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Food Safety and Traditional Food Processing Technologies Training Material

"ENHANCING SOCIAL INCLUSION OF YOUTH THROUGH EMPLOYMENT IN AGRI-FOOD SECTOR"

AGRI FOOD PROJECT

Project Number:
2019-3-TR01-KA205-079155

2021

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CONTENTS

5.1 INTRODUCING FOOD TECHNOLOGY

Food Technology is a creative and technical issue and an essential life skill. Some food technologies were used thousands of years ago. In this Output students will be introduced to a range of concepts (microbiology, cross contamination, spores, risky groups, traceability, etc.), traditional and new technologies, etc., that will provide them with the basic knowledge and skills they will need if they want to start working in a food industry.

Food Technology is a good opportunity to find a job to make sure food products are produced safely, legally and to the requested quality. Food Technologists will be involved in developing manufacturing processes and recipes of food and drink products and may work on traditional or innovative ingredients, containers, or technologies to launch to the market new recipes and food concepts. Food industries must safeguard public health and provide to consumers food that is safe, unadulterated, and honestly presented.

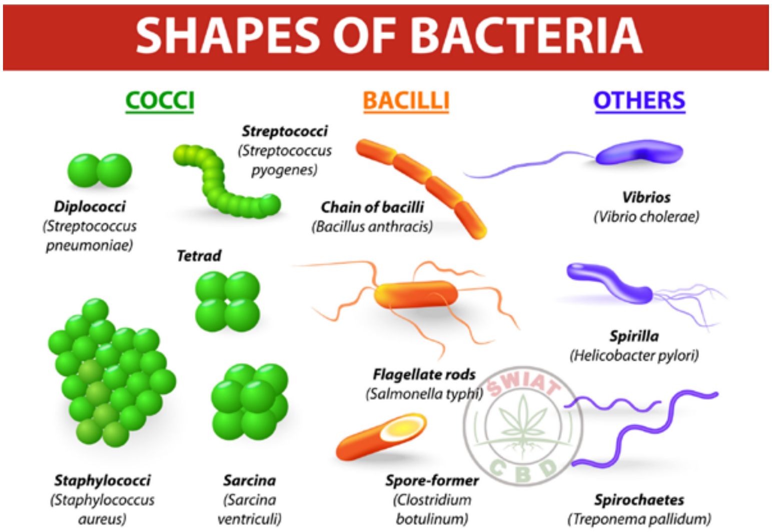
5.2 UNDERSTANDING MICROORGANISMS IN FOOD. TYPES OF BACTERIA

What are microorganisms?

Microorganisms are very tiny living organisms which cannot be seen with the naked eye, only with a microscope. A microscope is necessary to study microorganisms. It is an instrument with a set of lenses which amplify the image many times up to 1000x in the case of an optical microscope. Microbiology is the science that studies microorganisms

Types of microorganisms.

A bacterium is a very simple organism constituted by one single cell. A million of grouped bacteria would only cover the head of a pin. Some bacteria, in adverse conditions, can form very resistant structures called spores. When spores find good conditions, they transform into an active bacterium again. Bacteria found in food may have different shapes and different forms.



Viruses are even smaller than bacteria. Viruses are "obligate parasites" which means that they can only multiply inside a living organism called host. Viruses that cause food related diseases, can only multiply inside the cells of the human body. Someone infected with this type of virus, can contaminate food when handling it.

Although many **parasites** can be seen with the naked eye, during their life cycle they have larvae stages which are much smaller. Therefore, these organisms are studied within the scope of Microbiology. Parasites usually cause diseases.

The fungi are bigger than bacteria and can be **moulds** and **yeasts** and even mushrooms. Moulds usually spoil food. Some moulds are dangerous as they produce chemical substances that can cause illnesses. Some yeasts help in the production of some foods, but other yeasts can spoil food.

Where can microorganisms be found?

Microorganisms are present in the environment – in the air, in the water and in the soil – as well as in human beings and animals as well as in surfaces, tools and food:

- Animals: Microorganisms are present on the feathers, in the hair, on the skin and in the intestinal tract of animals.
- Soil/air/water: There are microorganisms naturally present in soil, and some which come from animal faeces and other waste. Microorganisms can be carried in the air and spread to other places. When pathogenic microorganisms are found in water it is not suitable for consumption without treatment, for example with chlorine.

- Humans: When a person speaks, coughs, sneezes, eats, or smokes, microorganisms are liberated with very tiny bubbles of saliva. This happens because microorganisms are present in a person's nose, throat, skin cuts and on unwashed hands.
- Surfaces / Kitchen Tools: Microorganisms can remain on kitchen tools like knives, forks, and spoons as well as on tables, countertops and kitchen sinks if, these items and surfaces are not properly cleaned.
- Food: Below you will learn that microorganisms need almost the same nutrients as man, that is why they can be found in our food.

Microbial food contamination.

Food contamination is a general term related with health problems arising from eating contaminated food. Food may be contaminated by microorganisms (bacteria, viruses, some parasites, and fungi and their products) or toxins present within the food itself (like in the poisoning mushrooms or shellfish). Other non-microbiological contaminants will be explained in point 5.3.

Also, bad handling practices, specially at home can contaminate food. For example, food prepared on unwashed surfaces that previously were in contact with raw meat, fish, poultry, sea food or eggs can become contaminated. This is called cross-contamination.

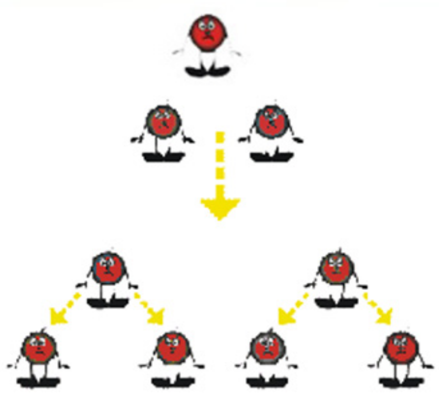
Strict controls should be considered to avoid contamination along the food chain:

At farm: Vegetables that are eaten raw, such as lettuce, may be contaminated by bacteria in soil, water, and dust. Raw meat can carry many foodborne bacterial diseases. Fresh eggs may be contaminated.

At factory: The contamination risk is minimum because of good hygiene and good manufacturer practices that are compulsory to be implemented. If there are some accidental contamination, food is eliminated.

At home: Cooked food can also be contaminated after cooking by bacteria carried by food handlers or from bacteria in the environment. However, properly cooked food can become re-contaminated if it meets plates, cutting boards, countertops, or utensils that were used with raw meat and not washed and cleaned.

These food contaminations in normal conditions are eliminated along the food chain, mainly by proper processing at food factory and using good handling and hygiene practices at home.



What are spores? Some groups of bacteria produce structures called endospores when environmental conditions are adverse. These spores are a dormant stage in the bacterial life cycle. This allows the bacterium to survive until conditions improve. Endospores have thick cell walls that enable them to survive to extreme temperatures, lack of nutrients or water, etc. The spores can remain sleeping for very long periods of time; some of them can survive for years. When conditions improve, the spores germinate into active bacteria again. Because endospores are so resistant, it is often difficult to remove them from foods through ordinary heating procedures.

The most important spore in food technology is the spore from Clostridium Botulinum. It can withstand extremely harsh conditions—including boiling water and exposure to many chemical disinfectants—over long periods of time. But under certain conditions, these spores can grow and make one of the most lethal toxins known that causes the botulism disease with potentially fatal consequences. The main conditions in which the spores can grow and make toxin are:

- Low-oxygen or no oxygen (anaerobic) environment
- Low acidity
- Low sugar content
- Low salt content

Botulism is a rare but serious illness that attacks the body's nerves. Symptoms of botulism usually start with weakness of the muscles that control the eyes, face, mouth, and throat. This weakness may spread to the neck, arms, torso, and legs. Botulism also can weaken the muscles involved in breathing, which can lead to difficulty breathing and even death. Some home-made canned, preserved or fermented foods can give the right conditions for spores to grow and produce the botulinum toxin.

Good and bad microorganisms.

Microorganisms can be useful. Useful microorganisms are applied in the production of some kinds of food like yogurt, bread, and cheese. Microorganisms can also be useful to the environment, helping in the treatment of organic residues and in some wastewater treatments.

- **Bread.** To make bread, one of the ingredients is baker's yeast which is a yeast paste (Saccharomyces cerevisiae).
- **Yogurt and cheese.** In the yogurt and cheese production lactic-acid bacteria are present.
- **Composting pile.** Composting is the natural way to treat the organic residues – fruit and vegetable peels and wastes, eggshells, coffee filters, bread.... Microorganisms in the soil decompose and transform wastes.
- **Wastewater treatment.** Some microorganisms eat the contaminated materials in wastewater, and it becomes clearer.

Microorganisms can be harmful. Microorganisms can be costly and harmful when they spoil food or cause diseases.

- **Spoiled food:** Sometimes on old bread there are very small white / green marks, these are moulds and in fruits like apples and peaches, soft brown zones appear, these are caused by another type of moulds.
- **Sick people:** Pathogenic microorganisms cause diseases. These microorganisms can be present in food in high amount without being noticed – they do not cause changes in the colour, in the smell, in the taste or in the texture.

It is important to remember that without the activities of microbes there would be no bread, cheese, beer, or chocolate. Food microbes, good or bad, are always on the menu.

"Good" microorganisms "Bad" or "Spoiling"microorganisms

Significant microorganisms in food processing

There are several microorganisms of concern. The most important pathogenic microorganisms that contaminate food are:

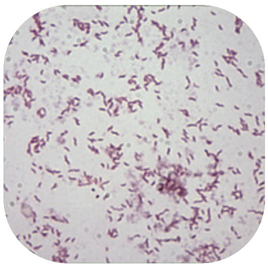
Salmonella

Type: Bacteria **Disease:** Salmonellosis

Can be mainly found: undercooked poultry and meat, raw meat and fish, raw eggs, homemade mayonnaise, some deserts with raw eggs, raw milk

Prevention: Cook eggs, meat and poultry thoroughly, avoid homemade mayonnaise and creams with raw eggs. Drink pasteurized milk.

Campylobacter jejuni

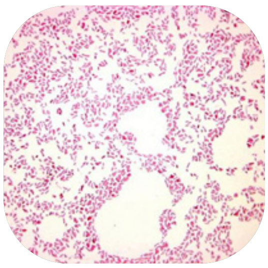


Type: Bacteria **Disease:** Campylobacteriosis

Can be mainly found: raw or undercooked poultry or pork, water from contaminated rivers, springs or fountains, raw milk.

Prevention: Cook chicken and pork thoroughly, drink pasteurized milk, avoid recontamination.

Escherichia coli (E. coli O157:H7)



Type: Bacteria **Disease:** infection by E.coli

Can be mainly found: unpasteurized apple juice and apple cider, soft cheese and contaminated water. Undercooked, contaminated ground beef.

Prevention: Cook foods thoroughly, drink pasteurized juices, use good hygiene practices

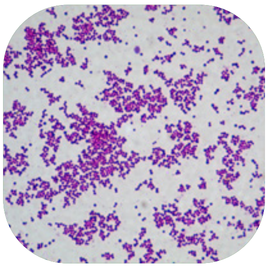
Shigella

Type: Bacteria **Disease:** Shigellosis or bacillary dysentery.

Can be mainly found: Unpasteurized milk, uncooked poultry unwashed vegetables, leftovers remained overnight.

Prevention: Cook food thoroughly, drink pasteurized milk, use good hygiene practices.

Staphylococcus aureus

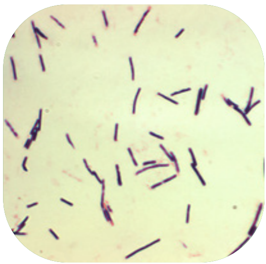


Type: Bacteria **Disease:** caused by toxins released in food by Staphylococcus aureus

Can be mainly found: Undercooked meat, poultry and eggs, improper storage of cream-filled pastries, leftovers kept at room temperature.

Prevention: Thorough heating and rapid cooling of food, proper refrigeration, cook food thoroughly, use good hygiene practices.

Clostridium perfringens

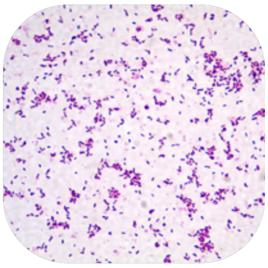


Type: Bacteria **Disease:** Perfringens food contamination

Can be mainly found: Undercooked meat, improper storage of cream-filled pastries, leftovers kept at room temperature

Prevention: Thorough heating and rapid cooling of food, cook food thoroughly, use good hygiene practices

Listeria monocytogenes

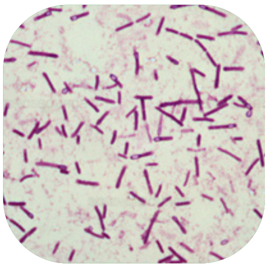


Type: Bacteria **Disease:** Listeriosis

Can be mainly found: uncooked meat and vegetables, unpasteurized (raw) milk or food made from unpasteurized milk.

Prevention: Drink pasteurized milk, cook food thoroughly, wash fresh vegetables and fruits thoroughly under running water, good hygienic practices.

Clostridium botulinum

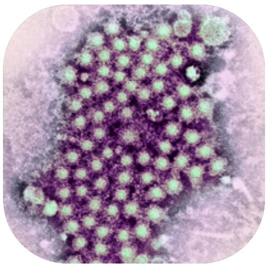


Type: Bacteria **Disease:** Botulism

Can be mainly found: raw or undercooked poultry or pork, water from contaminated rivers, springs or fountains, raw milk.

Prevention: Avoid consuming home-canned food, cook food thoroughly, refrigerate leftovers promptly.

Hepatitis A virus

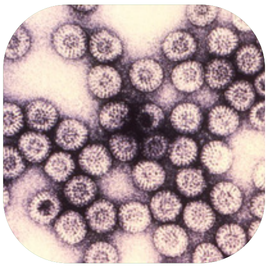


Type: Virus **Disease:** Hepatitis

Can be mainly found: raw fish, oysters, clams, mussels, scallops and cockles.

Prevention: Avoid eating fish and sea food from unknown sources, cook fish and sea thoroughly.

Rotaviruses

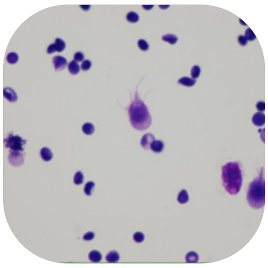


Type: Virus **Disease:** Viral gastroenteritis

Can be mainly found: Raw or mishandled foods

Prevention: Good hygienic practices. Cook thoroughly

Giardia lamblia

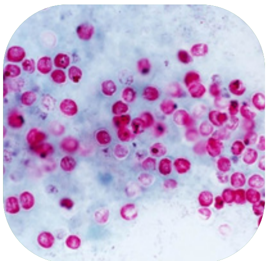


Type: Parasite **Disease:** Giardiasis

Can be mainly found: contaminated water, uncooked vegetables

Prevention: Cook thoroughly, avoid drinking water from springs and rivers.

Criptosporidium parvum



Type: Parasite (Protozoa) **Disease:** Crisptosporidiosis

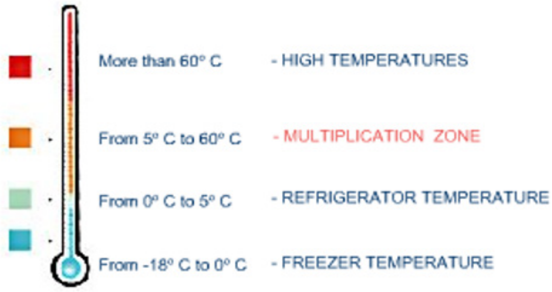
Can be mainly found: Contaminated water, apple juice non pasteurized, vegetable and fruit salads.

Prevention: Cook thoroughly. Good Hygienic practices.

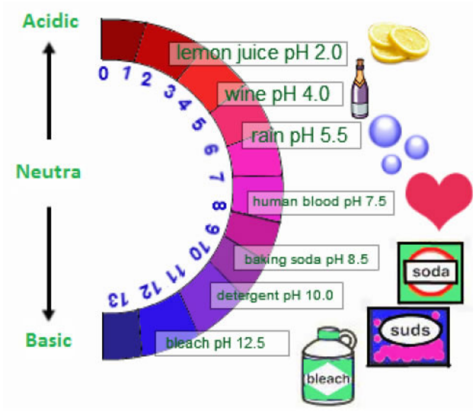
What do microorganisms need to grow?

Microorganisms need some conditions to grow:

- **Nutrients:** Microorganisms need nutrients and can find them in food, especially in milk and dairy products, in meat, in fish and in eggs.
- **Water:** Most foods have sufficient water to allow the growth of microorganisms. Microorganisms do not grow in dry foods, like sugar and flour. However, they can survive as spores, and once water is added, they may multiply again.
- **Temperature:** All microorganisms have a temperature at which they grow best, these temperatures are different for different microorganisms. Pathogenic bacteria grow between 20 and 40°C, and some can grow at lower or higher temperatures. The human body temperature (37°C) is perfect for these bacteria. At freezer temperatures the microorganisms stop growing, at refrigerator temperatures are still active although they grow very slowly, at room temperature microorganisms grow very fast (this is the Danger Zone) and at high temperatures microorganisms are destroyed but spores can resist at temperatures higher than 100°C.



- **pH:** Acidity is measured by a parameter called pH, that varies between 1 and 14, corresponding 1 to the more acidic and 14 to the most basic values. Most microorganisms multiply better in foods with a pH between 4 and 9. Some foods are more acid than others. For example, lemon and orange are more acid than apple or milk.



- **Oxygen:** Many of the microorganisms need oxygen to grow, they are called aerobic microorganisms. Others only grow in total absence of oxygen, they are called anaerobic microorganisms. Others may grow in the presence or absence of oxygen, they are called facultative aerobic microorganisms.
- **Time:** When the above factors are favourable, microorganisms just need time to grow.

5.3 IMPORTANCE OF FOOD SAFETY

Definition

According to Wikipedia "Food safety is a scientific discipline describing handling, preparation, and storage of food in ways that prevent foodborne illness. This includes several routines that should be followed to avoid potentially severe health hazards. In this way food safety often overlaps with food defence to prevent harm to consumers. The tracks within this line of thought are safety between industry and the market and then between the market and the consumer. In considering industry to market practices, food safety considerations include the origins of food including the practices relating to food labelling, food hygiene, food additives and pesticide residues, as well as policies on biotechnology and food and guidelines for the management of governmental import and export inspection and certification systems for foods. In considering market to consumer practices, the usual thought is that food ought to be safe in the market and the concern is safe delivery and preparation of the food for the consumer."

Where can food be contaminated?

As you already know, food can be contaminated at any point of the food chain. To prevent that contamination there are some practices that help people to assure food safety:

- At the farm: The farmer shall apply the Good Agricultural and Veterinary Practices.
- At the factory: Food processors shall apply good hygienic practices and assure the control of the process.
- At the shop: In this point of the food chain there shall be assured hygiene and good storing conditions.
- At home: At home it is very important to follow some important rules about hygiene and good preparation practices.

What are foodborne diseases and risk groups?

A foodborne disease occurs when someone eats food contaminated with one or more contamination microorganism. This happens when pathogenic bacteria find good conditions to grow in food.

Some microorganisms cause foodborne diseases because they are able to grow in the human body. Others, when they grow in food produce toxins (poisons) that are responsible for the disease. This is the case of the Clostridium Botulinum toxin and the botulism disease that may have fatal consequences.

The usual symptoms of a foodborne disease are almost the same:

- Vomiting
- Diarrhea
- Abdominal ache
- Fever
- Headache
- Tiredness
- Muscle ache

The incubation time is the period between you eat the contaminated food and you start feeling sick. It can vary from hours to days.

Sometimes in a group of people that eats the same food, some people get ill and other do not. This happens because people have different body defense mechanisms. Infants, pregnant women, old people and people with chronicle diseases (hepatitis B, AIDs, diabetes) have the greatest risk, and may become ill after ingesting food contaminated only with a few pathogenic microorganisms. They are the risk groups. The meals to these people must be prepared more carefully.

Different types of food contamination: physical, chemical and microbiological hazards

Food contamination occurs when something which might be dangerous is present in food that is reasonably likely to cause illness or injury in the absence of its control.

Biological hazards include harmful bacteria, viruses or parasites (e.g., salmonella, hepatitis A, etc.). **Chemical hazards** include compounds that can cause illness or injury due to immediate or long-term exposure (poisons, pesticides, etc.). **Physical hazards** include foreign objects in food that can cause harm when eaten, such as glass or metal fragments.

due to immediate or long-term exposure (poisons, pesticides, etc.). Physical hazards include foreign objects in food that can cause harm when eaten, such as glass or metal fragments.

It is important to understand that, for the purposes of Food Safety, hazards only refer to the conditions or contaminants in food that can cause illness or injury to people. Many conditions are totally undesirable in food, such as the presence of insect's residues, rodents or other animals' hair or filth, etc. All these defects must be controlled in food processing, but they often are not directly related to the safety of the product. Unless these conditions directly affect food safety, they are not considered as a food safety hazard.

Economic fraud and violations of regulatory food standards are also undesirable, but they are not considered a food safety hazard. Food fraud is a collective term used to encompass the deliberate and intentional substitution, addition, tampering, or misrepresentation of food, food ingredients, or food packaging; or false or misleading statements made about a product, for economic gain. But if a public health threat becomes involved, the effect is an adulterated product and a food safety incident and not a food fraud. Fraudulent activities are characterized by their intentional nature, aimed at an economic gain, in violation of legal rules and at the expense of the immediate customer or the final consumer.

Contaminated food is not fit for human consumption. Food contaminations are normally eliminated by good agricultural and veterinary practices at the farm, proper processing of food in the factory and using good handling practices at home.
Cooking is the art, science, profession, and hobby of preparing food for human consumption. You cook in your kitchen. Because eating is a universal human drive, cooking is a nearly universal cultural feature and we need factories, big kitchens, to prepare food for all the population.

As you know, when you cook you have to observe some hygiene rules: wash your hands, clean surfaces, don't cross contaminate (if you cut raw meat, bacteria will spread from the meat to the knife, if you then use the same knife, without washing it thoroughly, to chop a cucumber, the bacteria will spread from the knife to the cucumber), etc.

In your kitchen, you cook with small kitchen appliances and utensils. In the factory are used big equipments. In your kitchen you cook for your family. In the factory you cook for thousands of families. So, it is clear that in the factory the Food Safety Standards must be even stricter. So, factories must control food quality and food safety. Some of the controls that must be done are the following:

• **In the labs:** raw material inspection, water quality and cans checking, incubation tests of the final product, etc.
• **In the process plant:** Maintaining high standards of cleanliness and hygiene for equipment and personnel.
• **In the buildings:** high standards of cleanliness and safety measures, constant maintenance of barriers to prevent entry of insects, birds and rodents.
• **In the stores:** Storage control, labelling, stock rotation of raw materials and canned products.

What is traceability?

Food factories must implement traceability systems, for example, to track the grain in a breakfast cereal box to the field and the oranges in a bottle of juice to the orchard. Traceability is to know from where comes the food you eat. Traditionally it has been studied the way from the farm to the fork (or from the tree to the table), but when you buy a food product you would like to know: where does it come from? in which country has been processed? etc. We want to know now in the opposite way: from the fork to the farm (or from the table to the tree).

Most important Food Safety Standards: HACCP, IFS, BRC, FSMA. What is HACCP?

NASA USA developed a reliable approach to food safety to assure that astronauts food was safe. This new approach focused on preventing the introduction of hazards in the process of manufacturing food, rather than looking for the effects of those hazards in the finished product.

The system they developed represented a major improvement in safe food production, and by the 1990s, would come to be the internationally recognized a Hazard Analysis Critical Control Points HACCP approach to food safety. HACCP is included in the Codex Alimentarius that is recognized by both the World Health Organization and World Trade Organization.

The Seven Principles of HACCP:

1. Conduct a Hazard Analysis
2. Determine Critical Control Points
3. Establish Critical Limits
4. Establish Monitoring Procedures
5. Establish Corrective Actions
6. Establish Verification Procedures
7. Document the system

HACCP starts by reviewing every step in the whole manufacturing process: raw material production, procurement, handling, manufacturing, distribution, and consumption of the finished product. All potential risks for biological, chemical, and physical contamination must be considered. Once those risks are identified, a HACCP management plan calls for controlling the hazards by identifying and implementing preventive measures. This HACCP plan must be based on good scientific evidence in identifying and controlling of risks.

When a hazard has both a significant chance of occurring and causing harm to a consumer is called Critical Control Point CCP that must be controlled, prevented, eliminated or reduced to an acceptable level. Every CCP will have a critical limit: the maximum or minimum value that reliably prevents, eliminates, or reduces a hazard to an acceptable level. In some processes, the critical limit might be a measure of water activity (aw) that prevents microbial growth, or a measure of time and temperature, etc.

After identifying your CCPs and establishing critical limits a method for monitoring them must be developed and implemented. Monitoring CCPs will help to observe when the process is going out of control so that corrections must be made to keep it in control.

Although the HACCP management system is designed to prevent hazards, sometimes the actual process deviates from the planned one. Therefore, a food company must develop corrective actions that will help keep potentially hazardous food away from consumers. A complete HACCP plan will include instructions on what to do in the case of a deviation, the person(s) responsible for implementing corrective actions and requiring that the deviation and corrective action be recorded.

The HACCP plan should be routinely verified to ensure that it is effectively preventing and controlling hazards and that it is being executed and applied consistently. This is generally accomplished both through periodic internal audits and external third-party audits. The seventh principle requires the company to keep records documenting that it is done what it said. Clear and consistent records make it possible to demonstrate that the food you manufacture was produced safely. With an effective HACCP program, your food company will become more efficient, lower the number of complaints, and recalls and will save money in the medium-term.

What is IFS?

International Featured Standard IFS Food is a Global Food Safety Initiative GFSI-recognised standard for certifying the safety and quality of food products and production processes. The standardized IFS Food evaluation system helps to reduce the need for repeat audits, which saves the food company time and money. The programme also helps to improve the understanding of quality and safety processes across the organisation and throughout the entire supply chain, providing standards that deliver uniformity and transparency.

What is BRC?

The British Retail Consortium BRC Global Standard for Food Safety began in the UK to help the food industry meet legislative requirements of the EU General Product Safety Directive and the UK Food Safety Act. Since that time, the Standard has received global recognition with over 20,000 certified sites worldwide. The Standard is a Global Food Safety Initiative GFSI recognised certification program.

BRC certification is an internationally recognized mark of food safety and quality. Certification is achieved by undertaking a third-party audit against Standard requirements by an accredited certification body (CB). BRC rates CBs on their technical performance and efficiency in customer service.

What is FSMA USA?

Generally, domestic and foreign food companies selling their food products in the United States of America must comply with the requirements for risk-based preventive controls mandated by the Food and Drug Administration FDA USA Food Safety Modernization Act FSMA as well as the modernized Current Good Manufacturing Practices CGMPs of this rule, unless an exemption applies. This rule, which became compulsory in September 2015, requires food companies to have a food safety plan in place that includes an analysis of hazards and risk-based preventive controls to minimize or prevent the identified hazards.

What is the European Food Safety Authority EFSA?

The European Food Safety Authority EFSA provides independent scientific advice to the decision makers who regulate food safety in Europe. Food is essential to life. EFSA's scientific advice helps to protect consumers, animals, and the environment from food-related risks.

Europe's food chain is continually evolving and EFSA's remit has evolved to cover an increasingly complex number of areas related to the safety of the food chain: food-borne diseases, contaminants, animal health and welfare, plant protection, food production and distribution as well as food sector innovation to name a few. One of EFSA publications is a brochure that shows in a simple and instructive way how the advice that EFSA provides to risk managers underpins many of the laws and regulations in place to protect European consumers from food-related risks from field to fork.

5.4 HOW PASTEURIZATION AND OTHER TRADITIONAL TECHNOLOGIES ARE USED DURING PROCESSING TO IMPROVE FOOD SAFETY. TIME TEMPERATURE RELATIONSHIP.

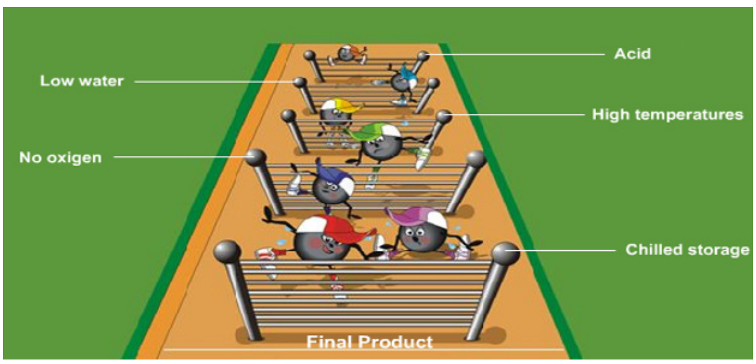
Introduction to food preservation technologies

For centuries foods have been preserved using the combined application of several preservative methods (e.g., heating, chilling, drying, curing, conserving, acidification, oxygen-removal, fermenting, adding preservatives, etc.). More recently the underlying principles of these traditional methods have been defined (i.e., Temperature, time, water activity aw, pH, competitive flora, various preservatives, etc) and effective limits of these factors for microbial growth, survival and death were established.

Hurdle technology

Hurdle technology is the term often applied when foods are preserved by a combination of processes (hurdles). This approach involves the use of existing and novel preservation techniques to establish a series of preservative factors that the target microorganisms would not be able to overcome. Hurdles include temperature, water activity, redox potential, modified atmosphere, preservatives, etc. The concept is that for a given food the bacteria should not be able to "jump over" all the hurdles present, and so should be inhibited. This is because different hurdles in a food often have a synergistic (enhancing) or additive effect.

Combinations of hurdles have the potential to effectively achieve microbial stability and safety, while maintaining the sensory, nutritive, and economic attributes of a food. For example, can ensure destruction of pathogens but guarantee preservation of heat sensitive functional food components. Hurdle technology is applicable both in large and small food industries. Hurdle technology is now widely used for food design in making new products according to the needs of processors and consumers. Some examples of foods preserved by combined processes include canned foods, fruit juices, salamis.



This multi-targeted approach is more effective than single targeting and allows hurdles of lower intensity, improving product quality. Up to now more than 50 different hurdles have been identified in food preservation like temperature, water activity, pH, acidity, high pressures, etc. Traditionally different methods have been used to avoid food spoilage. You can easily find in the supermarket's food products preserved by the following methods:

Freezing, which slows both food spoilage and the growth of microorganisms and, by turning water to ice, makes water unavailable for bacterial growth and chemical reactions. Avoid frozen foods with evidence of thawing-that means the food has been defrosted and frozen again. Avoid damaged bags or containers. Try to carry the frozen food in a thermal bag.

Freezing is a mean of preserving food through the application and maintenance of extreme cold temperature (-4°C to -40°C). It is effective because most of the water of the food tissue is changed from the liquid to the solid state. This change in the physical state of water retards enzymatic action and stops microbial growth, the cause of food spoilage, thus preserving food. Many foods can be frozen for twelve months or more without major changes in size, shape, texture, colour and flavour.

Regarding packaging it uses freezer-safe packaging to maintain best quality while foods are frozen:
• Plastic containers that are freezer-safe do not become brittle and crack at cold temperatures.
• Glass jars made from thick, tempered glass, such as canning jars.
• Wax-coated cardboard boxes with a liner (freezer-safe plastic bags, foil, or freezer paper) for soft or liquid foods.

How do you process frozen food?

Current methods of freezing typically use the air blast method, where ultra-cooled air is blown on the food in a narrow tunnel, or by the indirect method, where the food is passed along metal plates cooled by a refrigerated liquid. Food can also be frozen cryogenically.

Important concepts for effective freezer management are:
• Maintain freezing temperature
• Rotate foods consistently (first in, first out)
• Thaw foods properly (always in the refrigerator, never at room temperature)
• Plan how you will maintain or use the food in case of a power outage

Vegetables/ Meat/ Dairy/ Fruits	Refrigeration	Freezing
Pears	5 Days	One year
Butter	1-2 months	9 months
Milk	8-20 days	3 months
Lean fish	1-2 days	6-10 months
Fatty fish	1-2 days	2-3 months
Poultry	1-2 days	6-9 months
Bread	1-2 weeks	2-3 months
Flour	1 year	1-2 years
Corn	1-2 days	8 months
Green peas	1-2 days	8 months
Spinach	5-7 days	8 months

Table 1: Comparison of the Shelf Life Data of Frozen and Refrigerated Foods

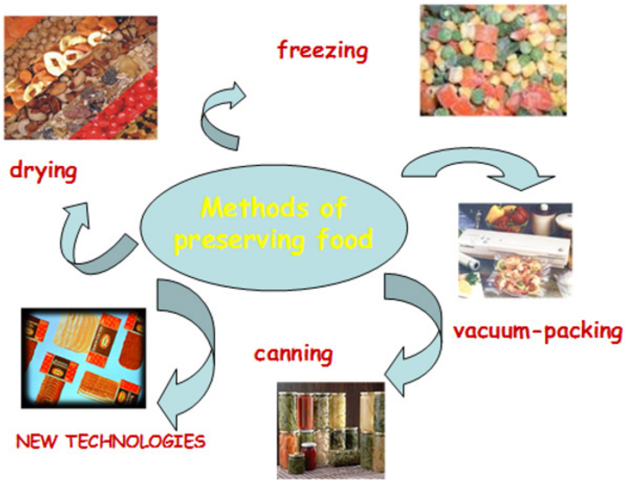
Drying, which removes water required for bacterial growth. Drying is the simple process of dehydrating foods until there is not enough moisture to support microbial activity. Drying removes the water needed by bacteria, yeasts, and moulds need to grow. If adequately dried and properly stored, dehydrated foods are shelf stable (safe for storage at room temperature). The drying food preservation method is easy to do, very safe, and can be used for most types of foods (meats, fruits, and vegetables).

You can use dried foods in a variety of ways:

- eat dried foods as is (such as snack and dried fruits)
- rehydrate dried foods with water (such as adding vegetables to a meat stew)
- grind dried foods into a powder (for example, grind tomatoes to a powder that you can reconstitute with water to make tomato sauce).

If you want to store dried food longer or use it to grind to a powder (such as tomatoes to make sauce), then you want them to be crisp and brittle. Less-dry products have considerably shorter shelf life (from 2 weeks to 2 months). Very dry foods, if properly stored, may last several months.

Vacuum-packing, with no oxygen to be used by microorganisms. Vacuum packing is a method of packaging that removes air from the package prior to sealing. This method involves (manually or automatically) placing items in a plastic film package, removing air from inside and sealing the package. Shrink film is sometimes used to have a tight fit to the contents. In an almost oxygen-free environment, like in vacuum packaging, the spoilage bacteria do not multiply very fast, so the loss of food quality is slowed down. Some pathogenic (illness-causing) bacteria, however, like low-oxygen environments and



Other traditional methods are:

Salting, many microorganisms cannot live in a highly salty environment: water is drawn out of their cells because salt attracts water. Salting is an old-fashioned curing method for preserving vegetables. This technique was a popular food preservation method in the early twentieth century, especially during the first and second World Wars. Layering food with salt to preserve seasonal vegetables was promoted as an alternative to canning in order to save glass, metal, and fuel needed for the war effort. Using high salt cures vegetables, maintains them in a near-fresh state. Many people familiar with salt-cured vegetables consider the product to be far superior in taste and texture to canned or frozen ones. While they don't ferment (or ferment only slightly), the vegetables are cured, in essence pickled, by replacing their cellular water with brine. Overall, the salting method is as much art as science, but very safe. Compared to canning salting is quicker and easier. Compared to freezing, it is less expensive.

Smoking helps inhibit microbial growth and curing. (usually meats or fish, but sometimes cheeses, vegetables, and even fruits). Smoking is a method of cooking foods over a fire. Wood chips are added to the fire to give a smoky flavour to the food. Smoking is different from drying. Smoking adds flavour to the meat, fish, and poultry, and provides a small food preservation effect. The drying action of the smoke tends to preserve the meat, and many of the chemicals present in wood smoke (e.g., formaldehyde and certain alcohols) are natural preservatives as well. The smoking technique involves hanging the meat or placing it on racks in a chamber designed to contain the smoke. Commercial smokehouses, usually several stories high, often use steam pipes to supplement the heat of a natural sawdust fire. Whatever the size of the smoking operation, it is imperative that a hardwood fire be used. The softwood of conifers such as spruce and pine contains pitch, which produces a film on the meat and gives a bitter taste. Generally, smokehouse temperatures vary from 43 to 71 °C, and smoking periods vary from as short as a few hours to as long as several days, depending on the type of meat and its moisture content. After smoking, the meat is chilled as rapidly as possible and cut and wrapped for the retail trade. In order to shorten the production process, commercial meats are sometimes artificially “smoked” by dipping them in a solution of preservative chemicals or by painting them with such a solution.

Fermentation is the transformation of some food components by bacteria or yeasts. Usually in an anaerobic way carbohydrate (like sugars) are converted into alcohol or lactic acid and gas. Fermentation is popularly taken to refer to the making of yoghurt. It must be kept in the fridge to improve its shelf life (the length of time a packaged food will last without deteriorating). Fermenting is one of the oldest and simplest forms of food preservation. Most fermentation processes are anaerobic. That is, they occur without air, in closed containers. The process produces acids that inhibit spoilage microorganisms and other components that improve texture and flavour. The process of fermentation destroys many of the harmful microorganisms and chemicals in foods and adds beneficial bacteria. These bacteria produce new enzymes to assist in the digestion. Foods that benefit from fermentation are soy products, dairy products, grains, and some vegetables.

Fermentation is a metabolic process in which an organism converts a carbohydrate, such as starch or a sugar, into an alcohol or an acid. For example, yeast performs fermentation to obtain energy by converting sugar into alcohol. Bacteria perform fermentation, converting carbohydrates into lactic acid. Fermentation is used for preservation in a process that produces lactic acid found in such sour foods as pickled cucumbers, and yogurt, as well as for producing alcoholic beverages such as wine and beer.

What are the three different types of fermentation?

- Lactic acid fermentation. Yeast strains and bacteria convert starches or sugars into lactic acid, requiring no heat in preparation.
- Ethanol fermentation/alcohol fermentation.
- Acetic acid fermentation.

Pickling is the process of preparing a food by soaking it in a light brine (salt) solution approximately during two days and storing it in a concentrated brine solution where the product is maintained until it's canned/jarred with heat and vinegar. This is an easy example of combination of methods: first a controlled fermentation and afterwards a heating method. Using low salt concentration will ferment the vegetables and create a tangy pickle. In this case, the role of salt is to create the right environment for desirable lactic acid bacteria (LAB). As LAB, grow, they increase the acidity of the brine and prevent the growth of spoilage bacteria. The result is pleasantly flavoured pickled vegetables, with less sharpness than vegetables preserved in vinegar solutions.

What is a thermal process?

Food preservation heat treatments began to be used in the early 19th century, thanks to the pastry chef Nicolás Appert, who discovered that if food was packaged in glass jars and heated afterwards, it was possible to prolong its preservation. Much progress has been made since then. A thermal treatment is the application of heat to food, either before or after sealing in a hermetically sealed container, for a period of time and at a temperature scientifically determined to achieve a condition of commercial sterility. The application of high temperatures is one of the most used methods to kill or control the numbers of microorganisms present within foods and on packaging surfaces. Evidence for its importance in today's food industry can be seen in the percentage of shelf space taken up in any supermarket by foods preserved by heat. Thermal processing is a general term that describes all forms of heat treatments in which microorganism numbers are controlled by heat. This includes heat processed container types such as metal cans, plastic trays, pouches, glass jars and even cartons. It also includes continuous thermal processes that take place outside of the package and are usually linked with aseptic or hot filling. Canning was an early terminology and nowadays the terms 'canning' and 'thermal processing' are often used for the same purpose.

Food canning is now a long established and well-understood technique, which has served consumers well for nearly 200 years. It is used to produce a wide variety of shelf stable products that can be stored at ambient temperatures for many months. In simple terms, heat is applied to foods packed into sealed or airtight containers, at levels sufficient to destroy the relevant microorganisms. The amount of time needed for processing is different for each food type, in that it depends on the presence of antimicrobial hurdles (e.g. water activity, acidity, preservatives) and the ability to transfer heat to the food centre (the coldest point). Temperature in the coldest point inside the container has to reach the proper value to eliminate microorganisms. Safety of thermally processed foods is assured using a system called Hazard Analysis and Critical Control Point, or HACCP. As already seen in a previous chapter, HACCP is a system that identifies areas of potential contamination within the food process, identifies Critical Control Points CCPs, to ensure that the product safety is always maintained. Validation of a thermal process and the determination of CCP levels is a challenging exercise that requires a variety of accurate tools.

Without simplifying too much, the manufacture of a thermally processed food can be broken down into two basic operations:

1. The food is heated to reduce the numbers of surviving microorganisms to an acceptably small statistical probability. This includes both pathogenic and spoilage organisms that are capable of growth under the intended storage conditions; and
2. The food is sealed within a hermetic package to prevent contamination of the food.

The thermal process has three phases according to the heat penetration rate:

• Heating, during which the product gradually acquires the desired temperature.
• Holding, the product maintains the desired temperature and remains constant for the established time thanks to the equipment's control instruments. Thermal centre or cold point of the product must be controlled using a thermal sensor.
• Cooling, in this phase the product is cooled to room temperature

Preservation methods such as traditional canning achieve this by sealing the food in its package before the application of heat to the packaged food product. On the other hand, continuous processing operations heat the food within a heat exchange system prior to dispensing it into the package. Both methods reduce the numbers of microorganisms in the food to commercially accepted levels and the packages prevent recontamination over the shelf-life.

Basis of a thermal process

The heat process must target the correct type of microorganism in order that the product has the correct shelf-life. This is because there are millions of types of microorganisms that can grow within food products and the selection of which ones to target is critical. Fortunately, only a few can cause damage to our health. The term 'commercially sterile' is commonly used for low acid foods. One of the definitions of commercial sterility is given by the UK Department of Health (DoH, 1994):

Commercial sterility is the condition achieved by the application of heat, which renders food free from viable microorganisms, including those of known public health significance, capable of growing in the food at temperatures at which the food is likely to be held during distribution and storage.

Controlling the product pH is critical so that the types of microorganisms that can grow in the food are also controlled.

The destruction of microorganisms by temperature increase depends on various parameters that must be controlled during treatment, the most important are:

• Characteristics of the food, such as humidity, water activity aw, pH and composition, especially in sugars since they influence microbial heat resistance. The most outstanding being the pH. In a medium close to neutrality (pH = 7) the resistance of vegetative and sporulated forms is maximum, decreasing this resistance as it moves away from neutrality, it should be remembered that lower values than pH 4.5 prevent growth in food. Thus in low acid products (with a pH above 4.5) such as vegetables, the temperatures to destroy spores must be between 115-150 °C, while in acidic products (with a pH below 4.5) such as tomatoes and most of the fruit: figs, pears, orange, pineapple, etc. temperatures to destroy spores are around 100 °C. So in many food products to use a milder preservation treatment temperature, an acidic governing liquid such as vinegar is added.
• Amount of microorganisms: the smaller it is at the beginning of the treatment, the smaller the residual quantity that will survive, so to destroy as many microorganisms as possible, it is necessary to use a quality raw material and use good handling practices throughout the food processing.
• Type of the microorganisms: the most heat-resistant are thermophiles, that is, those that grow best at temperatures between 45-70° C, and the sporulated genera that they can be thermophilic or not. To thermally destroy bacterial spores or endospores, temperatures above 100 °C must be used.

Time Temperature relationship

The thermal treatment is defined by the binomial of time and temperature to be used and therefore there are endless combinations to achieve the same goal of microbial reduction, differing only in optimizing the costs involved in selected temperature and time, it has also been seen that these in turn depend on the initial microbial load and the acidity of the food. The more the temperature increases, the higher the percentage of dead microorganisms, and the number of microorganisms decreases with the time of treatment, the longer the treatment, the more lethal it will be. Regarding temperature, the lethal range for vegetative forms is between 60-100 °C and for sporulated forms is between 100-150°C, but if the processing temperature is increased, the exposure time can be reduced to achieve the same percentage of dead microorganisms

Pasteurization is a heat treatment

Pasteurisation is a relatively mild heat treatment that is applied to acid foods, whereas sterilisation processes are aimed at destroying all pathogenic microorganisms and their spores. Pasteurisation processes are designed to eliminate vegetative spoilage microorganisms that are not very heat resistant, and the low pH value of the product inhibits the growth of any surviving microorganism and prevents spores germinating. Pasteurisation also inactivates enzymes, naturally present, that could cause chemical deterioration of the product on storage. Clostridium botulinum is the most heat resistant spore-forming bacteria known to produce a lethal toxin, but it cannot germinate or grow below a pH value of 4.5. However, there is a host of spoilage organisms (capable of producing gasses, taints or enzymes that can degrade the texture of the food) that are sensitive to pH and heat to differing degrees. The mild thermal process chosen must therefore take into account the actual pH of the product, as well as the types of microorganisms that are most likely to contaminate that product. An acidity level of pH 4.5 will inhibit the growth of most spore forming bacteria, and specifically C. botulinum. A mild heat treatment of 70°C for a few minutes will kill off all vegetative organisms, but not the bacterial spores.

Canned fruit is usually processed in hot water or steam because the acidity of the fruit allows a milder pasteurisation process. Some fruits are more sensitive to heat than others and therefore the selection and control of processing temperature is very important in determining the quality of the final product. For very heat sensitive products, it is best to choose hot water as the processing medium, because the heat transfer is gentler than from steam. The heat resistance of most microorganisms is closely linked to pH; the lower the pH, the more sensitive the microorganisms are to heat destruction. Although the pH of products discussed in this group can go as high as about pH 5, it is often more effective to acidify the product to pH < 4.2 or even < 4.0. Citric acid is most used for this purpose, as it imparts only a slight fruity flavour and is relatively inexpensive.

The pasteurization treatments used are:

- Low temperature for a long time LTLT, normally at 60 °C for 30 minutes, used for solid and liquid foods packaged or in bulk.
- High temperature for a short time HTST, normally at 77-92 °C for 15-60 seconds, only for liquid food in bulk, since the heating and cooling of the entire product must be instantaneous due to the short time the complete treatment takes.

In the pasteurization of food packaged in glass containers, heat is transmitted through water. It is important that the temperature difference between the container and the water is less than 20° during heating and less than 10° in cooling, so that the container does not break due to thermal shock, that is, due to a sudden change in temperature. If the container is metallic or plastic, steam can be used that causes a greater temperature difference, since there is little risk of thermal shock.

There are two ways of working: continuous and discontinuous. After continuous or discontinuous pasteurization, containers are cooled to 40 °C so that the water droplets that may remain on their surface evaporate and do not corrode it during storage and the labels can stick to the container.

Figure 1: continuous pasteurizer in a tunnel through which the already packaged food is treated.

What is thermal sterilization?

Thermal sterilization is the most widely used food treatment. It is the application of heat above 100 °C to low acidity products to mainly destroy sporulated bacteria such as C. botulinum and obtain a food free of the microorganisms that are capable to grow under normal storage conditions, allowing the shelf life of the food to be extended to several months if it is stored in the appropriate containers and in a cool and dry place. Packaged food is introduced into the sterilization equipment (retort). This is the main step of the treatment, in which it has to be controlled the temperature of the thermal source (water or steam), the temperature before, during and after the process, its duration and the degree of pressure if it is applied. The process must be monitored, and all these parameters controlled with the specific measuring devices. The most serious defects that occur in this step are usually related to a lower treatment in time and / or temperature than necessary to destroy the expected number of microorganisms.

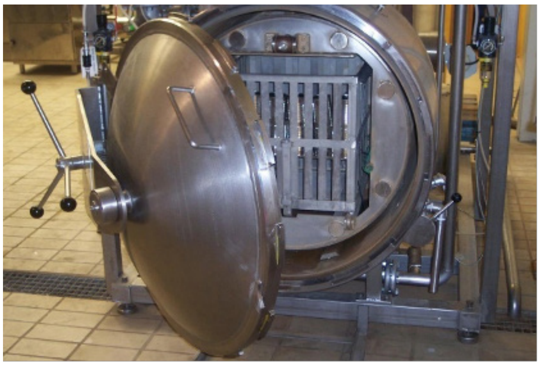
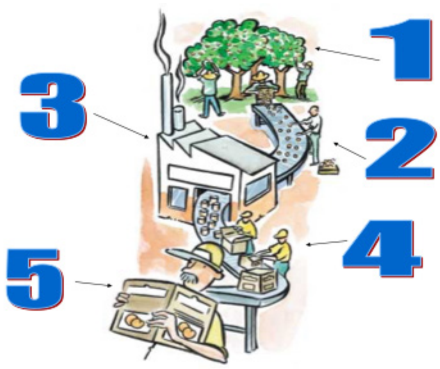


Figure 2. Retort for food Sterilization

Canning is the assembly of ingredients under reduced oxygen into a hermetically sealed can with associated heating and cooling cycles to render the contents statistically sterile for ambient-temperature distribution. It involves the application of blanching, blending with liquid, removing oxygen, placing in barrier packaging, hermetic sealing, heating, and cooling—a combination of multiple technologies which together provide for a safe quality level throughout the distribution channel.

Canning is a common preservation method in which food is sealed in a container and is heated at very high temperatures (between 115/120°C). Foods like vegetables, meats, seafood, poultry and dairy products can be preserved by this method. The temperature is critical in the canning process. To reach the high temperatures necessary to this process can only be reached in special equipment called sterilizers. If these foods are not processed in this way, bacteria called Clostridium botulinum can cause a disease, known as botulism, in the people who eat that food. Botulism can also be caused by foods that were canned or preserved at home. Be careful with home-made preserves.

What steps are followed by the canned fruit in syrup from the tree to the store?



As food enters the factory it passes through a series of critical steps, where opportunity for contamination can occur. Strict procedures are followed in all these risk steps to assure that food is safe and fit for human consumption.

1. Picking and transport to the factory of the raw material.
2. Factory: Receiving. Raw material must be not contaminated. It must be inspected when it enters the factory. Fruit that does not meet the specifications must be rejected. Accepted raw material can be stored under refrigeration until it is processed.
3. Factory: Industrial process. In the factory fruit is washed, peeled, weighed and graded according size, peeled, stoned or cored, halved, striped or diced, put in the container with added syrup, sealed, sterilized and cooled. Workers must wear overalls, caps and optionally gloves. Jewels are not allowed. Insects, birds, rodents and other animals are strictly prohibited. Glass light bulbs must be protected with plastic covers. Roofs must be in perfect conditions.
4. Factory: Packaging: Now fruit in syrup is labelled and packaged
5. Factory: Storing. Now is stored until dispatch to the stores. The storing conditions must be optimal (good temperature, clean, etc.) and follow the FIFO rule (First In First Out).

Do not buy cans which are swollen, crushed, leaking, or broken. If the label is bleached or not fixed to the body of the can, do not buy it – it means that the cans have been exposed to the sun or humidity for a very long period of time.

Other conservation techniques.

Modified-atmosphere packaging is a conservation technique that requires the clean preparation of product, reduction in temperature, clean filling into special high- or low-gas-permeability packaging, removal of oxygen (usually), elevation of carbon dioxide level, sealing, and maintaining the temperature at or near 0°C throughout distribution.

New food technologies are high pressure, pulsed electric fields, high-intensity light pulses, irradiation, etc. High pressure processed products and irradiated products are already commercially available in the supermarkets. Examples of high-pressure processed products include guacamole and fruit juices. Spices are example of irradiated products. Pay attention: Irradiated foods are not radioactive! The rest of new technologies are not totally developed and more studies from universities, institutes and technological centres are required to be used by the food industry.

5.5 TYPES OF CONTAINERS AND INGREDIENTS. IMPORTANCE OF CLOSURES AND NATURAL INGREDIENTS

Food is an active organic system that can react favourably or unfavourably with its packaging. Understanding packaging options and the way they work together with the product is therefore critical to the success of any food packaging system (Tucker, 2008). The functions of packaging are to contain, protect, preserve, portion, inform, promote and make portable. The packaging options for thermally processed foods include metal (mainly tinplate, but also aluminium) and glass and specific plastics (laminates and composites).

The primary packaging is the packaging that is in direct contact with the food. The protection and preserving functions are arguably the most important functions of primary food packaging, as it must keep the food in good condition until it is sold and consumed. If adequately packaged, the shelf-life of food may be extended, which allows the natural life of the food to be prolonged. This enables consumers to have choice in terms of the food available, and so food resources can be more equitably distributed.

Types of food containers

The most common type of packaging for high acid fruits is tinplate cans. Fruit can also be packed in plastic (HDPE, PP or multilayer) tubs or in glass. However, one of the factors that can limit the shelf-life of fruits packed in plastic is the barrier properties of the plastics, and specifically its ability to limit oxygen intake.

Metal containers. The most common form of packaging for thermally processed products is the can. The strength and non-breakability of metal makes it an ideal material for food packaging. Metal is also an excellent light and gas barrier, is quick and easy to seal and can withstand the extreme temperatures of food processing.

Cans are made from tinplate or aluminium.

Metal cans are available in many shapes and sizes to suit all types of products. They can be made from two pieces or three pieces of metal.

- Three-piece cans consisting of three components: a bottom lid, a cylindrical body and a top lid (with a lip, an opening, for a beverage can). The bottom lid is made by the can maker and the other is seamed by the canner after filling. These are referred to as the maker's end and the canner's end, respectively.
- Two-piece cans consisting of two components: a body integrated with a bottom lid and a lid with a lip (with a lip, an opening, for a beverage can),

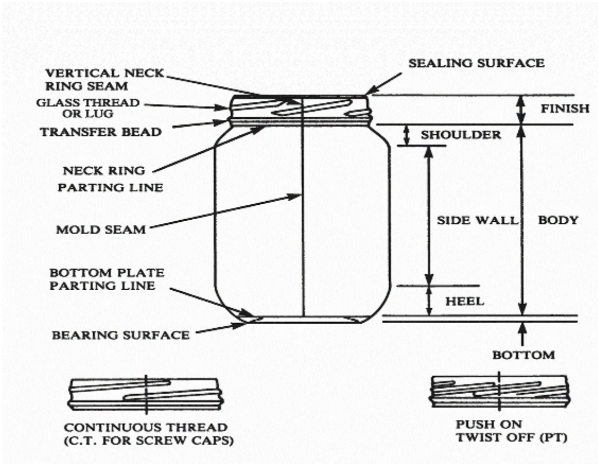
Advantages of two-piece cans over three-piece cans is that the can body has no side seam, and there's no seam between the body and the bottom end, so the can is tightly sealed with less consumption of raw materials and reducing the risks of leakage arising from imperfect seam formation; the can body can be fully decorated and printed and the can making process is easy and efficient. However, it also has the following disadvantages: it requires excellent performance of the can-making materials and a high investment in equipment. Besides, can-making technologies, equipment and dies must be excellent as well.

Glass containers

Glass is one of the oldest packaging materials used for food. It is almost completely chemically inert and therefore is suitable for packing many products and all foods.
The principles of processing in glass are basically the same as for cans, but there are certain modifications that are necessary to improve the thermal properties of glass, which make it less vulnerable to rapid changes in temperature.
The advantages of glass are many and include the following:
100% gas barrier;

- impervious to flavours and odours;
- no migrating chemicals to the food products;
- resistant to any chemical attack from food;
- can seal efficiently;
- relatively strong;
- allows the product to be viewed.

The main disadvantage of glass is that it can be broken and the broken pieces can be very sharp and constitute physical hazards. Other disadvantages are that clear glass is not a light barrier, so product deterioration can take place due to light (e.g. Vitamin B3 and colour loss), although this can be overcome by using tinted glass. Also, it is relatively heavy and is not suitable for products that are to be frozen.



Plastic containers

The term 'plastic' can refer to any of a group of synthetic or natural organic materials that may be shaped when soft and then hardened, including many types of resins, resinoids, polymers and cellulose derivatives. The development of plastics in general has revolutionised food packaging. Plastics are very versatile and can be engineered to replace most other packaging materials. Generally, plastics are lighter than glass or metal, they can be transparent or opaque, they can be very thin and flexible, or highly rigid (Hutton, 2003).

Plastic polymers are used to make many different packaging types. There are three main categories of plastic based packaging used for thermally processed foods. According to

Codex Alimentarius:

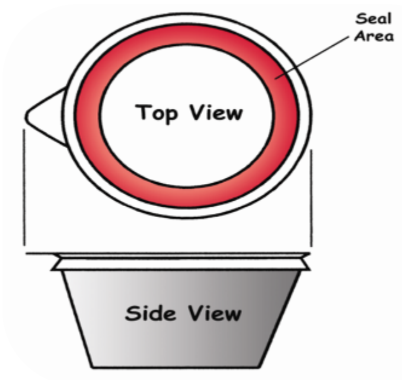
- 'Flexible container' means that the shape or contours of the filled, sealed container are affected by the enclosed product.
- 'Semi-rigid container' means that the shape or contours of the filled, sealed container are not affected by the enclosed product under normal atmospheric temperature and pressure but can be deformed by an external mechanical pressure as normal firm finger pressure.
- 'Rigid container' means that the shape or contours of the filled and sealed container are neither affected by the enclosed product nor deformed by an external mechanical pressure as normal firm finger pressure.

These sorts of containers can be made from various polymers or laminated or co-extruded materials (various plastic polymers, paper and/or aluminium) and has been one of the major packaging growth areas in recent years; both in technological and materials advances and in actual market share. Packaging films are used to construct the packages for many different types of convenience foods. Some important material properties are necessary to meet the requirements of these demanding convenience markets and include:

- a balance between toughness and stiffness;
- high strength and puncture and tear resistance;
- high temperature resistance (> 130°C is required for some reheat/cook-in-package applications);
- barrier properties (e.g. moisture, gas, odour, light);
- grease resistance;
- sealability;
- aesthetic properties and printability;
- processability/machineability (balanced surface friction);
- environmental friendliness (including recyclability).

Many types of polymers are utilized in plastic container for foods:

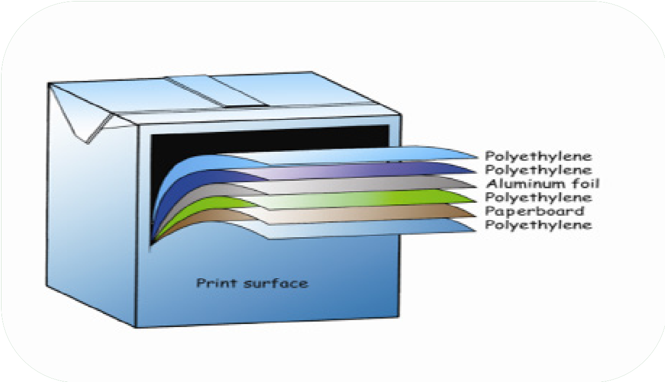
- Polymers used for retortable packaging
- Polypropylene (PP)
- Polyethylene terephthalate (PET)
- Ethylvinylalcohol (EVOH)



Retortable carton containers

Recently, retortable cartons designed for shelf-stable food products have been produced (www.tetrapak.com). They were designed as an alternative to the metal can for foods such as beans, vegetables, tomatoes, soups and sauces. The main advantages are efficient shelf-space usage; square packages are easily aligned on the shelf for a greater brand impact and they are also easy to open. They are made from pre-printed aluminium foil, laminate-based board.

The thermal process is very similar to that for cans and jars using overpressure.



Food-Container interactions

Different interactions can occur between a container and a food, depending on the packaging material and the type of food, but also on the environmental conditions that can speed up or slow down these processes. The most important interactions are:

PERMEATION: Transfer of matter (gases) or energy through the container. They can cause fat rancidity, browning/discoloration, loss of vitamins and growth of microorganisms.

SORPTION: Loss of aroma and flavour. 40% of the limonene present in orange juice is retained in the plastic container. Effects on the material: alteration of appearance and characteristics. The water plasticizes the EVOH increasing the permeation of gases and vapours.

MIGRATION: Mass transfer of the packaging material to the food and / or the environment. Migrants: substances that are transferred from the container to the product during storage or preparation (Low molecular weight compounds present in the container). Example: Migration of brick ink components to milk or juices.

What are active and intelligent containers?

Active Packaging: ‘packaging in which subsidiary constituents have been deliberately included in or on either the packaging material or the package headspace to enhance the performance of the package system’

Active packaging works in two different ways:

• By scavenging compounds which are detrimental for the product, e.g. gas (O2, CO2, ethylene, etc.)
• By releasing molecules improving the preservation of the product: CO2, Ethylene, SO2, aromas, ethanol, antioxidants, antimicrobials, etc.

There are 4 major groups of active packaging to better retain food microbiological or biochemical quality by mean of:
(I) Systems that absorb or retain undesirable substances, from the product or its environment (oxygen scavengers, moisture or odour absorbers, etc.)
(II) Systems that release or emit beneficial substances, to the product or to its environment (oxygen additions, moisture or odour emitters etc.)
(III) Systems with thermal effect: heat transfer
(IV) Systems that regulate the entry and / or exit of desirable and / or undesirable substances from the product environment

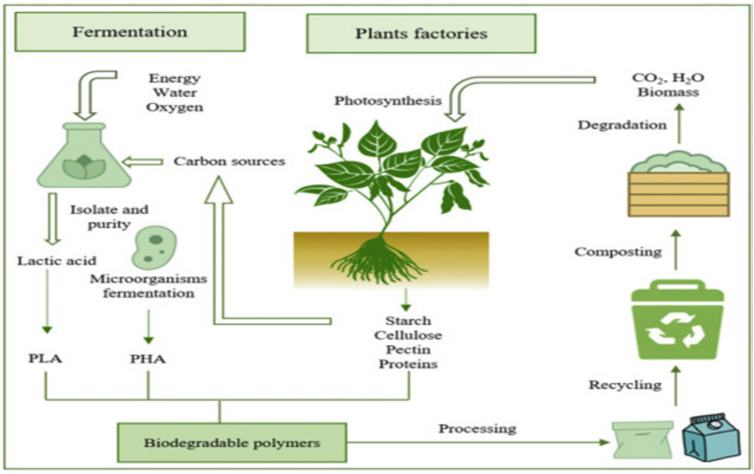
While active packaging technologies are designed to take a certain action in order to extend the shelf life of a product (e.g. release or absorb substances), intelligent packaging systems are designed to monitor and communicate the condition of packaged food or changes in the environment inside or outside of the package. The development of intelligent packaging was in part driven by the growing usage of active packaging applications, due to the need to monitor the performance of the latter.

EFSA defines intelligent packaging materials as “materials and articles that monitor the condition of packaged food or the environment surrounding the food”. They can communicate the conditions of the packaged product, but they do not interact with the product. Their aim is to monitor the product and transmit the information to the consumers. This can be information about the condition of a package and its contents, time of manufacture or storage conditions. Depending whether it is a simple or a reactive intelligent packaging, these can be placed on the primary (outside or inside), secondary or tertiary packaging.

There are three major types of intelligent technologies– indicators (of temperature, freshness, and gas concentration), data carriers (one- and two-dimensional barcodes, and radiofrequency identification tags (RFIDs)), and sensors (electrochemical, luminescence, biosensors and gas sensors).

What are biodegradable and recycled containers?

Biodegradable plastics seem like they are everywhere, but they still make up a tiny proportion of the plastics we use. As of 2018, biodegradable and bioplastics combined made up just 1% of the global plastics market. Though their usage is growing, they are still only forecast to account for 2.5% of the market by 2020. There is a distinction to make between different types of bioplastics. It's possible, for example, for some fossil fuel-derived plastics to be made from bio-based materials. On the other hand, there are plastics produced from plant-based materials which are chemically distinct. It's the latter group that we'll be focusing on here. Biodegradable plastics come in different varieties with varying uses. The three most used types are polylactic acid (PLA), thermoplastic starches (TPS), and polyhydroxyalkanoates (PHAs).



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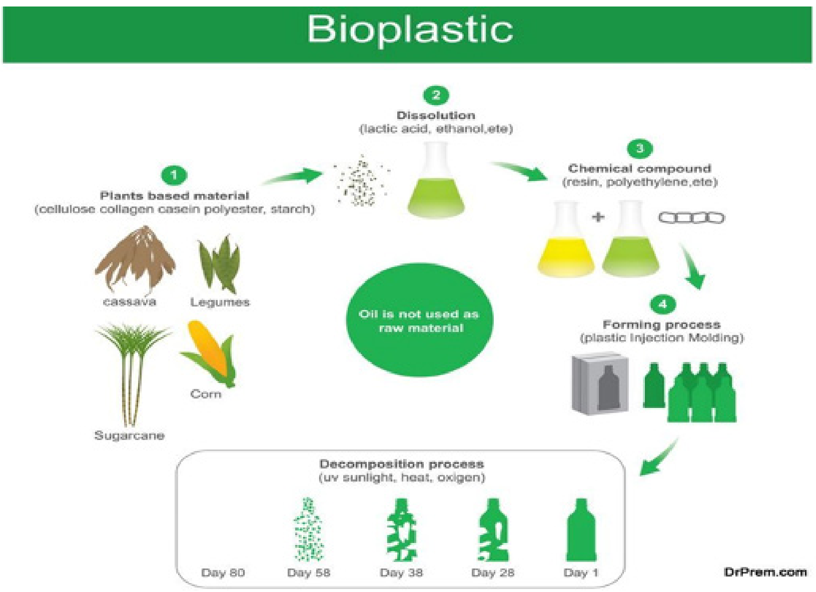
All these plastics are more expensive to produce than plastics produced from fossil fuels (on a weight basis). According to the Earth Institute at Columbia University, PLA can be 20-50% more costly than conventional plastics. Crops from which the raw materials are harvested need to be grown, and this requires land, fertilisers, water, and time. As the enthusiasm for biodegradable plastics increases and more cost-effective production methods become available, the cost of these plastics is dropping, but they are currently still expensive. That is not to say that their production is without its benefits. The volume of greenhouse gases emitted during their manufacture is less than that of fossil fuel-based plastics. It is estimated that if all plastic production were to switch to biopolymers, the greenhouse gas emissions in the United States would be reduced by approximately 25%. Biodegradable plastics do, as their name suggest, biodegrade – but the conditions need to be right. They need a moist environment with plenty of oxygen (aerobic conditions, to give it the technical term). They also need the correct microorganisms, pH and temperature for optimum break down. Buried under all of the other trash at your local landfill site, it's very unlikely that these conditions are being met. While they might still break down more quickly than conventional plastics, it's going to be more than a matter of months or even years.

Biodegradable plastics are designed for industrial high temperature composting facilities. The problem? These facilities are not available everywhere. And if the biodegradable plastics end up in a recycling bin with other plastics, they can contaminate them and cause problems. PLA can cause issues with the recycling of another common plastic, polyethylene terephthalate (PET). For this reason, many recycling facilities do not accept products made from biodegradable polymers.



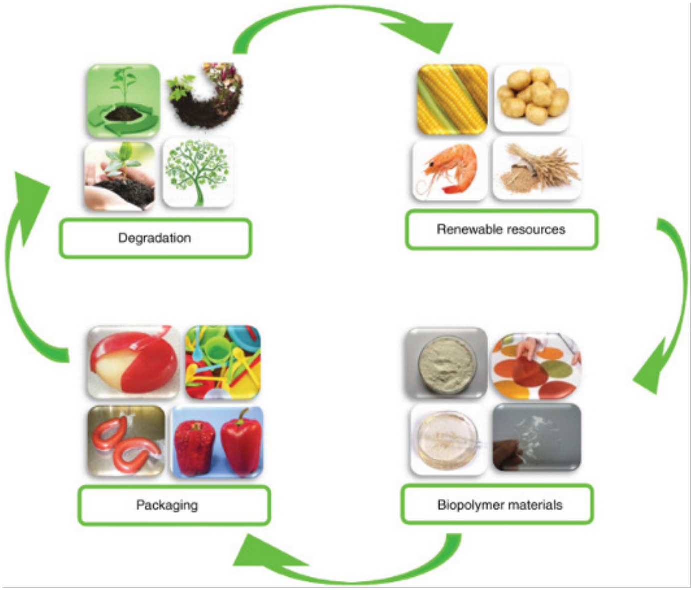
In short, biodegradable plastics are likely to become even more widely used in the future. This is a positive from an environmental perspective but will also require countries to develop infrastructure for optimal recycling of these materials. Gradually, they will allow us to reduce our reliance on oil-based plastics and non-renewable resources, as well as reducing greenhouse gas emissions.

Plastic is one of the most common materials in the world in the manufacture of food packaging. These can be made only of plastic or formed by a layer of plastic on another material such as metal or paper. There is also another option: the use of recycled plastic, which can be used, under certain conditions, in contact with food, as admitted by the European Food Safety Authority EFSA.

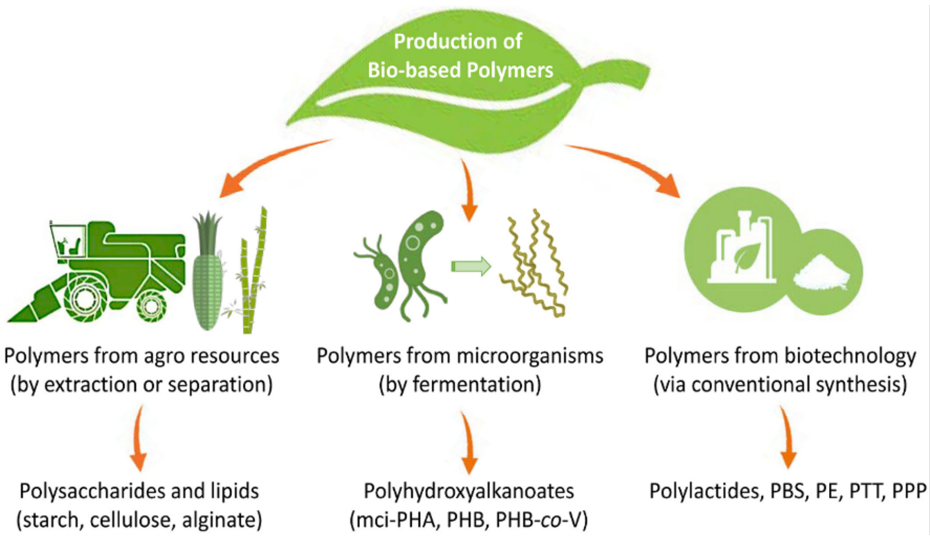
In 2008 European legislation regularizes the use recycled materials throughout Europe. Regulation (EC) 282/2008. A functional barrier is a layer on the inside of food contact materials and objects that prevents the migration of substances behind it into food. Only materials that contain recycled plastic that is obtained from an authorized recycling process, and on which EFSA issues a favourable opinion, can be marketed. If the evaluation is positive, the European Commission includes the recycling process in an European Registry. The recycling process must eliminate contamination or reduce it to levels that do not pose a risk to human health. To recycle PET plastic (one of the easiest to recycle) destined for the manufacture of new packaging for food and beverages, only plastic for food grade can be used. One of the problems is that the amount of good quality food grade PET is limited, which makes it a more expensive product than new PET.

Biopolymer containers.

In order to increase sustainability in the food industry, while maintaining product quality, the use of biopolymer packaging materials presents an attractive, eco-friendly alternative to synthetic polymers due to availability, low cost, and renewable raw materials and agro-industrial waste (biomass) usage. Materials used for biopolymer preparation are polysaccharides, proteins, or lipids, based on the compositional units. In order to improve biopolymer material properties, they can be laminated or formed as composites. In addition, biopolymer materials can be edible and/or active with strong antioxidant and/or antimicrobial properties.



The use of biopolymers brings new opportunities, not only from the point of replacing conventional polymers and other materials that are widely used in food packaging (glass, paper, metals, etc.), but also in the way it opens up a whole new level of properties and characteristics. Bio-based resources are the base source for production of biopolymers in food application, while in practice, bioresource content may be different. Biopolymers can be produced by microorganisms through fermentative processes of different bioresources [e.g., polyhydroxyalkanoates (PHAs)] and biomass may be produced directly from different kind of plant (starch, cellulose, etc.).



Natural food ingredients in food industry: Concepts and characteristics

Food additives are a large group of substances that are added to foods either directly or indirectly during the growing, storage or processing of foods for one or more of the following purposes:

1. Improve or maintain nutritional value
2. Enhance quality
3. Reduce wastage
4. Enhance consumer acceptability
5. Improve keeping quality
6. Make the food more readily available
7. Facilitate preparation of food

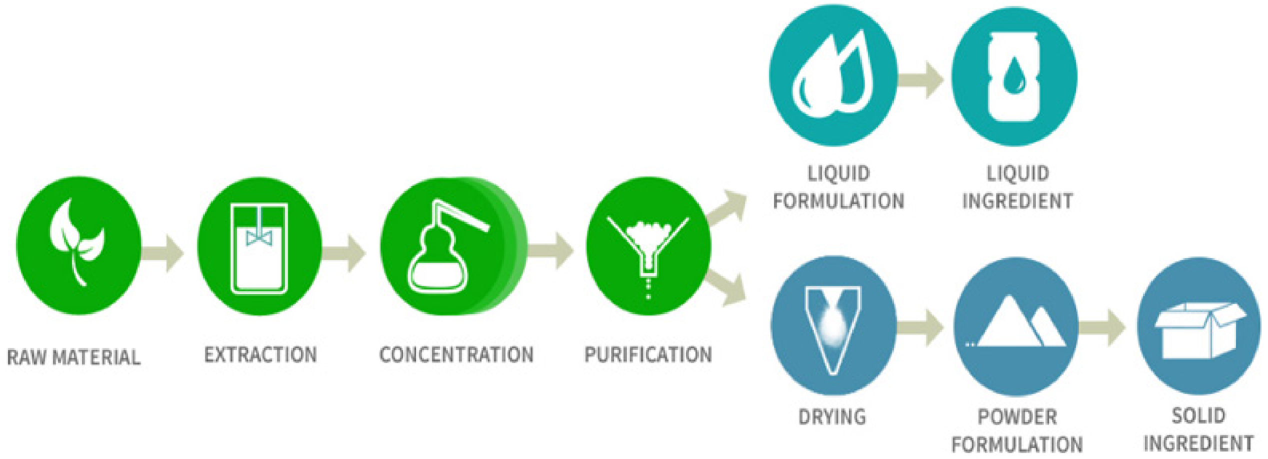
In the United States of America, FDA refers to natural ingredients as "ingredients extracted directly from plants or animal products as opposed to being produced synthetically". According to the Natural Ingredient Resource Centre (www.naturalingredient.org)

Natural Ingredients are:

- grown, harvested, raised and processed in an ecological manner.
- not produced synthetically.
- free of all petrochemicals.
- not extracted or processed using petrochemicals.
- not extracted or processed using anything other than natural ingredients as solvents.
- not exposed to irradiation.
- not genetically engineered & do not contain GMOs (genetically modified organisms).

Natural ingredients do:

- not contain synthetic ingredients.
- not contain artificial ingredients including colours or flavouring.
- not contain synthetic chemical preservatives



Classification of natural ingredients

Natural In gredients can have technological effects: colouring, sweetening, regulate the acidity, act as antioxidants, preserve, enhance the flavour, etc.
Natural Ingredients can be classified into:
- Natural colourings
- Natural sweeteners
- Natural acidity regulators
- Natural antioxidants
- Natural preservatives and antimicrobials
- Natural flavour enhancers
- Natural functional ingredients
- Natural emulsifiers and stabilizers.

The most demanded natural ingredients are those with antioxidant and/or antimicrobial effects.

Industrial use of natural food ingredients.

One of the keys to success when developing a food product is to know the various basic ingredients that are added to foods, as well as how they are used. The most extended Natural Ingredients in the food industry are: Flavours, Colorants, Antioxidants, Antimicrobials, Stabilizers and Acidity regulators. For functional foods are of high importance the Natural functional ingredients. All of them give the industry the option to use the Clean Label with the important benefits that this implies.
Flavours

Natural flavours can be used in all the food and beverage industries: bakery, confectionery, dairy goods & ice cream, soft & alcoholic drinks, savoury products (ready meals, pies, soups, snacks, etc.) and many other industry sectors.

Flavours are available in liquid, spray dried encapsulated powder and emulsion forms. For some applications, like bakery, they must be tested to remain stable in the very high temperatures and stresses of the manufacturing processes

Natural colours and extracts

Natural colours and natural extracts are both healthy and help food to look its most delicious. Any chef will tell that “we eat with our eyes first”, which means the appearance of food is as important as the taste. Natural colours are designed specifically to enhance the look of food, while keeping it healthy and natural, for most applications and technological processes. Unlike colours, natural extracts (including botanical and herbal extracts) are multi-functional as they combine colour with flavour and natural antioxidants to create a well-rounded food enhancing product. It must be ensured that pH, dosage level, exposure to light and processing temperature are all correct. Natural extracts and colours can be found come in different strengths and solubility to suit every technological process and food product (water soluble, oil soluble and spray dried forms).

Natural antioxidants

Natural antioxidants provide an effective alternative to the synthetic antioxidants traditionally used in the food industry. It is well known that antioxidants play a key role in maintaining the flavour and colour integrity of food products, but natural antioxidants also help protect the nutritional quality of food. With several different naturally-sourced options available, these label-friendly products can be used in a large variety of applications to keep your foods tasting better, looking better and lasting longer.

Natural antimicrobials

Bacteriocins are antibacterial proteins produced by bacteria that kill or inhibit the growth of other bacteria. Many lactic acid bacteria (LAB) produce a high diversity of different bacteriocins. Though these bacteriocins are produced by LAB found in numerous fermented and non-fermented foods, nisin is currently the only bacteriocin widely used as a food preservative.

Natural stabilizers

Chemical modification of gums and starches is widely performed to improve functionality and enhance stabilizing properties. However, the modified compounds can no longer be claimed as natural. U.S. definitions of the term are strict, especially as applied to stabilizers. Natural gums and starches are not chemically modified, just isolated from the plant to obtain a concentrated, more commercially viable food ingredient. For centuries, we have derived hydrocolloids from products biosynthesized naturally by plants.

Naturally occurring water-soluble gums exhibit a wide variety of functions: thickening, texturizing, film-forming, water-binding and/or gelling properties, given specific conditions. The properties of these complex carbohydrates are affected by many factors: functional groups as constituents; molecular size; orientation and molecular association; water-binding and swelling; concentration; particle size; and degree of dispersion. Food-grade starches come from corn, tapioca, potato, rice, sorghum, wheat and other cereals, and from roots, e.g., potato and tapioca. Potato and tapioca starches have relatively higher molecular weight than cereal starches and, at low temperature, have less of a tendency to undergo retrogradation (e.g., crystallization).

Natural acidity regulators

Acidity regulators, or pH control agents, are food additives added to change or maintain pH (acidity or basicity). They can be organic or mineral acids, bases, neutralizing agents, or buffering agents. Natural acetic (vinegar), citric (lemon), malic (apple), etc., acids may be found for their use in the food industry.

Functional Ingredients

Functional Ingredients are natural ingredients that have:

- Health-promoting
- Energy boosting and/or
- Disease preventing benefits

They have gained increasing popularity in the food industry, and there are a surprising range of benefits available.

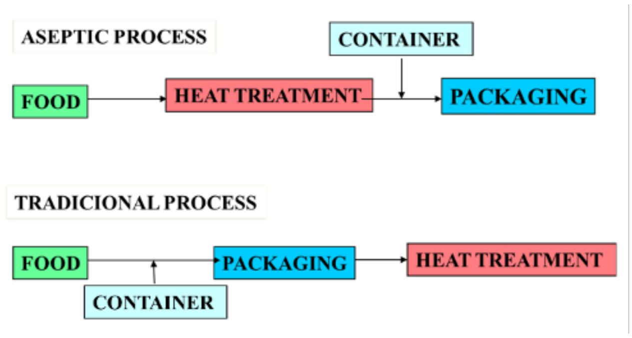
Nutraceuticals

The word is a contraction of nutrients and pharmaceuticals which hints at their functional nature. These products are widely used in health food, functional drinks and pharmaceutical applications. The consumption of Nutraceuticals is claimed to improve the overall health and well-being of a person. Phytonutrients are health-supporting compounds found in fruit, vegetables, nuts and herbs. They are used in functional foods and are known as a specific category of nutraceuticals. They act specifically as antioxidants, cholesterol fighters or immune boosters. Labels with fewer additives and ingredients as much natural as possible: They are called “clean labels”, one of the most frequent demands by consumers today. To reduce the amount of numbers “E” and to incorporate “free” claims. But it is not easy to adapt food products to this demand, without this implying lower the quality of the products and without this implying an additional cost.

5.6 ASEPTIC PROCESSING AND PACKAGING SYSTEMS.

Introduction

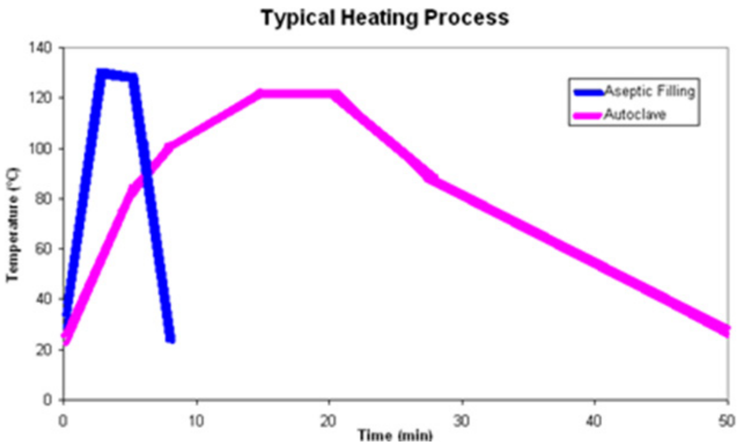
Aseptic processing and packaging are the filling of a sterilized product in pre-sterilized containers, followed by aseptic hermetic sealing with a pre-sterilized closure in a microorganism-free atmosphere. Aseptic packaging is an alternative technology to the classic heat treatment in autoclaves with great potential use in liquid and crushed food products; especially in dairy products, foods for infants, those especially aimed at the elderly and the fourth age or other products of habitual consumption such as broths, creams, soups, sauces, purees, juices and drinks in general. Thanks to this technology, the products are no longer exposed to long-term heat treatments that affect the nutritional and organoleptic quality of the food. The fundamentals of this technology lie in the filling of the previously sterilized containers with the food product that has also been previously sterilized. This process must be carried out under aseptic conditions, to subsequently seal the containers hermetically and avoid contamination. While in the traditional methods the heat treatment is applied to the already packed product affecting the container and food, in aseptic filling it is applied only to the food and not to the container. This reduces the time used in the heating and cooling processes of the food.



To obtain these aseptic conditions, a system must be incorporated into the production and packaging equipment that allows maintaining microbiological safety that involves the following aspects:

- Sterilization of the packaging environment and equipment that will be in contact with the food.
- Use of sterile containers that have a sufficient tightness to prevent microbiological recontamination and maintain the commercial sterility of the product after packaging.

Both the container and the closure method used must be able to prevent the passage of microorganisms into the already sealed container during storage and distribution, so it is important that the packaging has barrier properties to minimize chemical changes in the product during storage. Sterilization equipment for aseptic packaging improves food heating and cooling processes, reducing them to the shortest possible times, in contrast to conventional heat treatments in autoclaves that require high treatment times.



Higher heat treatments that products undergo in conventional autoclaving processes can lead to undesirable damage to the product, caused by chemical changes or degradation caused by temperature, for example changes in colour, texture, taste, or reduction in nutritional properties as loss of vitamins.

Why is aseptic technology successful?

The main reasons for the great development of aseptic packaging, and that make it considered today as one of the most widespread packaging technologies with the greatest future are:

1. It allows a better adjustment of the heat treatment to the real conditions of the product, that is, a reduction of the necessary treatment time at a certain temperature, with benefits in the quality of the product.
2. Sensory and nutritional improvement. In food, as it undergoes less heat treatment, physical-chemical changes (texture, colour and flavour) are reduced as well as the loss of nutrients that take place during the prolonged thermal process.
3. The formation of unwanted volatile compounds (as furans) due to overheating is avoided.
4. More natural products since it avoids the need to add chemical preservatives in non-sterile products.

5. Lower requirements for packaging materials. Since the packaging materials are not heated as in conventional autoclave sterilization processes, they do not need to withstand the high treatment temperatures nor are they subjected to the corresponding mechanical stress. On the one hand, the mechanical and structural needs of the container are lower, which can translate into a reduction in the thickness of the container (lower cost). On the other hand, the range of possible materials to be used in aseptic packaging is considerably expanded.

6. Reduction of migration from packaging materials. Migration is a physical-chemical process strongly dependent on temperature, that is, it increases exponentially when high temperatures are used.

7. Less environmental impact. The estimate Carbon Footprint is lower, mainly due to the reduction of energy consumption (electricity and water vapor) and the lower requirements regarding resistance of the container, which can lead to a reduction in the amount of material required.

8. Cost reduction. Although the initial investment in equipment is higher (60 - 65% depending on the volume), it pays off in an approximate period of 2 years (more than acceptable) due to its lower costs (labour, energy, packaging, water, cleaning / disinfection and environmental fees).

9. As it is a continuous process with a high degree of automation, the needs for variable labour and energy are reduced, which also implies a proportional reduction in fixed costs. It also presents a lower cost of the container as already mentioned. Less water consumption by being able to use an ozone-CIP in cleaning / disinfection. Less floor space is also required for installations.

In resume, the many advantages, both in reducing costs and in increasing the nutritional and sensory quality of the product, make the investment in equipment and facilities pay off in a relatively short time. Therefore, aseptic packaging is considered one of the most relevant food processing technologies and with the greatest potential scope of application.

Aseptic processing systems.

Although the equipment for aseptic processing systems varies, all systems have certain elements in common.

Food treatment:
- A pumpable food product
- A means of controlling and documenting the rate of product flow through the system.
- A method of heating the product to sterilization temperatures.
- A method of holding the product at an elevated temperature long enough for sterilization.
- A method of cooling the product to fill temperature.
- A means of sterilizing the system prior to production and maintaining sterility during production.
- Adequate protections to protect sterility and prevent non-sterile product from reaching the filling equipment.

Packaging:
- Separate sterilization of the container.
- Maintaining the asepsis of the container, the product, and the place of packaging.
- Introduction of the cold product or at room temperature in the container or container without allowing any contamination.
- Watertight closure of the full container.

Aseptic food treatment: Thermal and cooling processes.

A heater heats the food product to sterilization temperature. There are two main categories of food heaters in aseptic processing systems: Direct and indirect heating.

Aseptic food packaging.

Aseptic containers are those in which the product is filled under sterile conditions in containers that have been previously sterilized. Then, the thermoformed plastic container is hermetically sealed. The first aseptic packaging equipment began with milk in Brik cartons in the 1950s, now moving to PET containers (polyethylene bottles) and multilayer plastic bags pre-sterilized with Gamma rays.

Different types of containers can be sterilized by various means:

metal cans: superheat to sterilize containers
- Preformed plastic bottles: hydrogen peroxide and heat, or saturated steam
- Packages formed from laminated paperboard: hot hydrogen peroxide, or hydrogen peroxide and ultraviolet irradiation
- Thermoformed containers: extrusion temperature (dry heat) or hydrogen peroxide and heat
- Plastic bags: gamma irradiation, heat extrusion, or by chemical agents such as hydrogen peroxide

5.7 SHELF-LIFE STUDY OF FOOD PRODUCTS: DETERMINATION OF "BEST BEFORE" DATES

Shelf-life definition.

Shelf-life is defined as a period of time for which a product remains safe and meets its quality specifications under expected storage and use. Shelf-life study is an assessment of the growth of microorganisms likely to be present in, or able to cross contaminate a batch of product.

Shelf-life studies should be carried out in the following circumstances:
- new or modified product development,
- new process development or modification,
- new packaging development,
- any significant change of ingredient/s or packaging to an existing product,
- changes in the production site or production equipment, or
- no shelf-life studies have been performed previously.

What are "use by" or "best before" dates?

Shelf-life determines the durability date and is expressed as a "use by" or "best before" date. The application of each type of expiry date is laid down in the Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the Provision of Food Information to Consumers as well as in other guidance documents.

However, the terms "Use By" and "Best Before" are not interchangeable and should be applied as follows:

USE BY: Must be used for those foods which are highly perishable from a microbiological point of view. After a relatively short period, these foods are likely to present a risk of food poisoning. Typically, this form of date coding is found on fresh and ready to eat foods such as cream cakes or cooked meat. After the 'use by' date food is deemed unsafe and it is a criminal offence to sell it.

BEST BEFORE/BEST BEFORE END: This kind of expiry date is used to indicate the period for which a food can reasonably be expected to retain its optimal conditions and so relates to the quality of the food. This date is the point at which the taste or eating quality may begin to decline. The food will still be safe to eat beyond this point, but it will not be at its best

.

In view of the vast range of food products, the expected shelf life related to the quality of the product can range from a few days (bread and baked goods) to greater than a year (canned goods, dry goods, frozen food). Similarly, the 'best before' date accommodates the wide range of shelf life applied to such products. Accordingly, the Regulation recognise that the format of the coding needs to be flexible for the range of dates covered. For a shelf life under 3 months, an indication of the day and the month is sufficient; between 3 months and 18 months an indication of the month and year is sufficient; for more than 18 months, an indication of the year is the minimum required.

What factors affect shelf life?

The following factors affect the shelf life of a food product:

Raw materials

If incorporated into another product without being processed or significantly changed (e.g. chilled ham placed on a chilled raw pizza or included in a sandwich), the life of the final product should not exceed the life declared for the raw material. If a raw material is changed during processing (e.g. by being cooked) or if the storage requirements change (e.g. chilled raw material but frozen final product) the life given to the final product should be re-assessed. The food safety controls used to set the raw material life should be understood to ensure that any impact a change may have is understood. Examples are: if a raw material has a long shelf life due to being very dry (low Aw) and it is then added to a wetter product (higher Aw), the shelf life is likely to reduce. If packed in Modified Atmosphere Packaging (MAP), the shelf life only applies whilst the packaging remains sealed and the shelf life may significantly reduce when the package is opened e.g. a bag of salad is opened and the salad added to a sandwich. Even if MAP has not been employed, fresh produce will naturally modify the atmosphere in the pack and so again opening the pack may have an impact on the remaining life.

Product description

The type of recipe (e.g. sliced honey roast ham) is not sufficient information on which to base the shelf-life of a product and therefore it is inadvisable to simply copy the life assigned to someone else's product or from a similar in-house recipe. For products where Listeria monocytogenes is a hazard, shelf life must be established according to Annex II of Commission Regulation (EC) 2073/2005 on Microbiological Criteria for Foodstuffs. Controls used in a designated ingredient to ensure food safety such as pH, type of acid, preservative, water activity and humectant may be specific to that ingredient and may not be of the same type, added in the same quantity or may not be present at all in similar ingredients. Once combined in a recipe, their effectiveness may also be reduced or increased on interaction with other ingredients. The mix and quantity of ingredients used in the recipe may also affect parameters such as leaching of colour in layered product or the rate of fat oxidation, which in turn can influence consumer acceptance and therefore the shelf life of the product.

Type of packaging

Use of MAP for the food may give a longer shelf-life than would otherwise be possible. Vacuum packaging can extend product life by removing all air from a package which is then sealed. The removal of the air is the key factor for preservation in these products although it should be noted that for some chilled foods this can increase the risk from some types of food poisoning bacteria, e.g. Clostridium botulinum, that will only grow in the absence of oxygen and in such cases additional controls will be required to be used in combination. 'Active' packaging materials in the form of sachets or altered packaging materials may be used to extend life either by adding or removing gases (e.g. oxygen) from a pack or by controlling the rate at which certain gases can pass through the film. Different packaging materials may react differently on contact with food and consideration should be given to potential migration of chemicals from different packaging materials over time.

Temperature

The temperature to which foods are exposed may greatly affect the length of time that a food remains safe or of a suitable quality for consumption. Selection of the most appropriate temperature regimes and applying them consistently is therefore extremely important not just for finished product but also during preparation. While instruction may be given for a food to be stored at +5° C or below, as it is reasonable to expect higher temperatures to occur in a consumer's car and that the food will actually be held at below +8° C due to the normal operating temperature of a domestic fridge, these temperatures must be taken into account when setting the shelf-life. In some cases, the difference between the safe shelf life that can be obtained under ideal conditions and the shorter shelf life that occurs when allowing for such abuse is referred to as a 'buffer'. However, it is advisable to think of this as a safety zone designed to protect both the consumer and the manufacturer or seller of the food

Hygiene

Product design and assessment in isolation does not provide enough information to enable the setting of shelf-life in relation to food safety. It is therefore important to consider the personnel hygiene as well as the hygienic design of the building, processes, equipment's and storage.

Process design

Bacteria are highly unlikely to be completely absent from anything other than highly specialised food production areas or types of foods (e.g. NASA's meals for astronauts) and so it is important to build up a clear picture of where bacteria may exist, how quickly numbers increase and how they might contaminate the food. The effectiveness of cleaning, the length of time equipment is used before being cleaned and the sources of bacteria should therefore be carefully assessed. It is advisable to make use of laboratory testing to analyse findings and validate hygiene programs.

Equipment design and storage

The harder equipment is to clean and the longer it takes to clean, the less likely it is to be cleaned and disinfected effectively. It is unlikely that equipment will remain in a hygienic condition indefinitely without specific controls being applied. The frequency of use and the controls in place to prevent recontamination of clean equipment should therefore be understood before deciding upon the shelf-life to apply.

Expected usage after opening

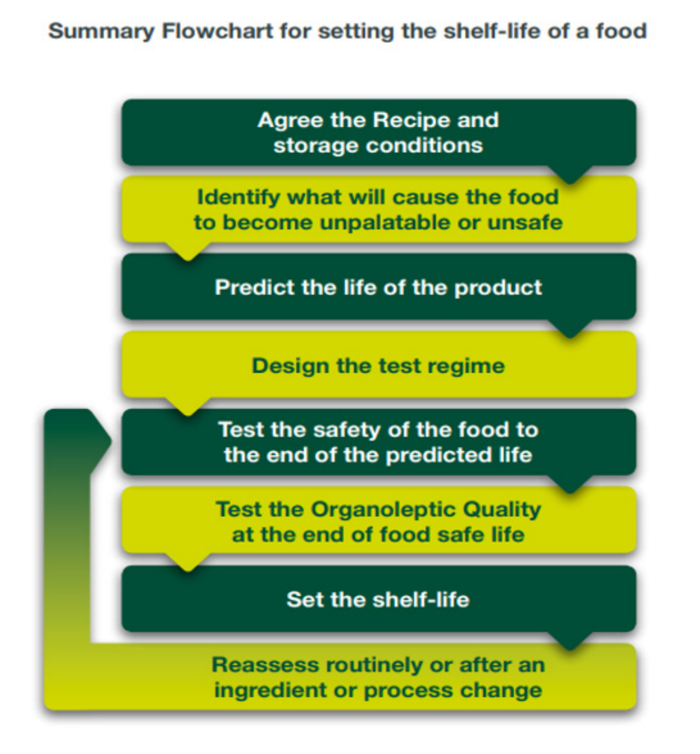
Different foods can be expected to be used in different ways: from a packet of cereal being opened and lasting a few weeks to an ice cream lolly that is likely to be consumed immediately on opening. Where there is any likelihood of a foodstuff not being consumed immediately on opening, this secondary or open life must also be allowed for taking into account all of the factors described above in relation to the food and the consumer's environment such as a domestic kitchen. It is a legal requirement to provide the consumer with any special instructions 'if they will need them to use the food appropriately'. This includes instructions on preparation such as defrosting or cooking, how to store the food once the package is opened, or to consume immediately.

Validating the shelf-life proposed for a food

Once the above factors have been understood and a shelf-life proposed, testing will need to be undertaken to identify the actual life of the product. This must consider both the shelf-life assigned to the unopened pack and any secondary use-by instructions that apply after the primary package has been opened. Shelf-life prediction software is a useful tool for identifying the possible life that may be achieved based on data entered for several parameters. The food to be tested must be made in exactly the same manner and on the same equipment as will be used during a normal day's production. Where a long production run is applied, consideration must be given to all factors that may impact the shelf life. It is therefore advisable to take samples throughout the production periods. Both the organoleptic quality and the food safety standards achieved will need to be tested which in general will require the use of taste panels and microbiological analysis as a minimum. As the organoleptic qualities of the food will generally require the food to be eaten, it is highly advisable to first undertake microbiological testing of the food to provide assurance that it is safe to eat on the day of testing. If any legal claims are made (e.g. in respect of nutritional content) then this will also need to be checked because nutrients may degrade over time.

When deciding upon the test method, reference should be made to customer and legal requirements, both of which may require pathogen testing to be undertaken e.g. legislation and guidance in relation to the presence of Listeria monocytogenes or Clostridium botulinum.

It is also advisable to ensure that accredited test methods are being used. Where a specific pathogen and/or spoilage microorganism is identified as likely to be present in a food then challenge testing may be appropriate. However, expert advice should be sought to ensure that all the limitations of such testing are fully understood. Once a shelf-life study has been validated and the product is placed on sale, repeat testing should then be scheduled even if no obvious changes have been made to the recipe. This will ensure that any variation that may occur within the supply chain, affecting ingredient quality without your knowledge, is also considered.



- Make use of technical expertise
- Ensure that shelf-life trials are carried out using the same ingredients as are to be used in the production plant, and using the same factory equipment and procedures in the manufacturing environment as will be used during standard production
- You cannot copy the shelf-life assigned to a similar product
- Do not extend the life of the original ingredient(s) unless you have altered them in some way that enables the extension e.g. cooking and have validated that it has been effective
- If an ingredient is changed, it must be reviewed its effect on the finished product's shelf life
- Do not rely solely on shelf-life prediction software
- Routinely schedule end of shelf-life safety and quality testing
- Assume the food will not be kept in perfect conditions after it has left your control

5.8 OTHER INNOVATIVE TECHNOLOGIES

Introduction

To meet the demands of the 21st century consumer (convenience foods, higher sensorial and nutritional quality, additive free/natural, functional products, etc.), food companies need to innovate by using the latest non-thermal technologies. Thermal methods, traditionally used in the food industry for food preservation, carry disadvantages like vitamin destruction or flavour changes that can be avoided with non-thermal or innovative technologies. In this chapter you will learn about the most innovative food technologies.

What is High Pressure Processing HPP?

High Pressure Processing is a cold pasteurization technique by which products, already sealed in their final package, are introduced into a vessel, and subjected to a high level of isostatic pressure transmitted by water. High pressures inactivate the vegetative flora (bacteria, virus, yeasts, moulds and parasites) present in food, extending the products shelf life importantly and guaranteeing food safety. HPP respects the sensorial and nutritional properties of food, because of the absence of heat treatment, and maintains its original freshness throughout the shelf-life.

High Pressure Processing Technology (HPP) main advantages:

- Characteristics of the fresh product are retained. Sensorial and nutritional properties remain almost intact. Greater food quality.
- Destroy pathogens (Listeria, Salmonella, Vibrio, Norovirus, etc.). Food safety is assured.
- Extends product shelf life. Lower claims, improved customer satisfaction.
- Reduces drastically the overall microbiological spoiling flora: Higher quality along shelf life.
- Avoids or reduces the need for food preservatives (Natural/Additive Free).
- New innovative food propositions. Products that cannot be thermally treated can now be High Pressure Processed. Innovative and competitive advantages
- Able to shuck mollusks or extract crustacean meat without boiling: Higher yields, fresh flavour, minimum hand labour...
- Only needs water (which is recycled) and electricity: Environmentally friendly

High Pressure Processing is an innovative although industrially mature technology that is consolidating its position as the most natural alternative for processing of a wide range of food products. HIPERBARIC equipment provide a technological solution totally in line with the requirements of today´s food market: natural, fresh, safe and convenience foods. It can be used in a wide range of products: meat, seafood, ready-to-eat, vegetable and fruit products, dairy, juices.

What is Radiofrequency RF food processing?
The high frequency technique consists in exposing the product in flow to electromagnetic waves whose length and frequency are typical of radio waves.

Radiofrecuency (RF) main advantages are:
- The sterilization at low temperatures produces a considerable improvement of the organoleptic quality of the processed product (lower thermic deterioration).
- Longer shelf-life.
- Heating is instantaneous (50°C in 0,2 seconds) and uniform on the entire product mass.
- Considerably fewer residual deposits in the plant reduces the number of washings otherwise necessary: productivity of the plant is consequently increased.
- Easy upgrading of old plants by the addition of a radio frequency generator.

It can be used in Fruit & Vegetable Cubes, Marmalades & Jams, Fruit Jams for Yogurt & Pastries Milk based Creams, Milk and its by-products, Fresh Cheese Spreads, Vegetable Drinks, Fruit Puree....

What is Microwave (MW) food processing?

Although microwave heat treatment of food has been known since the late 1940s, it was not until the 1960s that household microwaves became popular, especially in the United States, where they were first used. The advantages over conventional treatments are speed, cleanliness, selective heating of the food, absence of contact with hot surfaces, cost reduction, quality improvement and energy saving.

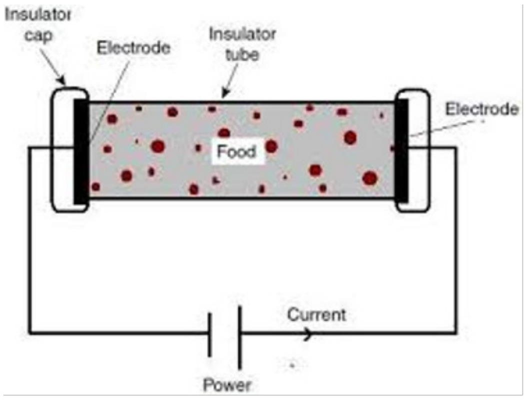
Lack of uniformity in temperature distribution is one of the biggest drawbacks of microwaves, since it affects the final quality of the product. Another disadvantage of microwave heating as opposed to conventional heating is the need for electrical energy, which is its most expensive form. Due to the absence of hot surfaces in contact with the food and the speed of the process overheating is avoided, preserving the quality of the processed product and reducing costs.

Microwaves (MW) main advantages are:
- The main advantage is the place where the heat is generated, namely the product itself. Because of this, the effect of small heat conductivities or heat transfer coefficients does not play such an important role.
- Therefore, larger pieces can be heated in a shorter time and with a more even temperature distribution. These advantages often yield an increased production

Microwaves have been used in recent years in applications such as the drying process during pasta manufacturing, blanching vegetables, and pasteurizing packaged foods. It has been proven that it could be particularly useful for pasteurization treatments at high temperature and short times and UHT of milk, cream, yogurt, sauces, purees and baby food.

What is Ohmic heating?

For food processing applications, ohmic heating may be defined as a process where an electric current is passed through the food with the main purpose of heating it. Under these circumstances, heat is internally generated due to the food's electrical resistance. And this simple fact is responsible for the particular characteristics of this technology. Ohmic heating is often placed among the so-called "novel food processing technologies". The main innovation brought by ohmic heating is the way through which it allows the heating of foods (internal heat generation). This makes all the difference from other commercially available heat processing technologies where heat is either transmitted by conduction or convection (as happens with most types of heat exchanging equipment).



Ohmic Heating (OH) main advantages are:

• In microwave heating, heating is achieved only in a certain depth of the product while ohmic technology heats the entire volume, no matter its size,

• Its ability to heat materials rapidly and uniformly: the over processing of the foods is therefore prevented and so is the further destruction of nutrients and flavour compounds, leading to a higher quality product, both from the nutritional and the organoleptic points of view.

• the involvement of no hot surfaces.

• high efficiency: once virtually all of the electrical power supplied to the system is dissipated as heat in the product (typical efficiencies of ohmic heaters are above 95%)

• possibility of handling slurries with high solid contents (products with up to 80 % particulates can be processed)

Despite these advantages, there are potential problems with ohmic heating; the main being related with products with low electrical conductivity values (e.g. those with high fat contents). In this case, ohmic heating might just not be applicable due to the high power input required to process such products.

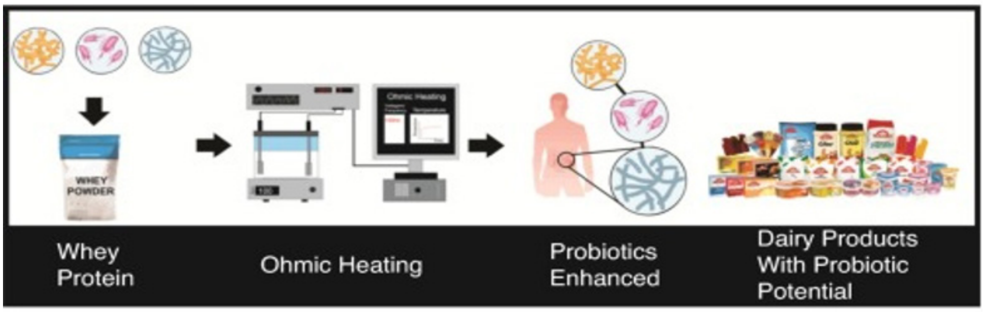
Other limitations include:

• the energy costs of electrical heating systems

• the limitation imposed by the minimum and maximum values of the electrical conductivity allowed

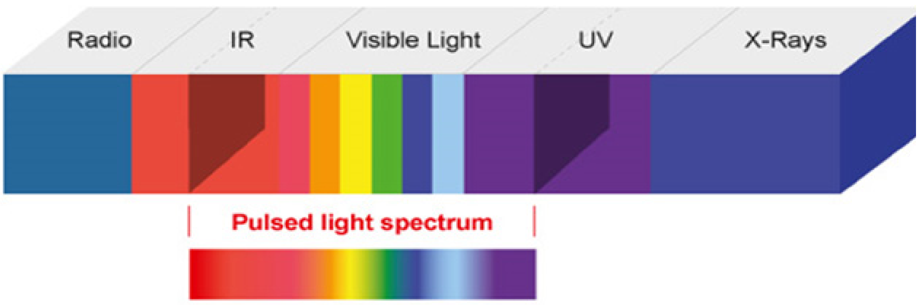
• the limitation imposed by the maximum power available from the local electrical supply

Ohmic heating can be considered a High Temperature Short Time (HTST) aseptic process. The potential applications of this technique in the food industry are very wide and include blanching, evaporation, dehydration, fermentation, pasteurisation and sterilisation. The advantages discussed above make ohmic heating especially useful for very sticky (viscous) materials or fluids containing solid particles; it may also be used wherever non-uniform heating must be avoided or where mechanical agitation to improve heat transfer is not recommended.



What is the Pulsed Light PL technology in food processing?

One of the novel technologies that has gained increasing interest in recent years is pulsed light (PL) technology. The potential applications can be clustered into three groups: sterilization/pasteurization of food, packaging materials and food contact surfaces; food enhancement in molecules of interest, such as vitamins; and the improvement of functional properties of some molecules. Pulsed light, which is sometimes known as pulsed ultraviolet light (PUV) or pulsed white light (PWL), is a versatile emerging technology that has been proposed as a feasible technique for different operations of interest in the food industry, from liquid food pasteurization to food enhancement.



PL technology is a good choice for surface decontamination of different kinds of solid foods such as fruit, vegetables, bakery products, meat products, fish and eggshells, obtaining reductions of up to five log cycles. The use of PL has been also proposed for water treatment and liquid food cold pasteurization, using continuous flow reactors.

In these kinds of food, the transmittance, especially UV transmittance, is the critical characteristic. Consequently, PL has been suggested for high transmittance foods like clarified juices. The treatment of liquid foods with poor transmittance, like milk, liquid egg, or smoothie, is now being investigated and some promising results have been obtained.

5.9 Basic points if you want to start working in a food industry

Food technologists, working in factories, universities and technological centres are those creative people that we also thank for new snacks, orange juice with extra calcium and new ice creams. Without food technologists' supermarkets would be boring.

Who invented corn flakes and marshmallows?
Who designs food for missions in space?
Who invents new containers?
Who works daily for the food safety?

If food companies want to be competitive, they must work hard to create new food products, new containers, assure food safety and quality, etc. This is not an easy task. People on charge of these activities, food technologists, work hard to give us the pleasure to find so many tasty food products in the supermarket. They work in laboratories and pilot plants (small factories), carry out sensory analysis (pilot tests) and consumers evaluation test, etc. Universities, Institutes and Technological Centres have specialised researchers and technologists that may play a very important role in the factory innovation activities.

If you work in a Food Industry you will have to control food quality and food safety:
In the laboratories:

- raw material inspection
- water quality
- package checking
- final product inspection

During processing:

- process measurements
- equipment performance
- high level of cleanliness
- equipment hygiene
- workers hygiene.

In the buildings:

• high level of cleanliness
• barriers to prevent entry of insects, birds, and rodents
• condition of roofs, walls, and pavements

In the warehouse:

• storage conditions
• labelling
• stock rotation

If you work in a food industry you will have to pay special attention to:

• Security: companies will not market food that is not safe.
• Responsibility: companies will assume responsibility for the food they produce, transport, store or sell are safe.
• Traceability: companies must be able to quickly identify their suppliers or customers.
• Transparency: companies will immediately inform the competent authorities if they have reason to think that the food under their responsibility is not safe.
• Emergency: Companies will immediately withdraw a food from the market if they have reason to believe they are not safe.
• Prevention: each company must know the risks that may appear in its manufacturing process and will control them.
• Cooperation: the companies will cooperate with the competent authorities in the actions undertaken to reduce the risks.

And remember "Just about everything we put in our mouths has been grown, manufactured, or packaged with the help of science and technology. And food safety is always present."

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Project Number:
2019-3-TR01-KA205-079155

2021