COURSE TITLE: FOOD AND INDUSTRIAL MICROBIOLOGY
COURSE NO. - DTM-321: CREDIT HRS-3 (2+1)

FOOD PRESERVATION
NON THERMAL METHODS:
LOW TEMPERATURE & FREEZING

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Food preservation is mainly based on

Prevention and delaying of microbial degradation of food component.

Prevention or delaying the self decomposition of the food materials.

Preventing the damage cause by insects, animals, mechanical etc.

Microbial decomposition of foods will be prevented if all spoilage organisms present in food are inactivated and the processing condition restricts the entry of other contaminating viable microorganisms responsible for creating abnormal condition in food. Sometimes enzymes present in a food already produced by various types of organisms may continue to be active and responsible for creating spoilage problem if a suitable preservation technique not chosen for preservation purpose.

Methods of food preservation

- ✓ Asepsis- keeping out microorganisms
- ✓ Removal of microorganisms
- ✓ Maintenance of anaerobic condition
- ✓ Use of high temperature
- ✓ Drying and smoking
- ✓ Use of chemical preservatives
- ✓ Irradiation

Asepsis

Natural protection - outer layer of animal and plant tissue protects the inner layer free from microorganisms. This protective covering will delay / prevent microbial decomposition e.g. shells of nuts, skins of fruits and vegetables etc.

Packaging of foods - such as wrapping, hermetically sealed containers. This methods will prevents primarily contamination during handling.

Sanitary methods of handling and processing foods e.g. in the dairy industry, contamination with microorganisms is avoided as much as possible in the production and handling of milk.

Food industries - attention is given to prevention of the contamination of foods (from raw material finished products).

Removal of microorganisms

(a) Filtration is a successful method used for complete removal of microorganisms by using a pre-sterilized filters. It is used in soft drinks, fruit juices and water.

(b) Centrifugation used in treatment of drinking water and for removal of heat resistant bacteria from milk but it is not very effective all microorganisms can’t be removed.

(c) Washing is helpful in removing soil microorganisms from fresh fruits and vegetables that may be resistant to heat process during canning but the quality of water should not contaminate these items.

(d) Trimming Simply to trim away the spoiled portions of a food.

Maintenance of anaerobic conditions Anaerobic conditions can be achieved by a complete filling (No head Space) or by replacement of air by C02 or N2 and others. Spores are resistant to heat and may survive in canned food but they unable to germinate in absence of oxygen.

Use of high temperatures Temperature and time used in heat processing will depend on:

(a) The effect of heating on the food (b) Other preservative methods employed

Heat treatments used on foods: (a) Pasteurization (b) Heating at 100°C (c) Heating > 100°C.

Heat Treatment ↑ Microorganisms ↓

Use of low temperature

Low temperature reduces the activity of microorganisms by reducing the chemical reaction and action of enzymes. Low temperature will prevent growth of microorganisms and slow down the metabolic activity resulted in delayed / prevent spoilage. Chilling at low temperature of 4°C can prevent the growth of food poisoning microorganisms except the *Clostridium botulinum* type E and restrict the growth of a number of different spoilage microorganisms. Thus, it is used everywhere for temporary preservation of food. Few Psychrotrophs can grow at low temperature range e.g. *Flavobacterium* spp. and *Pseudomonas alcaligenes* but they often showed a low growth rate.

Freezing temperature helps to reduce the number of viable microorganism but does not sterilize the food. The percentage of microorganisms killed during freezing and storage depends on:

(a) Type of food

(a) Type of freezing

In case of fast freezing smaller ice crystal will be formed and cause less mechanical destruction to food. Quick solidification ensures sudden death to microorganisms and inactivation of the enzymes and food quality after thawing will be better.


Where Food Goes in the Cold Storage Rooms
HOW TO AVOID PSYCHROPHILIC BACTERIA GROWTH AND CROSS-CONTAMINATION
UPPER SHELVES
milk, juices, iced tea, any items to be chilled but not too cold
MIDDLE SHELVES
items labelled refrigerate after opening, cakes, yogurts, cheese
LOWER SHELVES
- berries, hard vegetables
- poultry, eggs
-meats
SEPARATE STORAGE
fruits, herbs, fish
SHIPSAN Manual item: 3.4.33 - p. 62 - 6th bullet

Chilling (Why preferred ?)

- ✓ Preservation of foods at temperatures above freezing and below 15ºC is known as refrigeration or chilling.

- ✓ It is used to reduce the rate of biochemical and microbiological changes and hence to extend shelf life of fresh and processed foods.

- ✓ It causes minimal changes to sensory characteristics and nutritional properties of foods.

Chilling effects:

- ➢ Checked growth of microorganisms.
- ➢ Restricts postharvest and post slaughter metabolic activities of plant and animal tissues respectively.
- ➢ Deteriorative effect on chemical reactions including enzyme- catalyzed oxidative browning or oxidation of lipids and chemical changes associated with color degradation, autolysis of fish and loss of nutritive value of foods.
- ➢ Reduce moisture loss.

Categories of chilled food on the basis of their storage temperature range:

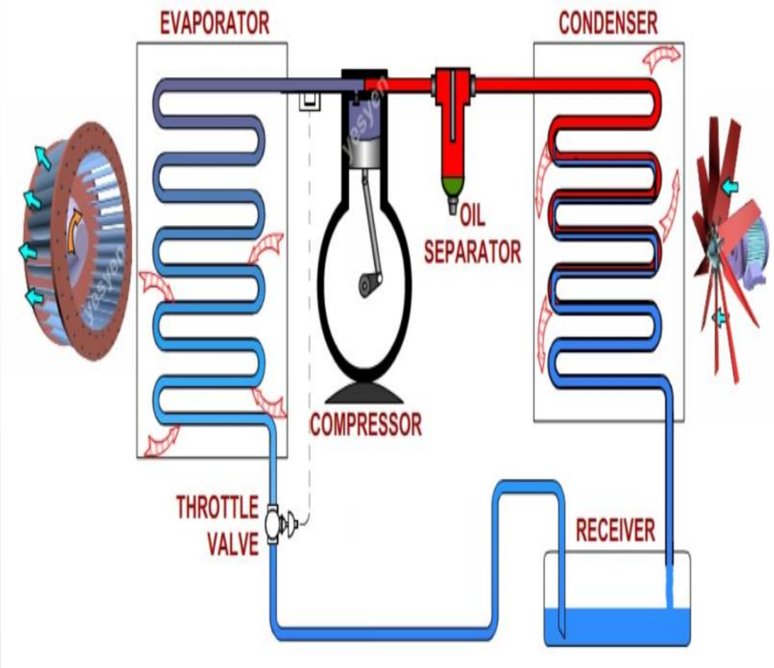
I. 1ºC to 1ºC (sausages, fresh fish, meats, smoked meat and ground meat)
II. 0ºC to 5ºC (pasteurized milk, cream, yoghurt, salad, sandwiches, baked foods, soups, sauces and canned meat)
III. 0ºC to 8ºC (Fruit juices and Soft fruits, hard cheese, butter and cooked rice,)

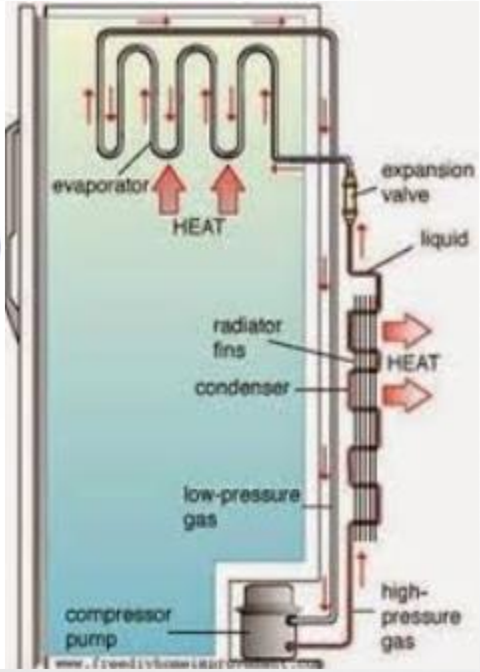
Chilling Equipments

- Mechanical refrigerators
- Cryogenic systems

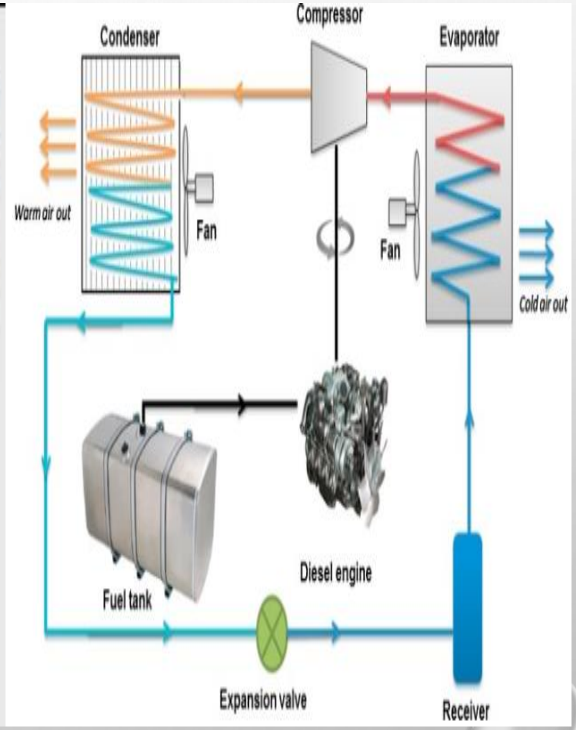
Mechanical refrigerators --- Mechanical refrigerators have four basic elements: an evaporator, a compressor, a condenser and an expansion valve. A refrigerant circulates between the four elements of the refrigerator, changing state from liquid to gas and back to liquid.

Cryogenic systems --- Cryogenic chillers use solid carbon dioxide, liquid carbon dioxide and liquid nitrogen. Solid carbon dioxide removes latent heat of sublimation and liquid cryogens remove latent heat of vaporisation.





Mechanical refrigerators



Cryogenic system refrigerators

Super chilling

Super chilling is one of the method that can be used to maintain food products at a low temperature. Generally, super chilling is positioned between freezing and refrigeration (conventional chilling), where the surrounding temperature is set below the initial freezing point. It is a process by which the temperature of a food product is lowered to -1 to -4 °C by means of slurry ice or in super chilled chambers without ice.

Definitions of super chilling

Super chilling is that where temperature of food is maintained below 0°C but ice crystals are not generated. Super chilling is defined as a technology where food is stored just below the initial freezing temperature.

Freezing

Freezing is the unit operation in which the temperature of a food is reduced below its freezing point and a proportion of the water undergoes a change in state to form ice crystals. Freezing process is a combination of the beneficial effects of low temperature at which micro-organisms cannot grow, chemical changes are reduced and cellular metabolic reactions are delayed.

Theory of freezing

Sensible heat is first removed to lower the temperature of food to the freezing point.

Heat produced by respiration in case of fresh foods (fruits and vegetables) is also removed.

Then latent heat of crystallisation is removed to form ice crystals.

The latent heat of crystallisation of other components of food (e.g., fats) is also removed.

Freezing techniques --- Plate Freezing: Product is pressed between hollow metal plates, either horizontally or vertically with a refrigerant circulating inside plates. immersion Freezing: Food can be frozen rapidly by direct immersion in liquid such as brine, syrup, glycerol, etc. at low temperature (-18 ºC).

Cabinet Freezing: Cold air is circulated in a cabinet where product is placed on a tray.

Advantages of Freezing

- Many foods can be frozen.
- Good natural color, flavor and nutritive value can be retained.
- Texture usually better than for other methods of food preservation.
- Foods can be frozen in less time than they can be dried or canned.
- Simple procedures.
- Adds convenience to food preparation.

Disadvantages of Freezing

- Texture of some foods is undesirable because of changes due to the freezing process.
- Initial investment and cost of maintaining a freezer is high.
- Storage space is limited by how much the freezer will hold.

EFFECT OF FREEZING ON MICROORGANISMS

Considering the effect of freezing on a number of microorganisms that are unable to grow at freezing temperatures, it is well established that freezing is one method of preserving microbial cultures and freeze drying being perhaps the best method known. However, freezing temperatures have been shown to effect the killing of certain microorganisms of importance in foods.

The salient facts of what happens to certain microorganisms upon freezing:

1. Showed sudden mortality immediately on freezing and it varies with species.

2. The proportion of cells surviving immediately after freezing die gradually when stored in the frozen state.

3. This decline in numbers is relatively rapid at temperatures just below the freezing point, especially about -2°C but less at lower temperatures and it is usually slow below -20°C.

Bacteria differ in their capacity to survive during freezing with cocci being generally more resistant than Gram-negative rods. Of the food-poisoning bacteria, *salmonellae* are less resistant than *Staphylococcus aureus* or vegetative cells of clostridia, whereas endospores and food-poisoning toxins are apparently unaffected by low temperatures. From the strict stand point of food preservation freezing should not be regarded as a means of destroying food borne microorganisms.

Low freezing temperatures of about -20°C are less harmful to microorganisms than the median range of temperatures, such as -10°C. For example, more microorganisms are destroyed at -4°C than at -15°C or below. Temperatures below -24°C seem to have no additional effect. Food constituents such as egg white, sucrose, corn syrup, fish, glycerol, and undenatured meat extracts have all been found to increase freezing viability, especially of food-poisoning bacteria, whereas acid conditions have been found to decrease cell viability.

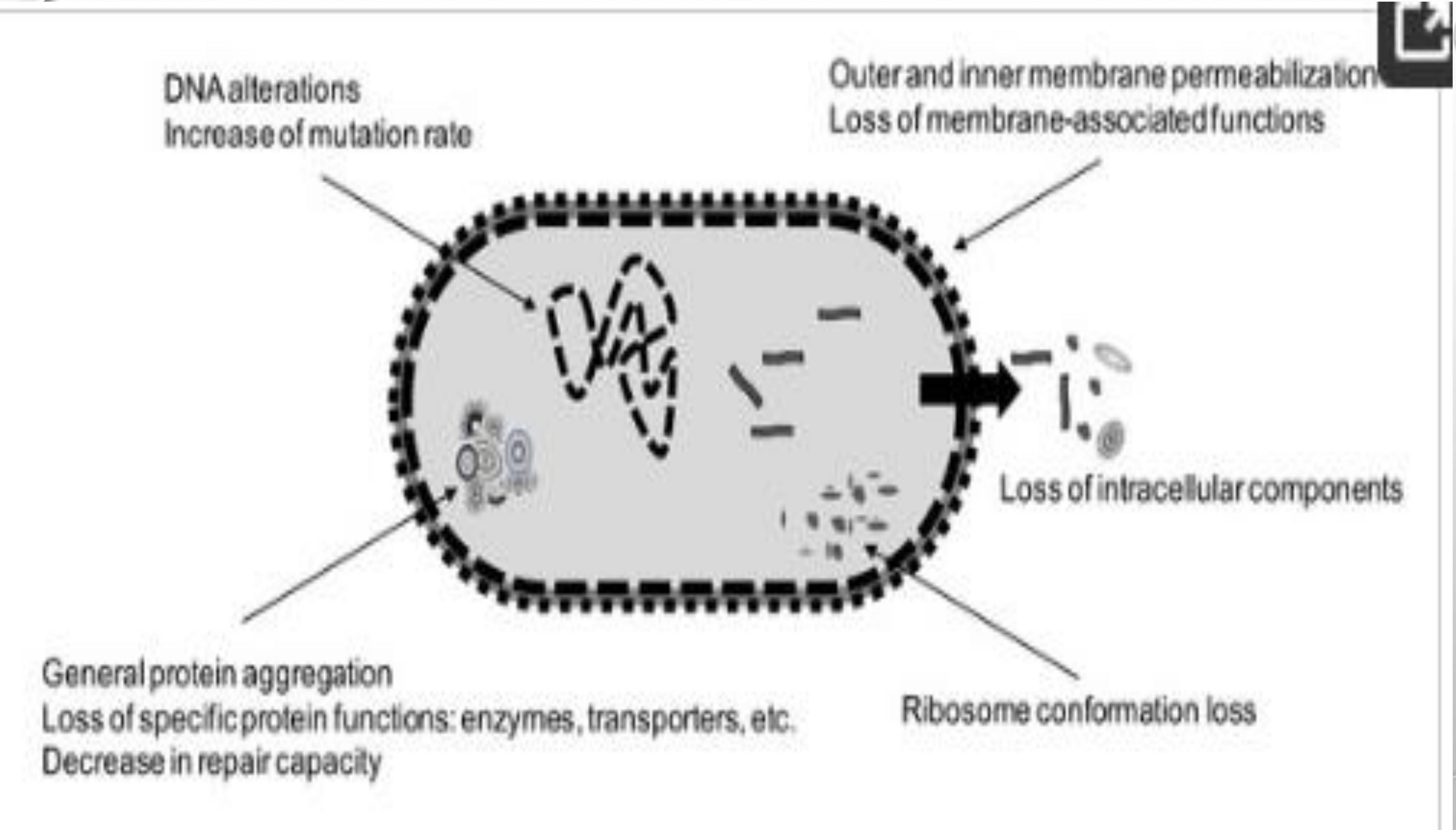
Microorganism	Common food sources	Survival T (°C)	Optimum growth T
Campylobacter jejuni	Raw chicken, foods contaminated by raw chicken, unpasteurised milk, untreated water	0 – 45 [3]	37 – 42 [3]
Listeria monocytogenes	Ready-to-eat foods, including raw milk, cheeses, ice cream, raw vegetables, fermented raw sausages, raw and cooked poultry, raw meats, raw and smoked fish	-1,5 – 45 [4]	-1,5 – 45 [4]
Yersinia enterocolitica	Raw milk, chocolate milk, water, pork, other raw meats	-1,5 – 44 [5]	-1,5 – 44 [5]
Aeromonas hydrophila	Seafood including oysters, water	-2 – 45 [4]	5 – 25 [4]
Plesiomonas shigelloides	Raw oysters	8 – 44 [5]	37 – 38 [5]
Pseudomonas spp.	Meat, fish, shell fish and dairy products	4 – 43 [6]	37 – 38 [6]
Penicillium, Cladosporium		-3 – 35 [7]	25 – 26 [7]

Consider some of the events / mode of action that are known to occur when cells freeze:

The water that freezes is called free water and it forms ice crystals upon freezing. Bound water remains unfrozen. The freezing of cells depletes them of usable liquid water and thus dehydrates them. At the same time freezing results in an increase in the viscosity of cellular matter and its direct consequence on water which is being concentrated in the form of ice crystals. Freezing results in a loss of cytoplasmic gases such as O2 and CO2 and a loss of O2 to aerobic cells suppresses respiratory reactions. In more diffuse state of O2 a greater oxidative activities observed within the cell and causes changes in pH of cellular matter. Various investigators have reported changes ranging from 0.3 to 2.0 pH units. Many researchers have also reported about an increases and decreases of pH observed upon freezing and thawing.

Freezing effects concentration of cellular electrolytes

Freezing effects concentration of cellular electrolytes. This effect is also a consequence of the concentration of water in the form of ice crystals. Freezing causes a general alteration of the colloidal state of cellular protoplasm. Many of the constituents of cellular protoplasm such as proteins exist in a dynamic colloidal state in living cells. A proper amount of water is necessary to the well-being of living cell and freezing causes some denaturation of cellular material.


DNA alterations
Increase of mutation rate
Outer and inner membrane permeabilization
Loss of membrane-associated functions
Loss of intracellular components
General protein aggregation
Loss of specific protein functions: enzymes, transporters, etc.
Decrease in repair capacity
Ribosome conformation loss

Freezing induces temperature shock in some microorganisms. This is true more for thermophiles and mesophilic than for psychrophiles. More cells die when the temperature decline above freezing is sudden than when it is slow. Freezing causes metabolic injury to some microbial cells such as certain *Pseudomonas* spp. Some bacteria showed increased nutritional requirements upon thawing from the frozen state.

Effect of Thawing -- Repeated freezing and thawing will destroy bacteria by disrupting cell membranes. Faster the thawing process the greater the number of bacterial survivors and the reason of this is not clear. It was pointed out that slow thawing showed potentially more detrimental effect than freezing.

THANK YOU