

High Temperature Food Preservation



- Heat kills microorganisms by changing physical and chemical properties of their proteins.
- When heat is used to preserve foods, microbial load is an important consideration.
 For example, bacterial spores are much more difficult to kill than vegetative bacilli.





Three basic heat treatments are used in food preservation:

 Pasteurization in which foods are treated at about 62°C for 30 mins or 72°C for 15-17 s

- Hot filling in which liquid foods and juices are boiled before being placed into containers
- Steam treatment under pressure, such as used in canning

Heat resistance of microorganisms is usually expressed as thermal death time (time necessary at certain temperature to kill stated number of particular microorganisms under specified conditions).



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Pasteurization

- 1. Process of heating a food-usually a liquid-to or below its boiling point for defined period of time.
- 2. The purpose is to destroy all pathogens, reduce number of bacteria, inactivate enzymes and extend the shelf life of food product.
- 3. Pasteurization kill most heat resistant non-spore forming organisms like *Mycobacterium tuberculosis* and *Coxiella burnetti*.
- 4. Permanent stability (shelf-life of about two years) is obtained with foods that can withstand prolonged heating, such as bottled juices.
- 5. There is a greater loss of flavour from foods that are exposed to a longer time-temperature relationship.
- 6. Temporary stability is only obtained with some foods where prolonged heating would destroy its quality.



- 7. "High Temperature Short Time" (HTST) and "Ultra High Temperature" (UHT) processes retain food's texture and flavour quality parameters.
- 8. Aims to reduce number of viable pathogens.
- 9. Heating may be done by means of steam, hot water, dry heat or electric currents.
- 10. Desired pasteurization can be achieved by combination of time and temperature such as heating food to low temperature and maintain for a long time i.e. LTLT -62.8 C for 30 min or by heating food to a high temp and short time: HTST-71.7 C for 15 sec.
- 11. Pasteurization is used when more rigorous heat treatment might harm quality of food product, as the market milk and for spoilage organisms which are not heat resistant, such as yeast in fruit juice.



Ultra heat pasteurization:

- Milk is heated to 120-138 C for 2-4 secs and followed by rapid cooling.
 - This treatment kills all spoilage microorganisms.
- UHT pasteurized milk is packaged aseptically resulting in shelf stable product that does not require refrigeration until opened.





Heat resistance of microorganisms and their spores

Thermal Death Time (TDT)

 Time taken to kill a given number of microorganisms/spores at certain temperature under specified conditions.

Thermal Death Point

 Temperature necessary to kill all the organisms in ten minutes.



Heat resistance of microorganisms

•Heat resistance of mold is 60 C in 5 to 10 min and asexual spores are more heat resistance than ordinary mycelium and require 5-10 C higher for their destruction.

•Aspergillus, Mucor, Penicillium are more resistant than yeast.

•Cells high in lipid content and capsule containing bacteria are harder to kill.

Heat resistance of enzymes

Food and microbial enzymes are destroyed at 79.4 °C.
Some hydrolases will retain a substantial levels of activity after an ultra high temperature treatment.
Bovine phosphatase, if present, in processed milk indicates that milk was not properly pasteurized.

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D-Value

D value (Decimal reduction time) is the time in minutes during which number of a specific microbial (cells or spores) population exposed to a specific temperature is reduced by 90% or 1 log (time required to reduce the population by a factor of 10, or by one log cycle). Expressed as DT = t min, where T is temperature (°C) and t is time (min) for 1 log reduction of microbial strain used.



For example, a D value at 72°C is 14 min means that for each 14 min of processing at 72°C, population of target microorganism will be reduced by 90%.

D value of organisms



Z-Value

It is the number of degrees the temperature has to be increased to achieve a tenfold (i.e. 1 log10) reduction in the D-value.

Z-value relates the resistance of an organism to differing temperatures.



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F-Value

F is the time in minute required to destroy microorganisms in a specified medium at 250 ° F.

12-D concept

- It is the time temperature process that will reduce most heat resistant *Cl. botulinum* spores by 12 log cycles.
- Processing of food for 2.52 min at 250 C reduces Cl. botulinum spores to 1 spore in 10¹² containers.



Effect of pasteurization

Food	Main purpose	Subsidiary purpose	Minimum
			processing
			condition
Fruit	Enzyme inactivation	Destruction of spoilage causing	65°C or 30 min
juice		microorganisms	77°C for 1 min
			88°C for 15 min
Beer	Destruction of		65-68°C or 20 min
	spoilage organisms		72-75°C for 1-4 min
Milk	Destruction of	Destruction of spoilage causing	68.2°C or 30 min
	pathogens	microorganisms and enzymes	71.7°C for 15 sec
Liquid	Destruction of	Destruction of spoilage causing	64.4°C or 2.5 min
	pathogens	microorganisms.	60° C for 3.5 min
Ice	Destruction of	Destruction of spoilage causing	71°C for 10 min
cream	pathogens	microorganisms	80°C or 15 min

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Blanching

A kind of pasteurization generally applied to fruits and vegetables, primarily to inactive natural food enzymes. A common practice when such food products are to be frozen, since frozen storage itself would not completely arrest enzyme activity.

Peroxidase and catalase are the most heat resistant enzymes; activity of these enzymes is used to evaluate effectiveness of blanching.

- Heating time depends on type of fruit or vegetable, method of heating, size of fruits or vegetable or temperature of heating medium.
- Rapid changes in colour, flavor and nutritive value occur as a result of enzyme activity.



- Blanching is a slight heat treatment, using hot water or steam, that is applied mostly to vegetables before canning or freezing.
- Main objectives of blanching are to inactivate enzymes, remove tissue gases, clean tissue, increase temperature of food.
- Blanching induces vacuum in canned goods, and also used to control fill into containers (spinach).

Vegetables	Blanching time(min) in water at 212°F
Beans	1-3
Beets	3
Corn	2-3
Peas	1-2
Spinach	1-2
Asparagus	2-12

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Sterilization (Retorting)

Sterilization destroys all pathogenic and spoilage microorganisms in foods and inactivates enzymes by heating.

All canned foods are sterilized in a retort (a large pressure cooker) and called commercial sterilization .

Food have a shelf life of more than two years.

- Foods of pH >4.6, such as meat and most vegetables must undergo severe heating conditions to destroy all pathogens. These foods are heated under pressure to 121°C for varying times.
- Severe conditions are applied to destroy Clostridium botulinum spores during processing.
- Spores are destroyed by heat or inhibited at pH of <4.6.</p>
- Destruction of vegetative and sporeforming organism and pathogens is secondary objective of commercially sterilized foods.

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Nicolas Appert, Parisian confectioner, established heat processing of foods in 1810.

The food product is washed, sorted, and graded and then subjected to steam for three to five minutes. This last process called blanching, destroys many enzymes in food product and prevents further cellular metabolism. The food is then peeled and cored, and diseased portions are removed.

- For canning, containers are evacuated and placed in pressurized steam sterilizer at 121°C (removes *Bacillus* and *Clostridium* spores).
- If canning is defective, foods get contaminated by anaerobic bacteria which produce gas (*Clostridium* and coliform bacteria).

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Canning cooking fruits or vegetables, sealing them in sterile cans or jars, and boiling the containers to kill or weaken any remaining bacteria as form of pasteurization. High-acid fruits require no preservatives to can and holding for only a short boiling cycle, whereas marginal fruits (tomatoes) require longer boiling and addition of other acidic elements.

- Many vegetables require pressure canning.
- Food preserved by canning or bottling is at immediate risk of spoilage once the can or bottle has been opened.
- Lack of quality control in canning process may allow ingress of water or micro -organisms.
- Clostridium botulinum produces no gas or taste and remains undetected by taste or smell.
- Food contaminated in this way include corn, beef and tuna.



Proper canning techniques stop this spoilage by heating food for a specific period of time and killing these unwanted microorganisms.

In canning process, air is driven from jar and a vacuum is formed as jar cools and seals.

Water-bath canning and pressure canning are two approved methods of canning.

WATER-BATH CANNING KETTLE



- 1. Referred as hot water canning, uses large kettle of boiling water.
- Filled jars are submerged in water and heated to an internal temperature of 212°F for specific period of time.
- 3. Used for processing high-acid foods (fruit, items made from fruit, pickles, pickled food, and tomatoes).



Pressure canning uses large kettle that produces steam in locked compartment. Filled jars in kettle reach an internal temperature under a specific pressure that is measured with a dial gauge/weighted gauge on the pressure-canner cover. Pressure canner should be used for processing vegetables and other low-acid foods (meat, poultry and fish).



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Drying

- Drying reduces water activity sufficiently to delay or prevent bacterial growth.
- Drying is done to produce concentrated form of foods, inhibits microbial growth and autolytic enzymes, retains most nutrients.
- Drying can cause loss of some nutrients (thiamine and vitamin C.
- Sulphur dioxide is sometimes added to dried fruits to retain vitamin C.
- Meat can be dried (pig meat, since it is difficult to keep without preservation).
- Fruits can also be dried (apples, pears, bananas, mangos, papaya, and coconut and grapes).







Drying is used for cereal grains (wheat, maize, oats, barley, rice, millet and rye). Several types of dryers: drum dryer, cabinet dryer, tunnel dryer, rotary dryer, spray dryer and solar dryer. Basic methods of drying involves air and contact drying under atmospheric pressure. Heat is transferred through food either from heated air or heated surfaces, and resulting water vapour is removed with air current.

Solar drying, sun drying, drum and spray drying use this technique.



Advantages of Drying



No refrigeration is required for dried products



Disadvantages of Drying



2.

 Changes in flavour and texture if drying is not properly controlled with regard to maximum temperatures

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Microwave Sterilization

- Microwave oven works by passing non-ionizing microwave radiation, usually at frequency of 2.125 GHz through food.
- Microwave radiation is between common radio and infrared frequencies.
- Microwave heating takes place due to polarization effect of electromagnetic radiation at frequencies between 300 MHz and 300 GHz.
- Delivers energy to food package under pressure and controlled temperature to achieve inactivation of bacteria harmful for humans.
- Microwaves interact with polar water molecules and charged ions.

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- The friction resulting from molecules aligning in rapidly alternating electromagnetic field generates heat within food.
- Colour, texture and sensory attributes of foods
 processed by microwave sterilization are often better
 compared with that of conventionally retorted foods
 while meeting microbial safety requirements.
- US Federal Communication Commission (FCC) allocates
 915 MHz and 21250 MHz bands for industrial and
 domestic microwave heating applications.
- Microwave sterilization technology using combination of 915 MHz microwave and conventional heating to improve heating uniformity.
- Microwave ovens use electromagnetic radiation to excite water molecules in food.



- Actual waves penetrate only about 10 inches from the source of the radiation. Within the food, waves only penetrate 3/12 to 1 inch on all sides.
- Heat is produced within the food by the friction of water molecules, which spreads to the centre of food by conduction.
- Small portions are cooked rapidly in microwave ovens.
- Microwave heating reduces process time and improve food quality.
- Microwave sterilization can achieve the same reduction of bacterial population as conventional retorting.



- Products intended for microwave sterilization are usually packaged in plastic trays/pouches.
- Ability of plastics to withstand oxygen permeation will affect organoleptic/sensory acceptance of product during storage.
- Normal shelf life expectancy of microwave-sterilized products pre-packaged in plastic containers or pouches is 2-3 years or longer.

Microwave sterilization





Applications

