UNIT8. Control of Microorganisms in Foods – Part 1

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Dear students in this chapter on control of microorganisms in foods part 1 you will learn about the principles and methods of food protection and preservation, which includes:

The standards for the number of microbes than is permitted in various food are specified in our country by Food Safety and Standards Authorities of India (FSSAI). Every company dealing with food needs to take their approval and adhere to the conditions laid by them. This is mainly to prevent the spoilage of food and further to take care of the consumer's health. They also lay down the standards for the containers, preservatives nutritional conditions, contaminants and storage. The details of FSSAI Laws will be dealt in another chapter.

Introduction: Nature provides protective coverings around the food. It may be in the form of shells of nuts, dry skins of cereals or thick skins of fruits and vegetables. In animal based foods, the shells of eggs, the rubbery skin or fat layers on meat or fish provides the protection. These protective coverings also prevent or delaysmicrobial colonisation and further decomposition.

The aim of food protection and food preservation is to prevent contamination and spoilage of foods. A number of food preservation methods are used today has their origin dating back to ancient time.

One of the most important waysto preventing contamination is by adopting good **food handlers' hygiene**. This includes a set of practices that should be followed by all the personals involved in handling food at any stage of the food supply process. Food handlers' hygiene in both retail and commercial premises, where food and drink is sold to customers is of critical importance.

The same principles should also be practiced at the domestic premises. The importance of good food handlers' hygiene is:

- To prevent food contamination and spread of disease.
- To ensure the good health of people eating the food.
- To protect the health of the food handler.

All the food handlers should avoid bad habits such as scratching, touching the hair, nose or mouth, having unclean hair, unclean and long fingernails. They should refrain from smoking, coughing or sneezing in food handling and preparation areas. They should be healthy and should not be carring any contagious diseases like skin infections, diarrhoea or sore throats. They should always wash their hands before they enter the premises where food is prepared or handled and after using the toilet.

Some of the general principles for preventing food contamination:

- Water used in food preparation should be of good quality and adhere to the standards specified by FSSAI.
- All the utensils must be kept clean and covered.
- All surfaces that come into contact with food should be well cleaned.
- The areas used for storage, preparation and serving of food should be free of pets, rats and insects.
- All type of prepared food should be clearly labeled, covered.
- Food and the utensils should be kept separate from chemicals and poisons.
- Cloths and handling aids that come into contact with dishes and utensils, and that are used to cover food, need to be changed daily and washed in hot water before use.

Food preservationmeans techniques that allow food to be kept for a specified, extended periods of time without losing nutritional quality. They should also prevent the growth of unwanted microorganisms. The three basic objectives of food preservation are

- Prevention of contamination of food from damaging agents.
- Prevention or delay of growth of spoilage microorganisms.
- Delay of enzymic spoilage due to the presence of naturally occurring enzymes within the food (self-decomposition).

During storing or preserving food, the conditions required for the spoilage systems have to be removed. Like we humans, microorganisms also need food and water. Further, they also need a suitable pH and temperature to grow. Hence, food preservation techniques aim to target and limit these requirements. Food preservation depends on the methods which effectively manage the microbial content of foods. They should also alter or delay the activities of enzymes in the food. These techniques may be applied separately or in combination. Thus the aim of food preservation should be to prevent contamination in the first place, to reduce the population of contaminants, and to prevent microbial growth.

Food can be damaged either by insects, animals or by mishandling. The damaged portions are then exposed for microbial attack. Therefore, care should be taken to minimize any damage to the foods. The pre-processing of food preservation divided into three stages of careful handling:

i. Proper packaging

ii. Quick and effective transportation

iii. Providing good storage facilities (silos for grains and cold storages for fruits and vegetables).

Once the food ingredients/raw materials are properly handled and managed the next step is Food preservation.

Food industry adopts several aseptic methods to prevent the contamination of foods during processing. Packaging of foods is to prevent contamination. The packaging material may range from simple wrappers to hermetically sealed containers of canned foods. Polythene bags and moisture proof wrappings like metal foils, mixtures of plastic, paper and foils are commonly used.

Various industries determine the process of food preservation based on their requirement. For example in the canning industry, the microbial load determines the temperature required to process. This is better known as aseptic canning. In the dairy industry, the quality of milk is judged by its bacterial content.

Some of the methods adopted to achieve good processed foods are:

Complete removal of microbes

Filtration is a method used for the complete removal of microorganisms. This method can be successfully applied only to clear liquidseg. Water, fruit juices, beer, soft drinks and wine. The filter used are made of asbestos pads, unglazed porcelain and similar materials. The filters are sterilised and made “bacteria proof” before they are used. The liquid is filtered by passing through the filters under pressure.

Inhibiting the growth and/or activity of micro-organisms

This may be achieved by storing at low temperature or drying or by providing anaerobic conditions or using chemicals.

When anaerobic (absence of oxygen) conditions are created, most of the aerobic organisms die. The spores may survive but will be unable to multiply in the absence of oxygen. This principle is used in canningand in packaged foods.

Holding the food material at Low temperature in cold storage slows down and sometimes prevents microbial activity.

Drying of foods is a very effective method for avoiding spoilage of food. All microorganisms need moisture and they cannot flourish in the absence of moisture.

Certain chemicals like sodium benzoate and potassium meta bisulphite are used as preservatives, but they should be used within the prescribed limits as any excess usage may result in poisoning.

By killing the micro-organisms using heat or radiation: The most common of all the methods and used from ancient times is heat processing. In radiation gamma rays or high speed electrons are used to destroy the micro-organisms. Such radiations are known as ionized radiations. This topic will be dealt in part 2 of this chapter.

Prevention or delay of self decomposition of food

This is commonly carried out by destruction or inactivation of food enzymes by blanching. Blanching is a process of dipping the whole food material in boiling water for a short period of time.This process inactivatesplant and microbial enzymes which if not inactivated might cause toughness and change in colour. Most of the plant and animal tissues contain enzymes which are active at room temperatures.An increase of temperature by 10°C doubles the rate of the chemical change. Rancidity of fats is an example of undesirable oxidation, which leads to the deterioration in flavour of food. Oxidation also leads to a loss of ascorbic acid and important vitamin required by the mankind. These endo enzymes softens the tissuefibres.The surfaces of cut fruits are oxidised and they turn dark thereby changing the colour, texture and nutritive value.

Fruits and vegetables are blanched before freezing to inactivate the oxidative enzymes. Blanching is carried out using hot water or steam and the time duration of treatment applied varies with the kind of food.Normally brief heat treatment is supposed to reduce of the number of micro-organisms on the food, enhance of the colour of vegetables such as peas and spinach. They also prevent damage caused by mechanical means, insects and animals.

Avoiding of recontamination

Hygienic storage of the finished products. Aseptic processing following of HACCP GMP ISO 9000 TQM need to be part of the production line. Some of the method in food processing in this are

Canning: Canning is a process in which over 100℃is used for killing all spoilage organisms and their spores as well as inactivating enzymes and sealing in sterile airtight containers. The packaging materials for canning can be tin or glass.In this process the food is sterilized. The objective of sterilization is to destroy all microorganisms in the food material. This prevents decomposition of the food, which otherwise would makes it unattractive or inedible. Sterilization also prevents any pathogenic (disease-producing) organisms from contaminating the food. Pathogenic toxins may be produced during storage of the food if certain organisms are still viable. Microorganisms are destroyed by heat, but the amount of heating required for the killing of different organisms varies. Also, many bacteria can exist in two forms, the vegetative or growing form and the spore or dormant form. The spores are much harder to destroy by heat treatment than are the vegetative forms.

It has been found that microorganisms, including *C. botulinum*, are destroyed by heat at rates which depend on the temperature. Higher temperatures kill spores more quickly. At any given temperature, the spores are killed at different times. As, some spores are more resistant to heat than other spores. If a graph is drawn, the number of surviving spores against time of holding at any chosen temperature, it is found experimentally that the number of surviving spores fall almost to zero.

Experimentally, it has been found that if the logarithm of *t*, the thermal death time, is plotted against the temperature, a straight-line relationship is obtained. This is shown in Fig. 1.

Fig 1

We can then write from the graph

$$\log t - \log F = m(121 - T) = \log t/F$$

Where*t* is the thermal death time at temperature *T, F* is the thermal death time at temperature 121°C and *m* is the slope of the graph.

The D-value of an organism is the time required in a given medium, at a given temperature, for a ten-fold reduction in the number of organisms. The z-value is a measure of the change of the D-value with varying temperatures.

It is possible to choose values of *F* and of *z* to suit specific requirements based on the contaminating organism.

Basically, heat treatment can be classified into three categories:

(i) Pasteurisation (temperature below 100°C) Pasteurisation is a heat treatment that kills part of the micro-organisms present in food using a temperature under 100°C. The temperature used ranges from 65-75°C. There are two ways of pasteurisation:

❖ HTST (High temperature-short time) Food product is heated at high temperature for a short time. For example, milk is heated to 72°C and held for 15 seconds.

❖ LTLH (Low temperature-long time) Food product is heated at a lower temperature for longer period of time. For example, milk is heated to 62.8°C and held for 30 minutes.

(ii) Boiling or heating at about 100°C. Most fruits and vegetables can be preserved for a longer time by applying heat at about 100°C. Inherent enzymes which initiate self-decomposition can be destroyed after boiling at 100°C. This process is called blanching.

(iii) Sterilisation (temperature 100℃ or above) It is a process that all micro-organisms are being killed at high temperature or radiation. The time and temperature necessary for sterilisation vary with the type of food. Few examples are listed in table 1

Table 1

However the type of food determines the type of treatment and not the type of contaminating organism for eg. If food is overcooked. Major changes occur in texture, flavor, and nutritional quality making them unpalatable.

Use of low temperature and cold preservation:

Low temperature can lower the rate of chemical reactions and the action of enzymes. Generally, freezing can prevent the growth of most food-borne micro-organisms and the usual temperature for cold storage is 4.5-7℃. Refrigeration temperature lowers the growth rate of micro-organisms and chilling can slow down the enzymatic and microbial changes in food. For frozen food, it should be stored at or below -18℃ where the enzymatic and microbial changes may be stopped or extremely slow.

Dehydration:

Drying or dehydration of foods as a method of preservation has a long history, especially in Chinese foods. Mushrooms, dried shrimps and salted fish are some typical examples. Both "drying" and "dehydration" mean the removal of water. "Drying" usually describes the process of drying under sunshine or open air. The other term, dehydration, usually describes the removal of moisture by applying artificial heat current under controlled conditions. Some of the differences of drying and dehydration are listed in Table 2.

table 2

Use of preservatives:

Preservatives serve as antimicrobials which prevent or slow down the growth of moulds, yeasts and bacteria. By preventing the growth of moulds, yeasts and bacteria, preservatives can improve the safety of food as well as prevent the wastage of seasonal surplus by making it last longer on the shelf or in the fridge. An ideal preservative should meet the following criteria: (i) can inhibit the growth of a wide range of micro-organisms (ii) should be non-toxic to humans (iii) should not be expensive (iv) should not affect the flavour, taste or aroma of the food product (v) should not be inactivated by the food (vi) should not promote the development of resistant micro-organisms (vii) should kill rather than inhibit the micro-organisms. Some of the common preservatives used in food are listed in Table 3.

Table 3

Brining and sugar solution preservation: It means the use of salt and sugar for food preservation. Sugar binds moisture and thus can preserve food by preventing the growth of microorganisms.

However sugars needs to be used in high concentration (65% or above). Products such as jams and jellies are preserved by using sugar. Most of the candies (both hard and soft) are preserved using sugar.

Salt in high concentration (15-20%) can prevent the water from being available for bacterial growth. This process is known as reducing the water activity (aw). It can slow down the growth rate of bacteria and thus the food is preserved. Salt can be used in brine (salt water) or applied to food directly. Most common salt used for such preservations is sodium chloride or common salt.

Pickling: is a process in which use of acids (vinegar or citric acid) Acids spices and brine are in combination (hurdle technology which will be dealt in part 2 of food preservation). This treatment lower the pH and thus inhibit the growth of many micro-organisms. It is more effective against yeast and bacteria than moulds. About 20% vinegar (acetic acid) prevents the spoilage of most products. It is used in the preservation of pickles, sauces and chutney. Another acid, citric acid, is also used in the preservation of certain fruits and vegetables. Products of jams, jellies and squashes may contain citric acid. It lowers the pH of the food products and can prevent the growth of moulds.

Conclusion: In this chapter we tried to understand the commonly used process of food preservation. Many of these techniques are widely used in home or cottage industries level with minimum machineries. The main intention are to see that the uncooked foods (raw materials) are handled carefully. Further the basic principles of hygiene are to be practice. Methods like cooking at high temperature and keeping them in closed containers, storing the cooked food at low temperatures are common practices at home levels. Understanding the D and Z values required for preventing the contamination and the temperatures to which the food can be taken without losing its organoleptic characters is important. Many of the foods that we use in our common day to day life arte processed in these manners eg. Milk, papad, pickle, jam etc.

Dear viewers the more modern technologies that the industries adopt to handle large quantity of foods will be taken up in the part 2 of food preservation.

Table 1. Time and temperature required for sterlisation of various food.

Type of food	Temperature	Duration
Fruit and tomato	100℃	30 minutes
Vegetables	116℃	30-70 minutes
Milk (ultra Heat Treatment (UHT))	135℃	not less then 1 second

Table 2 Differences between drying and dehydration.

Dehydration	**Sun-drying**
A faster process Under controlled hygienic conditions Not dependent on the weather Investment on machinery and processing cost is needed	A slower process Under open-air conditions with little hygienic control Not possible in cloudy weather or rainy days No machinery and processing cost is needed

Table 3. Some common preservatives

Preservatives	Target Organism(s)	Application(s) in Food
Sulfites	Yeasts and bacteria	Dehydrated fruits and vegetables, wine, juice, sausages
Sodium nitrate	Bacteria	Meat and meat products
Propionic acid	Moulds	Bread, cakes, cheese
Sorbic acid	Moulds	Cheeses, cakes, salad dressing, wines

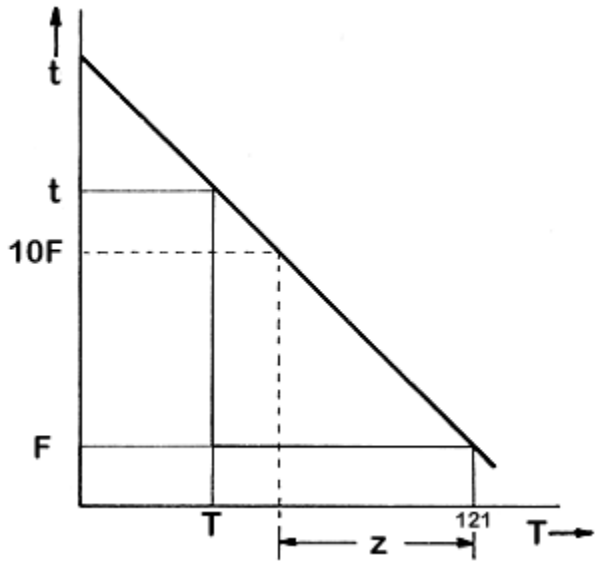

Figure 1. Thermal death time/temperature relationships