

Food preservation techniques and microorganisms

Expected Learning Outcome

- Methods of killing microorganisms or preventing their growth in food so as to ensure preservation of food for future use.
- Principles of killing /inhibiting microorganisms associated with foods by preservation methods involving use of low temperature, high temperature, radiations and chemicals.
- Importance of microbial endospores and cell aggregates on quality of processed foods.

4.1 Food preservation techniques and microorganisms

The foods of plant and animal origin contain several microorganisms and these along with natural food enzymes become active soon after the death of animal and harvest of plant foods. The intrinsic characters of the food and the environmental conditions influence the type and extent of microbial activity leading to spoilage which is characterized by deteriorative changes in food quality making it unfit for human consumption. The different preservation techniques have mainly aimed at reducing or eliminating microorganisms in food thereby prolonging or preventing the spoilage of foods. The preservation of foods is commonly done by use of low temperature, high temperature, drying, radiation and chemicals.

4.1.1 Preservation of foods with low temperature

Low temperature preservation of food is based on the principle of reducing the microbial activity by subjecting to low temperature condition. As all metabolic activities of microorganisms are catalyzed by enzymes, and enzyme reactions are dependent on temperature, the low temperature slows down enzyme activity, thereby brings about reduction in microbial activity. The reduced microbial activity prolongs shelf life of foods.

Shelflife of temperate and tropical water fish

Activity of microorganisms is known to decrease by two fold with every 10°C decrease in temperature. Fresh fish from temperate waters generally have prolonged shelflife than tropical fishes. This is because of the low ambient temperature in temperate waters coupled with low body temperature of fish, being cold blooded, lowers both enzymatic and bacterial growth, thereby reduces deteriorative change and helps in extending the shelflife.

In tropical waters, the high ambient temperature and high body temperature of harvested fish promotes deteriorative changes by enzymes and microorganisms and thus hastens the spoilage.

Methods of low temperature presentation

Low temperature preservation is generally attained by employing three different temperature conditions. They are;

- **Chilling temperature:** keeping foods at 10-15°C (slightly above refrigerated temperature).
- **Refrigerator temperature :** Keeping foods at 0~7°C
- **Freezer temperature:** Storage of foods below -18°C.

In Fisheries, fish are preserved by keeping at chilling temperature and by freezing.

Chill storage of fish

Chill storage is a process by which temperature of fish is reduced close to freezing point of water (0°C). This delays both biochemical and bacteriological processes, thus prolongs shelf life. Deteriorative changes are retarded as long as low temperature is maintained. This ensures preserving natural nutritional and functional properties of food.

Factors influencing quality of chilled food

- Quality of chilled food depends upon factors such as;
- Raw material quality
- Method and duration of chilling
- Efficiency of storage method

Chilling can be achieved by use of ice (crushed/flake ice) and use of homogenous coolant (cold air or cold liquid), and refrigerated temperature. Use of cold liquid may be in the form of chilled freshwater for light chilling or refrigerated seawater/brine to attain temperature of 0-1°C

Bacteria associated with low temperature storage

Several microorganisms are capable of surviving and growing at low temperature and cause spoilage. Bacteria capable of growing at or below 7°C are widely distributed. Gram negative bacteria are more common than Gram positive. Psychrotrophs grow well at this temperature. Growth at temperature below 0°C is caused mainly by yeasts and molds than bacteria because of low water activity. The lowest recorded temperature for growth of microorganisms in food is -34°C, by yeast.

The composition of microorganisms associated with fish changes during chill storage. Proportion of mesophiles decrease and psychrophiles dominate. Common bacterial genera associated with chilling temperature condition of foods are;

Acinetobacter, Aeromonas, Enterococcus, Pseudomonas, Vibrio, Erwinia, Moraxella, Enterobacter, Achromobacter, Flavobacterium, Micrococcus etc.

Extension of shelf life varying from 6 days to 30 days for different fish species has been reported by ice storage.

4.1.1.b. Preservation by Freezing

Freezing involves lowering of temperature of food to -20°C and storage at same temperature. At this temperature the water in food as well as in microorganism is converted to ice crystals which affect fluidity of cell. This ensures prolonged shelflife as microbial activity is completely stopped at this temperature condition.

Freezing is achieved by

- Quick freezing: where temperature is lowered to -20°C within 30 min.
- Slow freezing: where temperature is lowered to -20°C within 3~72 hours.

Quick freezing is more advantageous than slow freezing in achieving product quality. During freezing water in food is converted to ice crystals of variable size. Freezing also brings about changes in properties of food such as pH, titratable acidity, ionic strength, viscosity, osmotic pressure, freezing point, O/R potential etc. These changes along with non-availability of water make the environment unsuitable for microbial growth and activity.

Comparison of effect of freezing methods on microorganisms

Quick freezing	Slow freezing
Small ice crystals formed	Large ice crystals formed
Suppresses microbial metabolism	Break down of metabolic rapport and

	causes cell damage
Brief exposure to adverse conditions	Longer exposure to injurious factors
No adaptation to low temperature	Gradual adaptation
Causes thermal shock to microbes	No thermal shock effect
No protective effect	Accumulation of concentrated solutes with beneficial effects.
Drip loss is less	Drip loss is more

Shelf life of frozen foods

Frozen foods can be stored indefinitely without microbial spoilage, but not done so as they lose original flavour and texture after thawing. Thus frozen foods are assigned freezer life. Freezer life for frozen foods is determined based on texture, flavor, tenderness, colour and nutritional quality upon thawing and cooking. Freezer life of frozen stored food does not depend on microbiology of frozen foods.

Effect of freezing on microorganisms

Freezing causes sudden mortality immediately on freezing, varying with microbial species. The number of surviving microorganisms after freezing die gradually when stored in frozen condition. Decline in microbial number is rapid at temperature below freezing point (-2°C) than at lower temperature, and is slow below -20°C . Bacteria differ greatly in their capacity to survive during freezing. Generally cocci are more resistant than Gram negative bacteria. Food poisoning bacteria are less resistant to freezing while, microbial endospores and toxins are not affected by freezing.

4.2. Food preservation by high temperature

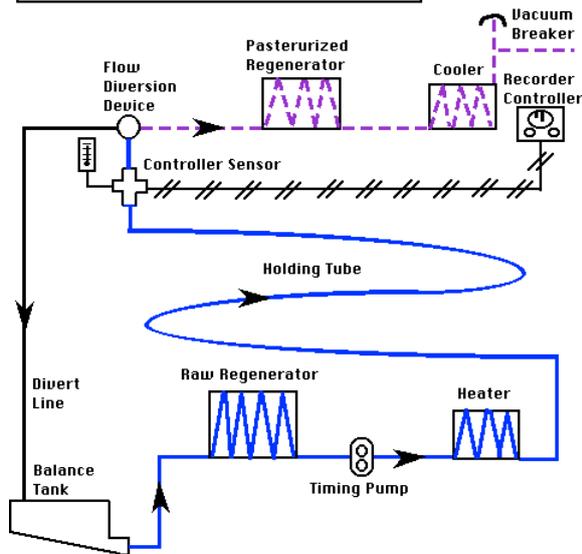
The high temperature preservation of food is based on destructive effect of heat on microorganisms, thereby extending shelf life of foods. High temperature refers to any temperature higher than ambient temperature applied to food. Preservation of foods by heat treatment can be done by two methods viz. pasteurization and sterilization.

4.2.1 Pasteurization

Pasteurization refers to use of heat at the range of $60\sim 80^{\circ}\text{C}$ for a few minutes for the elimination/ destruction of all disease causing microorganisms, and reduction of potential spoilage organisms. Pasteurization is commonly used in the preservation of milk, fruit juices, pickles, sauces, beer etc.

Pasteurization process which is commonly employed in milk preservation can be achieved by heating the milk at 63°C for 30 min, called low temperature long time (LTLT) process; or 72°C for 15 sec, called high temperature short time (HTST) process. This process destroys most heat resistant non-spore forming pathogens (Ex. *Mycobacterium tuberculosis*), all yeasts, molds, Gram negative bacteria and most Gram positive bacteria.

Basic Flow - HTST Pasteurization



Organisms surviving pasteurization

The pasteurization treatment does not bring about complete removal or destruction of microorganisms and some organisms survive pasteurization process. The surviving organisms are of two types:

- Thermoduric microorganisms
- Thermophilic microorganisms.

Thermoduric microorganisms are those which can survive exposure to relatively high temperature but do not grow at these temperatures. Example: The non-spore forming *Streptococcus* and *Lactobacillus sp* can grow and cause spoilage at normal temperature. So, milk needs to be refrigerated after pasteurization to prevent spoilage.

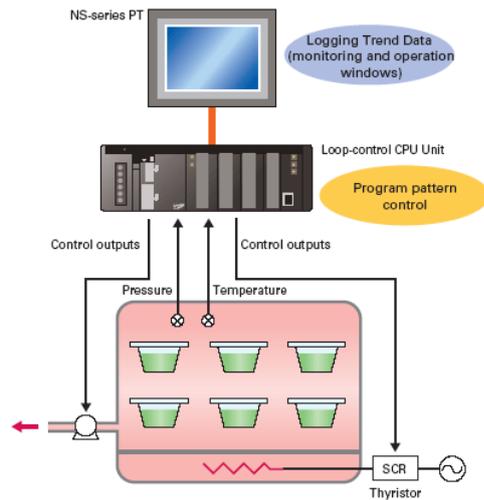
Thermophilic organisms are those that not only survive high temperature treatment but require high temperature for their growth and metabolic activities. Example: *Bacillus*, *Clostridium*, *Alicyclobacillus*, *Geobacillus* etc.

4.2.2. Sterilization

Sterilization or appertization refers to destruction of all viable organisms in food as measured by an appropriate enumeration method. This process kills all viable pathogenic and spoilage organisms. However, organisms that survive are non-pathogenic and unable to develop in product under normal conditions of storage. Thus, sterilized products have long shelf life.

Commercially sterile or commercial sterility is often used for canned foods to indicate the absence of viable microorganisms detectable by culture methods or the number of survivors is so low that they are of no significance under condition of canning and storage.

Processing of food for preservation using high temperature depends on the physical nature of the food. Foods (solid or semisolid) are generally processed by packing in cans, sealing and then sterilized. Most liquid foods are sterilized, packed in suitable containers and sealed aseptically. Temperature and time of sterilization given to a food depends on the nature (pH, physical state, nutritional type etc) of the food being processed.



4.2.3. Heat resistance of microorganisms

- Heat resistance of microorganisms is related to their optimal growth temperature.
- Psychrophiles are most sensitive and thermophiles are most resistant to heat treatment.
- Spore forming microorganisms are most resistant than non spore formers.
- Gram positive bacteria are more resistant than Gram negative bacteria.
- Yeasts and molds are fairly heat sensitive
- Spores of molds are slightly more heat resistant than vegetative cells.

Heat resistance of spores

Bacterial spores are more heat resistant than vegetative cells. Thermophiles produce more heat resistant spores. Since spore inactivation is the main concern in canned foods, high process temperature is used to achieve this. The heat resistance of bacterial endospore is due to their ability to maintain very low water content in the DNA containing protoplast. Presence of calcium and dipicolonic acid in high concentration in spores helps to reduce cytoplasmic water. Higher the degree of spore dehydration greater will be its heat resistance.