and other factors such as consumer preferences.

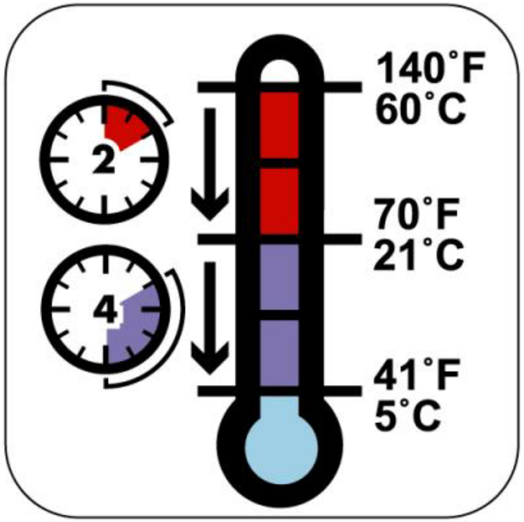
Chilling

As discussed earlier, refrigeration of perishable foods slows the growth of bacteria. Chilling processes often follow thermal processes, and must be designed to ensure that the food is cooled to a safe temperature within a specifically-allotted time.

The example on the right is taken from the US Food and Drug Administration's Model Food Code. In this example, cooling processes for foods must traverse parts of the temperature danger zone in defined periods of time. Cooling processes must traverse 60°C to 21°C within two hours, and then cool from 21°C to 5°C or cooler within an additional four hours.

There are two other important factors you must consider:

1. The critical temperature which must be monitored is the temperature of the food at its warmest point (usually the center), not the temperature of the cooling chamber itself.
2. Cooling processes slow as the food temperature approaches the temperature of the cooling chamber.



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Food Hygiene Control

Thermal Processing

Thermal processing in its various forms is the most common form of food processing used by the global food industry. Thermal processes can be conducted in batches (e.g. cooking in an oven or kettle) or may be continuous processes (e.g. high-temperature, short-time pasteurization).

Thermal processing kills vegetative bacterial cells and other microorganisms by denaturing proteins and other constituents, disrupting or destroying cell membranes, and other effects. It is important to note that bacterial spores can be very resistant to thermal processing, so certain types of thermal processing must take this resistance into account (e.g. canning of low acid foods).

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Food Hygiene Control

Types of Thermal Processing

There are several different general types of thermal processing. It is important to understand that microorganisms are destroyed by combinations of temperature and exposure time. High temperatures destroy microbes very quickly whereas lower temperatures take longer to achieve equivalent destruction of vegetative pathogens. Higher temperatures and times typically are used to produce shelf-stable foods.

Types of Thermal Processing (These time:temperature combinations are not equivalent.)

Type of Thermal Processing	Temperature Range	Approximate Time
Thermization	57-68°C (135-154°F)	15 minutes
Batch pasteurization, low temperature, long time (LTLT)	63°C (145°F)	30 minutes
Pasteurization, high tem-perature, short time (HTST)	72-74°C (135-154°F)	15-30 seconds
Ultra-high temperature (UHT) treatment	135-140°C (275-284°F)	3-5 seconds
In-container sterilization	115-120°C (239-248°F)	10-20 minutes

Other Common Processes

Acidification preserves food safety and quality by interfering with the growth of pathogenic microorganisms. For example, *Clostridium botulinum*, the bacteria which produces botulinum toxin, does not proliferate at pH values less than 4.6. Other microbial pathogens, such as certain strains of Salmonella and *Escherichia coli*, may survive in foods having pH values lower than 4.6 (e.g. in apple juices of pH 3.5), but these pathogens typically do not grow well at these low pH values.

Fermentation has been used for centuries to produce and/or preserve a wide variety of foods, including cheeses, yogurt, and certain meats, breads, cereals and vegetables. In essence, fermentation is a natural process whereby beneficial bacteria proliferate in a food matrix and produce acidic end-products (e.g. lactic acid) which inhibit the growth of pathogenic and spoilage organisms.

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Other Common Processes

Drying preserves food by reducing the water activity of the food and thereby prevents the growth of microbial pathogens. Dehydration of foods to a water activity (a_W) of less than 0.91 will inhibit the growth of most types of bacteria, although *Staphylococcus aureus* can tolerate a_W values down to 0.86. The growth of most molds is inhibited at a_W values less than 0.80, whereas no microbial growth will occur at a_W values less than 0.50. Besides dehydration, other ways to reduce the a_W value of a food include the addition of relatively large concentrations of salt or sugar.

Chemical Preservation is commonly used to control the growth of certain types of pathogenic microorganisms and spoilage organisms such as molds. Commonly used chemical preservatives in the food industry include sodium benzoate, potassium sorbate, calcium propionate, and various sulfiting agents such as sodium bisulfite. Sodium nitrite is commonly used to control the growth of *Clostridium botulinum* in fermented meat products. When used, food preservatives must comply with regulations on their appropriate concentrations and allowed uses in specific foods.

Other Common Processes

Irradiation technology has been safely used for decades to effectively kill microorganisms in several types of foods. In food irradiation, ionizing radiation is used to destroy microorganisms, bacteria, viruses, or insects that might be present. Further applications of irradiation include inhibition of sprouting and treatment to delay ripening. Despite its recognition as a safe and effective process for many years, irradiation is not commonly used in foods. In global commerce, irradiation is most commonly used to treat spices. Other common uses are for control of certain types of plant pests in tropical fruits. Regulations on food irradiation differ considerably among countries, so companies wishing to use this technology should carefully scrutinize regulatory requirements.

Vacuum or Modified Atmosphere Packaging is used to control the growth or microorganisms by reducing oxygen concentration. In modified atmosphere packaging, the reduced oxygen concentration is commonly offset by increased concentrations of other gases such as carbon dioxide. When using these technologies, one must be careful to evaluate the potential for proliferation and toxin production by organisms that proliferate in low-oxygen environments, such as *Clostridium botulinum*.

Microbial and other Specifications

Effective implementation of food safety management systems usually requires the establishment and monitoring of specifications for microbiological, chemical or physical parameters. When these specifications are used in any food system, they should:

- be based on sound scientific principles, and
- state, where appropriate, monitoring procedures, analytical methods and action limits.

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Food Hygiene Control

Prevention of Cross Contamination

Microbial pathogens can be transferred from one food to another, either by direct contact or by food handlers, contact surfaces or the air. Raw, unprocessed food must be effectively separated from ready-to-eat foods. This separation can either be physical (e.g. separate areas of a food production facility) or by time (with appropriate cleaning and disinfection practices followed between handling raw and ready-to-eat foods).

Personnel must practice appropriate behaviors in order to minimize the risk of cross contamination. These practices must include the use of effective hand hygiene (including glove use where indicated) and wearing clean outer garments including footwear. In sensitive areas, it may be necessary to control access of employees and take measures to ensure they are wearing clean protective clothing prior to entering the processing area.

Food contact surfaces, utensils, equipment, fixtures and fittings must be thoroughly cleaned and sanitized after raw food has been handled or processed. This is particularly true for meat and poultry processing operations.

Graphic: International Association for Food Protection

Food Hygiene Control

Prevention of Cross Contamination

Systems also must be in place to prevent contamination of foods with foreign materials such as glass or metal shards, dust, harmful fumes and unwanted chemicals. Suitable detection and screening devices should be used as appropriate to control physical hazards. In the case of chemical hazards, workers must ensure that the use of potentially hazardous chemicals in a food facility (e.g. disinfectants, lubricants, pesticides) is carefully controlled to ensure that contamination of raw materials or finished food products does not occur.

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In recent years, it has become increasingly apparent that food allergens can present a significant cross contamination risk in facilities that use potentially allergenic ingredients. Common food allergens include groundnuts (peanuts), tree nuts, eggs, milk, soy, wheat, fish and shellfish, although the specific list of food allergens usually differs from country to country. When processing allergen-containing and allergen-free foods in the same facility, using separate equipment, through cleaning, and appropriate sequencing of foods containing potential allergens are recommended control strategies.

Incoming Material Requirements

The quality and safety attributes of incoming food ingredients and raw materials can significantly influence the quality and safety of finished products. Steps must be taken to ensure that no ingredients or raw materials are accepted by the food establishment if it is a potential source of undesirable or unsafe contaminants which would not be reduced to an acceptable level by normal sorting and/or processing. Examples of potential contaminants that might be scrutinized in incoming materials include:

- parasites,
- undesirable microorganisms,
- pesticides,
- veterinary drugs, or
- toxic, decomposed or extraneous substances.

Where appropriate, specifications for raw materials and food ingredients should be developed and applied.

Specifications

A **specification** is a document that explicitly states essential technical attributes or requirements for a product and procedures to determine that the product's performance meets its requirements or attributes.

In this case, “product” in the above definition refers to incoming ingredients or raw materials.

Clear specifications are important because they:

- represent a contractual agreement between you and your suppliers (or your customers when the specifications refer to finished products),
- confirm that the parties have a clear understanding about the ingredient or product requirements, and
- provide legal protection in the event of a nonconformity or other disagreement.

Specifications

At a minimum, written product specifications should include the following elements.

- General product information – name of product, size of product
- General supplier information – name of company, production site details, date of specification issue and other information
- Food safety legal requirements for country of production – compositional, process, microbiological and quantity
- Food safety legal requirements for the country of sale – compositional, process, microbiological and quantity
- Quality standards/attributes

Special care should be taken to ensure that the written specifications comply with the legal requirements of the countries of production and sale (if different) of the ingredients.

It is relatively common for specifications written by a company to exceed strict legal requirements.

Incoming Material Requirements

Inspection and Testing

Raw materials or ingredients should, where appropriate, be inspected and sorted before use. Only sound, suitable raw materials or ingredients should be used by the facility.

Where necessary, laboratory tests should be conducted to ensure that the ingredients comply with the written specifications. When testing is conducted, a sampling program should be established to ensure that samples are representative of the received materials.

In the global food industry, it is relatively common for suppliers to provide documentation indicating that an ingredient is in compliance with the written specification. It also is common for this documentation to include a “Certificate of Analysis” or other written confirmation that the ingredient passed any required laboratory tests. When such an approach is used, it is prudent for the company receiving the product to conduct confirmatory testing to ensure the product meets the specifications.

Stocks of raw materials and ingredients should be subject to effective stock rotation. The industry standard for stock rotation is first in / first out.

Photo: U.S. Army Environmental Command / Flickr

Packaging

It is important to note that food packaging materials are often in intimate contact with the food product and could constitute a source of contamination if not manufactured appropriately using safe materials that are approved for food contact. Packaging materials or gases where used must be non-toxic and not pose a threat to the safety and suitability of food under the specified conditions of storage and use.

Packaging design and materials should provide adequate protection for products to minimize contamination, prevent damage, and accommodate proper labeling.

Where appropriate, reusable packaging should be suitably durable and easy to clean and disinfect.

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Water

The safety of water used in food processing operations is of critical importance. Contaminated water is a major global source of gastrointestinal and other illnesses.

Water derived from surface water sources or improperly constructed or improperly sealed wells is at high risk for contamination with microbial pathogens which can cause human illness. If pathogen-contaminated water is used in a food processing establishment, either as an ingredient or for other uses such as cleaning operations, the potential exists for these pathogens to contaminate and proliferate in food products.

Chemical contaminants in water sources also can be a significant public health concern. Two examples of contaminants that frequently contaminate ground water sources are nitrate and arsenic.

Photo: Public Domain

Water in Contact with Food

Potable water should be as specified in the latest edition of WHO Guidelines for Drinking Water Quality, or water of a higher standard.

Only potable water should be used in food handling and processing, with the following exceptions:

- for steam production, fire control and other similar purposes not connected with food; and
- in certain food processes, e.g. chilling, and in food handling areas, provided this does not constitute a hazard to the safety and suitability of food (e.g. the use of clean sea water).

Water recirculated for reuse should be treated and maintained in such a condition that no risk to the safety and suitability of food results from its use. The treatment process should be effectively monitored. Recirculated water which has received no further treatment and water recovered from processing of food by evaporation or drying may be used, provided its use does not constitute a risk to the safety and suitability of food.

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Water

Water as an Ingredient or for Making Ice and Steam

To avoid food contamination, water used as an ingredient should be potable as defined by WHO Guidelines for Drinking Water Quality or of higher quality.

Ice used in contact with food or as an ingredient should be made from potable water. Care should be taken to ensure that equipment used for manufacturing ice does not represent a source of contamination.

Steam used in direct contact with food or food contact surfaces should not constitute a threat to the safety and suitability of food. Ice and steam should be produced, handled and stored to protect them from contamination.

Photo: Leslie Bourquin

Management and Supervision

The type of control and supervision needed in a food operation will depend on the size of the business, the nature of its activities and the types of food involved. Small, family-owned facilities may have only one manager who is responsible for all operations. Larger companies typically will have several managers and supervisors with varying degrees of responsibility.

Managers and supervisors should have enough knowledge of food hygiene principles and practices to be able to judge potential risks, take appropriate preventive and corrective action, and ensure that effective monitoring and supervision takes place.

Photo: Public Domain

Documentation and Records

Appropriate documentation and routine record-keeping are necessary to demonstrate effective implementation of food safety systems. This documentation can enhance the credibility and effectiveness of the food safety control system, and serves as evidence that correct practices have been followed.

Where necessary, appropriate records of processing, production and distribution should be kept and retained for a period that exceeds the shelf-life of the product.

Additional information on record keeping will be presented in Module 3 – HACCP systems.

Photo: Public Domain

Recall Procedures

Procedures must be established to ensure that products can be effectively withdrawn from the market in the event of a food safety incident which requires a product recall.

Managers should ensure effective procedures are in place to deal with any food safety hazard and to enable the complete, rapid recall of any implicated lot of the finished food from the market.

Where a product has been withdrawn because of an immediate health hazard, other products which are produced under similar conditions, and which may present a similar hazard to public health, should be evaluated for safety and may need to be withdrawn. The need for public warnings should be considered.

Recalled products should be held under supervision until they are destroyed, used for purposes other than human consumption, determined to be safe for human consumption, or reprocessed in a manner to ensure their safety.

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