Food Preservation By Use Of High Temperature

For

M.Sc IV sem

Paper – Food Microbiology

(401- B)

Unit I- Topic II

Introduction

- Heat is one of the oldest methods in food processing and preservation.

- The use of high temperature to preserve food is based on their destructive effects on microorganisms and their spores.

- The killing of microorganisms by heat is supposed to be caused by the denaturation of the proteins and especially by the inactivation of enzymes required for metabolism.

- The heat treatment necessary to kill organism or their spores varies with the kind of organism, its state and the environment during heating.

Factors affecting heat resistance of microbial cells or spores

Certain factors are known to affect the heat resistance of cells or spores and must be kept in mind when heat treatment for the destruction of an organism and type of food are considered.

1. The temperature-time relationship- **The temperature and time shows inverse relationship with each other. The time of killing cells or spores under a given set of conditions decreases as the temperature is increased.**

2. Initial concentration of spores (or cells)- **The more spores or cells present , the greater the heat treatment is required to kill all of them. It has been suggested that the mechanism of heat protection by large microbial populations is due to the production of protective substances excreted by the cells.**

3. Phase of growth or age- **Bacterial cells tend to be most resistant to heat while in the stationary phase of growth and less resistant during the logarithmic phase. Heat resistance has been reported to be high also at the beginning of the lag phase but decreases to a minimum as the cells enter the log phase. Old bacterial spores are reported to be more heat resistant than young spores.**

4. Water- The heat resistance of microbial cells increases with decreasing humidity, moisture, or water activity (aw). Dried microbial cells placed into test tubes and then heated in a water bath are more heat resistant than moist cells of the same type.

5. Composition of the substrate in which cells or spores are heated-

a) **Moisture-** Moist heat is a much more effective killing agent than dry heat, and as a corollary dry materials require more heat for sterilization than dry heat.

b) **pH-** In general, cells or spores are most heat resistant in a substrate that is at or near neutrality. An increase in acidity or alkalinity hastens killing by heat , but a change toward the acid side is more effective than a corresponding increase in alkalinity.

c) **Other constituents of the substrate-**

- The presence of **sugars** causes an increase in the heat resistance of microorganisms suspended. This effect is at least in part due to the decrease in water activity caused by high concentrations of sugars.

• **Proteins** in the heating have a protective effect on microorganisms. Consequently, high-protein-content foods must be heat processed to a greater degree than low-protein-content foods in order to achieve the same end results.

•The effect of **salt** on the heat resistance of microorganisms is variable and dependent on the kind of salt, concentration and other factors.
Some salts have a protective effect on microorganisms, and others tend to make cells more heat sensitive.

It has been suggested that some salts may decrease water activity and thereby increase heat resistance by a mechanism similar to that of drying, whereas others may increase water activity (e.g., Ca^{2+} and Mg^{2+}) and, consequently, increase sensitivity to heat.

Thermal Destruction of Microorganisms

Heat resistance of microorganisms are usually expressed in following terms:

Thermal Death Time (TDT) is the time necessary to kill a specific number of microbial cells or spores at a specific temperature under specified conditions. This sometimes is referred to as the absolute thermal death time. By this method , the temperature is kept constant and the time necessary to kill all cells is determined.

Thermal Death Point (TDP): Temperature required to kill a given number of microorganisms in a fixed time, usually 10 minutes.

Decimal Reduction Time (D Value) The D value is the time in minutes required to destroy 90% or 1 log of microorganisms. Ex: The 12D concept is used in heat processing of high-pH foods (pH > 4.6, low acid foods such as corn, beans, and meat) to destroy the most heat-resistant spores of the pathogenic bacteria Clostridium *botulinum*. It means that the products are given heat treatment to reduce the population of C. *botulinum* spores by 12 log cycles. The 12D value at D121.1ºC is ca. 2.8 or ca. 3.0 min.

Heat treatments employed in processing and preservation of food

Development of several high temperature based methods like boiling, roasting, baking and other heat treatments are the greatest advance in food hygiene because such methods kills all the forms of microorganisms (vegetative and spore) and make the food safe.
Most commonly used methods of heat treatment used for food preservation are discussed below.

(1) Pasteurization (temperature – below 100^0 C)

(2) Heating at about 100^0 C

(3) Sterilization (temperature above 100^0 C) and

(4) Canning

1. Pasteurization

•Pasteurization is a heat treatment that kills part but not all the microorganisms present and the temperature applied is below 100^{o} C.

• The heating may be by means of steam, hot H_2O, dry heat or electric currents and the products are cooled promptly after the heat treatments.

•The surviving microorganisms are inhibited by low temperature (or) some other preservative method if spoilage is to be prevented.

•Pasteurization is used:

1. When more rigorous heat treatments might harm the quality of the products, as with the market mik.
2. When one aim is to kill pathogens, as with market milk
3. When the main spoilage organisms are not very heat resistant , such as the yeast in fruit juices.
4. When competing organisms are to be killed , allowing a desired fermentation, usually by added starter organism, as in cheese making.

Preservative methods used to supplement pasteurization include

(i) refrigeration e.g. of milk

(ii) keeping out microorganisms usually by packaging the product in a sealed container

(iii) maintenance of anaerobic conditions as in evacuated, sealed containers

(iv) addition of high concentration of sugar, as in sweetened condensed milk and

(v) presence (or) addition of chemical preservatives e.g. the organic acids on pickles.

Methods of pasteurization : Times and temperature used in the pasteurization process depend on the method employed and the product used.

-High temperature and short time (HTST)method - It employs comparatively high temperature for a short time . For milk it is 72°C for 15 seconds

Low temperature and higher time (or) Holding method (LTH) method – It uses a lower temperature for a longer time . For milk it is 62.8°C for 30 minutes.

•**These treatments are equivalent and are sufficient to destroy all yeasts, molds, gram negative bacteria, and many gram positives as well as the most heat resistant of the nonspore- forming pathogenic organisms *Mycobacterium tuberculosis* and *Coxiella burnetii*.**

•**The pasteurizing treatment of given fruit juices depends on their acidity and whether they are in bulk or in the bottles or can.**

•**Limitations: Though, this method kills the pathogens or bacteria present in the raw milk and makes is safe to consume without any health risk but there are few limitations discussed below:**

• **Due to loss of certain enzymes in food during pasteurization process, some people believe that raw milk is a better option to pasteurized milk.**

• **It is believed that milk pasteurized with HTST method may lose 1/3rd of the thiamine present in the milk and half of vitamin B12.**

• **Survival of heat resistant pathogens has increased the risk of the presence of bacteria even after pasteurizing the food.**

2. Heating at about 100^0 C

•This treatment is sufficient to kill almost all microbes but not spores.

•A temperature of approximately 100^o C is obtained by boiling a liquid food, by immersion of the container of food in boiling water or by exposure to flowing steam.

• Some very acid foods, e.g., sauerkraut may be preheated to a temperature somewhat below 100^o C, packaged hot, and not further heat processed.

•Blanching fresh vegetables before freezing or drying involves heating briefly at about 100^o C.

•Methods include :

1. Baking 2. Simmering (gentle boiling with the temperature about 100^o C.
3. Roasting 4. Frying 5. Cooking 6. Warming up 7. Blanching

3. Sterilization or heating above 100 ^{o} C

- This method uses temperature above 100^{o} C which are obtained by means of steam under pressure in steam- pressure sterilizers or retorts.

- By this method all microorganisms are completely destroyed due to high temperature. The time and temperature, necessary for sterilization vary with the type of food.

- Milk can be heated to temp. upto 150 C by use of steam injection or steam infusion followed by flash evaporation of the condensed steam and rapid cooling.

4. Canning process

• It may be defined as " the preservation of foods in sealed containers and usually implies heat treatment as the principle factor in the prevention of spoilage to destroy all kinds of microorganism including *Clostridium botulinium* spores".

•Canning (also known as hermetically sealed containers) is done in tin cans, glass containers, aluminium and plastic pouches.

•Canning process was developed by Nicolas Appert (called father of canning).

•In the process of canning, there is a careful preparation of food packed into a sealed tin, glass or plastic container which is subjected to defined high temperatures (above 100ºC) for an appropriate period of time and then cooled.

•During heating there is a removal of oxygen and further hermetic sealing of containers to avoid post-process contamination and boiling the food in the container to kill all the microbes and sealing the can (either before or while the food is in boiling process) to restrict and further prevent any new microorganisms from getting in.

•After the thermal processing, the sealed container must be cooled immediately to a temperature of about 38^{o}C to prevent unnecessary adverse effects of heat on the texture, flavour or colour of the food products.

•Thus, this sterilises the food so it will keep for a long period without any risk of spoilage by unwanted microorganisms .

This method involves the following steps:

1. Sterilizing the food products to be canned
2. Aseptic Packing (in sterile, air-tight stainless metal, glass or plastic containers) and
3. Hermetically sealing (with a complete, airtight seal)

➢Two approved methods of canning are :

1. Water-bath canning:

- It is sometimes referred to as the boiling-water method of canning or as hot water canning, is the simplest and easiest method for preserving high-acid food.

Filled jars are submerged in the water and heated to an internal temperature (100oC) for a specific period of time. This method is adequate to kill molds, yeasts, enzymes and some bacteria, making it safe for consumption at a later time .

•For example, acid foods such as fruit butters and spreads, fruit pie fillings, sauerkraut, pickles and pickled vegetables, jams and jellies can be safely processed by boiling water bath canning.

• Limitations- This method cannot be applied for processing low-acid foods as it never reaches super high temp to kill certain heat resistant bacterial spores or heat stable toxins.

2. Pressure canning-

•In pressure canning, a large kettle used and steam is produced in a locked compartment. The filled jars in the kettle reach an internal temperature of 116^{o}C under a specific pressure which is measured with gauge.

•It is useful for processing vegetables and other low-acid foods (i.e. meat, poultry, seafoods etc.).

• In such process, *C. botulinum* (the bacterium that causes botulism food poisoning), is destroyed in low-acid foods when they are processed at the correct time and temperature in pressure canners

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