Paper No.: 02

Paper Title: The Principles of the Food Processing & Preservation

Module No. : 05

Module Title: Heat Preservation & Processing

5.0 Introduction

The safety and storage life of many perishable foods can be enhanced by the use of high temperatures to inactivate undesirable disease and spoilage-causing microorganisms and to inactivate enzymes in food that can cause spoilage. Three categories of thermal preservation of foods are

- Blanching
- Pasteurization
- Commercial Sterilization

5.1 Blanching: Blanching is a form of thermal processing applied mainly to vegetables and some fruit by exposing them to heated or boiling water or even culinary steam for a short period of time. Blanching is a food processing operation designed to

- Inactivate enzymes in plant tissues so that enzymatic degradation does not occur in the interval between packaging and thermal processing or during frozen storage or in the early stages of food dehydration and after reconstitution of dehydrated plant foods
- Wilt vegetable products to enable packing of the products into containers so that proper fill weights can be achieved
- Drive off inter- and intracellular oxygen and other gases from plant tissues so that containers are not deformed by excessively high internal pressures due to expanding gases within the container and to permit formation of a vacuum in the container after thermal processing.

5.2 Pasteurization: Pasteurization is a thermal process that involves using temperatures of at least 72°C for 15 seconds (high temperature short time or HTST process), prior to packaging. Acid food products (pH < 4.6) are mainly pasteurized to inactivate spoilage-causing microorganisms. Pathogenic microorganisms cannot grow and do not survive very well in acid foods such as citrus juices or apple juice (with the exception of Escherichia coli 0157:H7).

In low-acid food products such as milk, the basis for preservation by pasteurization is to inactivate pathogenic (disease causing) bacteria and viruses. Many spoilage-causing microorganisms can still survive typical pasteurization process conditions.For example, in milk, the proteolytic and lipolytic bacteria are more heat resistant and can survive the pasteurization process. This explains why the typical spoilage pattern of pasteurized milk reflects the proteolytic (protein degradation) and lipolytic (lipid degradation) action of the psychrotrophic, spoilage-causing bacteria. Because pasteurization does not kill all the psychrotrophic spoilage-causing bacteria in milk, pasteurized milk must be refrigerated to maintain shelf life quality. The durable life date on milk containers reflects the storage life that can be expected when milk is held at 4 °C or lower.

5.3 Commercial Sterilization (CS): The basis for preservation by Commercial Sterilization (CS) is to destroy both spoilage and disease causing microorganisms in low-acid and acid foods, thus rendering the food "commercially sterile".

5.4 Commercially sterile means the condition obtained in a food that has been processed by the application of heat, alone or in combination with other treatments, to render the food free from viable forms of microorganisms, including spores, capable of growing in the food at temperatures at which the food is designed normally to be held during distribution and storage". Therefore, commercially sterilization involves the destruction of spoilage-causing and disease-causing microorganisms. Commercially sterile foods may contain small numbers of thermophilic bacteria spores; however, the spores cannot germinate and produce actively growing cells at room temperature.

5.5 Canning: Canning involves heating the food with a minimum treatment of 121°C moist heat for 15 minutes.The process usually involves pre-sealing the food in containers prior to heating. Canning can be traced back to the early 1800's. It is called the"botulinum cook". Today, if a can of food is being sterilized, each food particle must receive the heat treatment (e.g. 121°C for 15 min). When food is placed in a can, the heat treatment will change since heat transfer to the food takes place at a slower rate. Depending on the size of the can, the time to achieve sterility could be several hours. Most commercially sterile products have a shelf life of 2 years or more.

5.6 Ultra-High Temperature Processing (UHT) and Aseptic packaging: The combination of UHT and aspectic packaging is another form of commercial sterilization. It involves the application of "ultra high temperature" (heat) to food before packaging, then filling the food into pre-sterilized containers in a sterile atmosphere. This process will render the food shelf stable or commercially sterile without the need for refrigeration. UHT- Aseptic packaging is a relatively new development whereby food can be heated to 140-150°C very rapidly by direct injection of steam, held at that temperature for short period of time (e.g. 4-6 seconds) and then cooled, in a vacuum chamber to flash off the water added in the form of condensed steam. This is carried out as a continuous flow operation. The decrease in processing time due to the higher temperature, and the minimal come-up time and cool-down time leads to a higher quality product.

The UHT processed food is packaged aseptically into pre-sterilized containers. These are usually cartons made from laminated plastic, aluminum and paper, which are chemically sterilized with a combination of hydrogen peroxide and heat, and then filled in the same piece of equipment which is housed in a sterile environment. There are other forms of packaging that can also be used in aseptic UHT processing: plastic cans, flexible pouches, thermoformed plastic containers, bag-in-box, and bulk totes. UHT-aseptically packaged products have a shelf life of **6 months or more**, without refrigeration. It depends on the type of packaging being used. For example, Tetra Pak cartons can eventually be more prone to perforations in the packaging layers, whereas the newer plastic bottles are more resistant to pin hole formation allowing them to have a longer shelf life.

Some examples of food products processed with UHT are:

- liquid products: milk, juices, cream, yogurt, wine, salad dressings
- semi-liquid/solid products: baby foods; tomato products, fruits and vegetable juices, soups

Contrary to popular opinion, UHT processed milk and juices do not contain added agents to provide the long storage life at ambient temperature in the laminated cartons. The products are preserved solely through the application of heat. It is critical that the sterilized products are transferred to packaging equipment under aseptic conditions, to avoid contamination after thermal processing. Please note that many products that are UHT treated are not aseptically packaged. This gives them the "advantage" of a longer shelf life at refrigeration temperatures compared to conventional pasteurized products. However, this does not produce a shelf-stable product at ambient temperatures due to the possibility of post-processing recontamination.

5.7 Selection of Heat Treatments

The intensity of the heat treatment employed for a particular food preservation application depends upon a number of factors. The main considerations in selecting the required temperature-time conditions for thermal processing are:

- What is the objective or purpose? (blanching or pasteurization or commercial sterilization)
- Are there additional preservation steps? (Is it combined with other preservation method?)
- What are the physical, chemical properties of the food? (Type of food)
- What is the heat resistance of microorganisms in the food?

Here are some examples to illustrate these points:

Foods that will be consumed within a short period of time after processing can have storage life extended by a combination of pasteurization and refrigerated storage (used for pasteurized milk and for pasteurized, vacuum packaged, cured meats). Longer storage times at ambient temperatures in evacuated sealed containers requires the use of commercial sterilization. The time-temperature combination required for pasteurization and commercial sterilization is determined by the most heat-resistant disease-causing and spoilage-causing microorganisms in the particular food commodity.

For a particular food commodity, the type of thermal processing operation and the rate of heat penetration into the slowest heating portion of the food within a particular container are governed by the food's physical properties (solid vs. liquid, or solid particles suspended in a liquid) and chemical properties (pH, fat content, presence or absence of heat-inducible thickening agents, food components that have protective or antagonistic effects on the thermal resistance of microorganisms). It is imperative that thermal preservation processes be designed so that the slowest heating portion of the food commodity receives the specified time-temperature thermal treatment to minimize risks of illness and/or post-processing spoilage.

The thermal processes applied to foods are governed by the heat resistance of the microorganisms in the food. In low acid foods which are to be thermally processed and vacuum sealed within gas-tight containers, the microorganism of most concern is Clostridium botulinum. The habitat of Clostridium botulinum can be soil (agricultural and forest), water (fresh, brackish and marine) and mud (fresh water and salt water). As a consequence, all foods of agricultural and fisheries origin must be considered as being potentially contaminated with Clostridium botulinum spores.

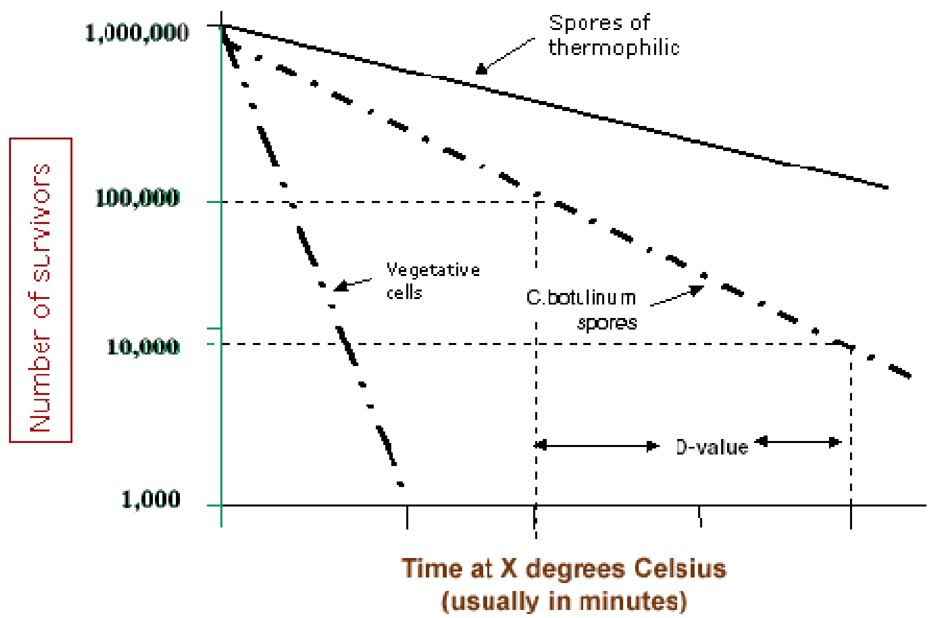
Thermal preservation treatments of low acid foods that are to be packaged and stored under anaerobic conditions must be designed to ensure the destruction of any Clostridium botulinum spores that may be present in the food with the provision of a wide margin of safety. Actively growing vegetative Clostridium botulinum cells produce a very potent neurotoxin.

5.8 Destruction of *C. botulinum* Spores: To determine the thermal resistance of heat-resistant spores in foods, "Inoculated pack studies" are carried out using a non-pathogenic spore-forming bacterium, *Clostridium sporogenes* PA3679 (a putrefactive anaerobe). Since PA3679 spores are more heat resistant than those of *Clostridium botulinum* spores, a process designed to kill PA3679 spores will definitely kill *Clostridium botulinum* spores with a wide margin of safety.

5.9 Determining the Appropriate Temperature and Time Needed

5.9.1 Thermal Death Curves: When microorganisms (bacteria, such as vegetative cells and spores, moulds, viruses and yeasts) are exposed to high temperatures capable of causing death of the organisms, one observes that the population is not killed instantaneously. We see that microbial death during thermal processing follows a logarithmic order. This means that bacteria are killed by heat at a rate that is nearly proportional to the number present in the system being heated.

Figure1: Thermal Death Time Curve



The survivor curve or thermal death rate curve plotted in the figure depicts the logarithmic order of death. You will note that the time taken to traverse one logarithmic cycle represents the time, at a constant temperature, required to kill 90% of a microbial population. The exposure of microorganisms to a specific temperature for a period of time required to kill 90% of the population is defined as the decimal reduction time or D-value.

While the **thermal death curve** describes the rate of death of a particular microorganism under a specified set of conditions. A **thermal death time curve** (figure 1) can be constructed from a number of thermal death curves by exposing the microorganism to a variety of temperatures and determining the decimal reduction time at each temperature.

The **thermal death time curve** provides information about the time required to kill a particular microorganism in a particular food at a variety of temperatures. All of the time-temperature combinations along the plotted thermal death time curve represent the same killing power, with lower temperatures requiring longer time of exposure. You should also note that any point above the line (e.g., 100 minutes at 110°C) will ensure that the microorganism is killed, while time-temperature combinations that fall below the plotted line (e.g., 100 minutes at 104°C) represent conditions that will not kill all of the microorganisms present. The thermal death time curve that vegetative bacteria cells have a much lower heat resistance than spores.

Foods that are a combination of solids and liquid components heat up by a combination of convection and conduction heating. Note the location of the cold points in relation to conduction heating (in the geometric centre of a cylindrical container) and convection heating (one third of the way up the centre axis measured from the bottom of the cylindrical container). The cold point of a container of food must receive the required amount of thermal energy to ensure killing of Clostridium botulinum spores that may be present and to ensure a sufficient margin of safety. If a food formulation is changed such that the mechanism of heat transfer is altered from convection heating to conduction heating, and if the processing times are not altered to accommodate the change in mechanism of heat transfer, the food could be under processed and could pose a potential health hazard with respect to botulism.