A study material for M.Sc. Biochemistry (Semester- IV) of Paper EC-01 Unit IV

The Microbiology of Food Preservation (Part I)

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Food preservation

❖Food products can be contaminated by a variety of pathogenic and spoilage microorganisms, former causing food borne diseases and latter causing significant economic losses for the food industry due to undesirable effects; especially negative impact on the shelf-life, textural characteristics, overall quality of finished food products. Hence ,prevention of microbial growth by using preservation methods is needed.

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Why food preservation is indispensable:

temperature, humidity ,oxygen and light are reasons of food deterioration. Microbial effects are the leading cause of food spoilage .Essentially all foods are derived from living cells of plant or animal origin. In some cases derived from some microorganisms by biotechnology methods. Primary target of food scientists is to make food safe as possible ;whether consumed fresh or processed. The preservation, processing and storage of food are vital for continuous supply of food in season or off-seasons . Apart from increasing the shelf life it helps in preventing food borne illness.

Principles of Food Preservation

❖**Inhibits the growth and activity of Microorganisms:** Asepsis, drying,low temperature, chemicals, heating or radiation.

❖**Protecting against self decomposing food (**inhibits the activity of endogenous enzyme-phenolase, delaying non –enzymatic browning).

❖**Protection from spoilage by insects and rodents.**

❖**Protection against losses by mechanical causes.**

Food preservation techniques: Variously classified

A. Food preservation techniques can be broadly classified into two basic types on ability to kill or retard microbial growth:

1) Bactericidal methods
2) Bacteriostatic methods

B. Based on the mode of action, the major food preservation techniques can be categorized as

(1) slowing down or inhibiting chemical deterioration and microbial growth,
(2) directly inactivating bacteria, yeasts, molds, or enzymes, and
(3) avoiding recontamination before and after processing .

A number of techniques or methods from the above categories are shown in Figure I While the currently used traditional preservation procedures continue in one or more of these three ways, there have recently been great efforts to improve the quality of food products principally to meet the requirements of consumers through the avoidance of extreme use of any single technique.

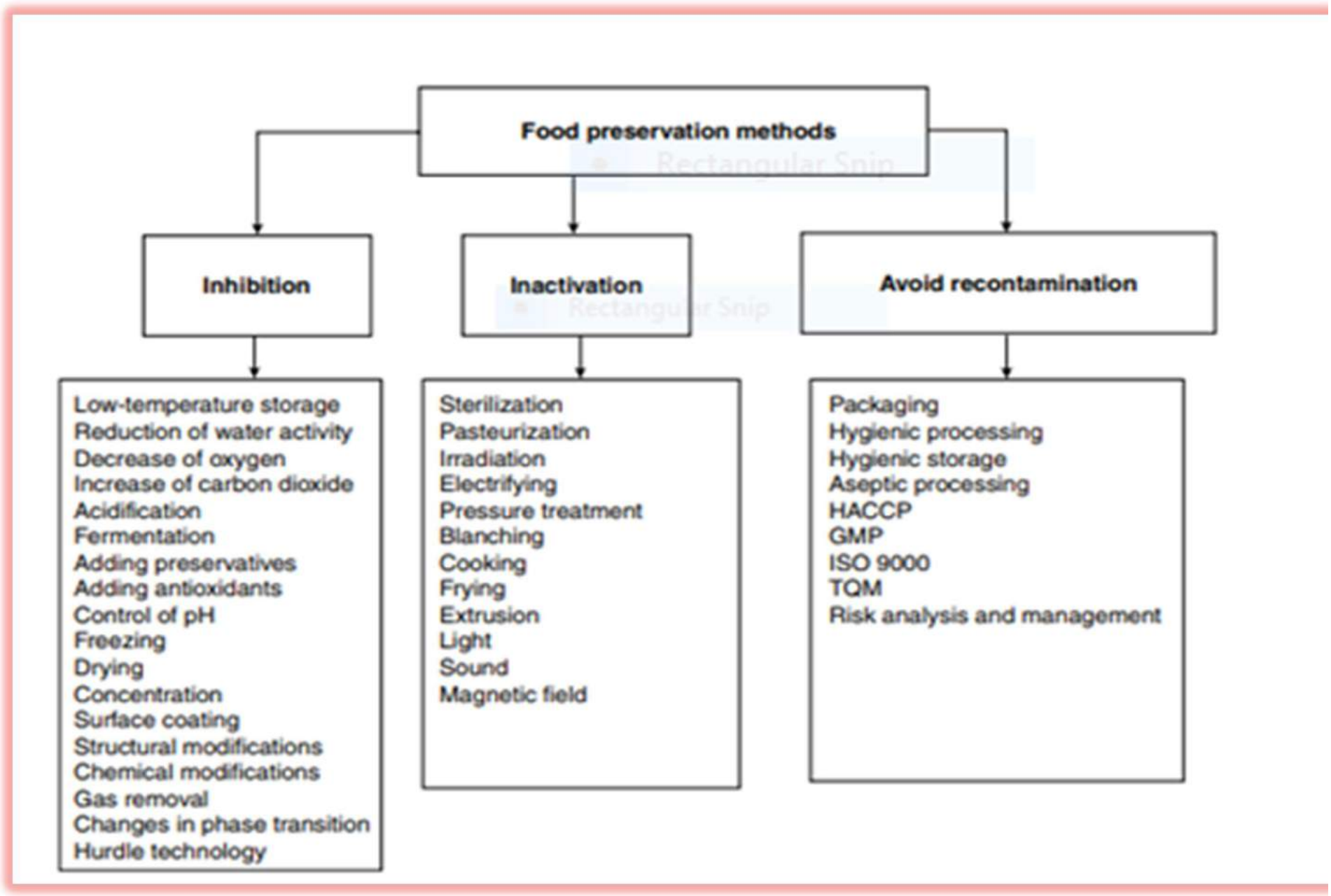


Fig. I: Ref: **Gould.G.W.1989, In –Mechanism of action of Food prevention Procedures. Elseviers Applied Science London)**

C. FOOD PRESERVATION METHODS

1) Conventional

Preservation by low water activity
Preservation by low pH and organic acids
Preservation by carbon dioxide, nitrite, nitrate, sulphite.
Preservation by modified and controlled atmosphere.
Irradiation preservation of foods.
Preservation by low temperatures.
Combined methods of food preservation.

2) Modified preservation methods of modern era

Pulsed electric fields
Ultraviolet radiation
High pressure
Sound in food preservation
Application of bacteriocin in food preservation

D. Method of food preservation

1. Physical

2. Chemical

Physical Methods ---

[a]Thermal food preservation-Adding or removing heat to food to destroy spoilage and pathogenic microorganisms and enzymatic destruction as well as alter shelf life of food and maintainance of its quality.

- Blanching
- Pasteurization
- Sterilization
- Dehydration
- canning

[b] Non- thermal food preservation

Cold processing- heat removal from food to slow deterioration by enzymes and microorganisms

Refrigeration

Chilling

Freezing

Irradiation

High pressure processing of food (pascalization)

Microwave heating

High intensity white light and UV light food preservation

Pulsed electrical field technology

Vacuum packing

Chemical Food Preservation

Works as direct microbial poisons or reduces pH to a level that prevents the growth of Microorganisms.

1.Organic acid and its esters -- Propionates , Benzoates , Sorbates, Acetates

2.Nitrites and Nitrates

3. Sulfur Dioxide and Sulphites

4. Ethylene and Propylene Oxides

5.Sugars and Salts

6.Alcohol

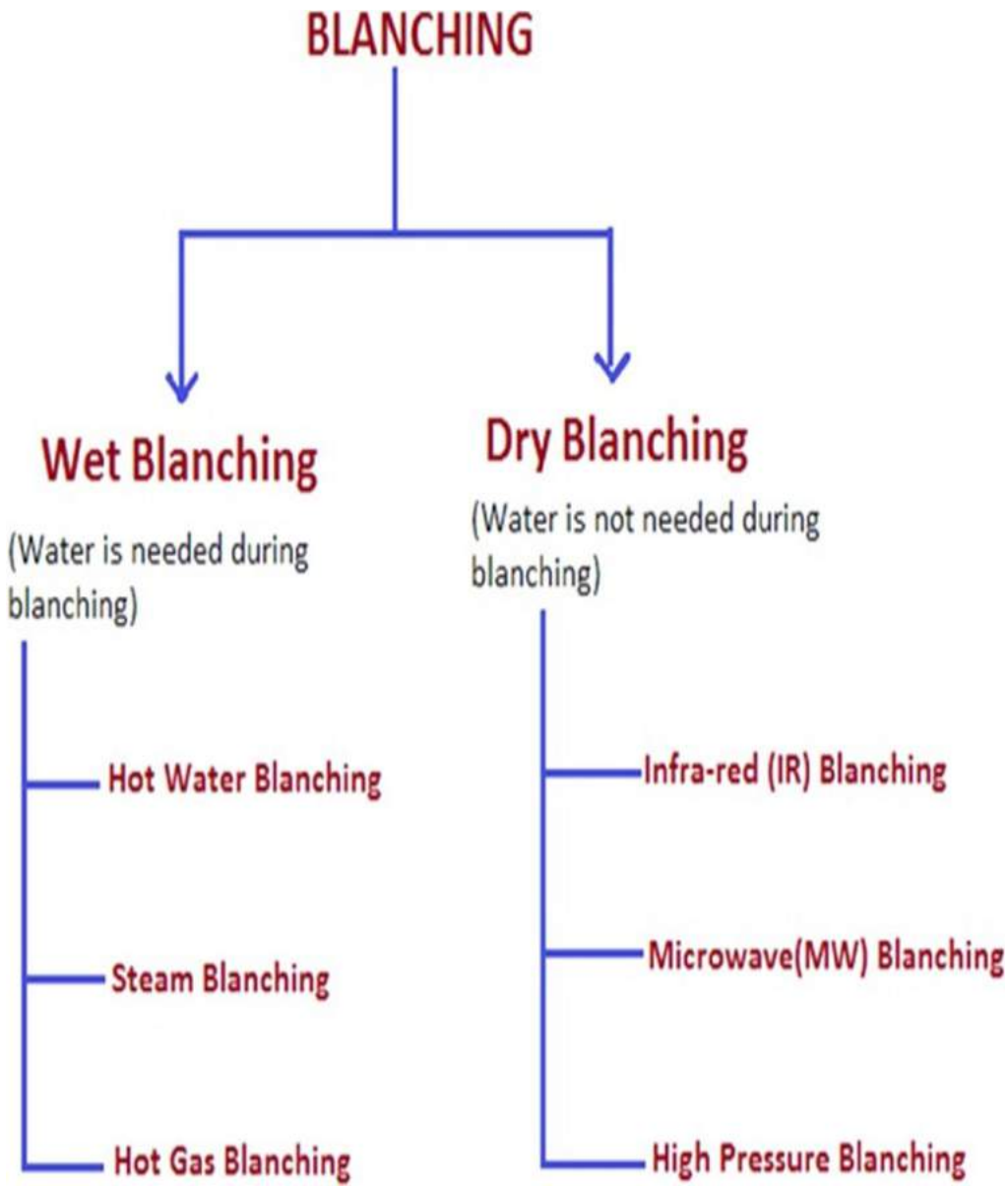
7. Formaldehyde

8.Food additives

9.Antibiotics

Blanching

Food is immersed in boiling water or steam to destroy enzymes.
It may be followed by cooling.
Functionally the tissue softens to fill the containers.
It reduces dirt, microbial load, pesticide residue.
Destroys many enzymes in the food product and prevents further cellular metabolism.
Drawbacks to blanching process includes leaching of water – soluble and heat sensitive nutrients.
It is not intended as sole method of preservation; instead as a pre-treatment before freezing, drying and canning.

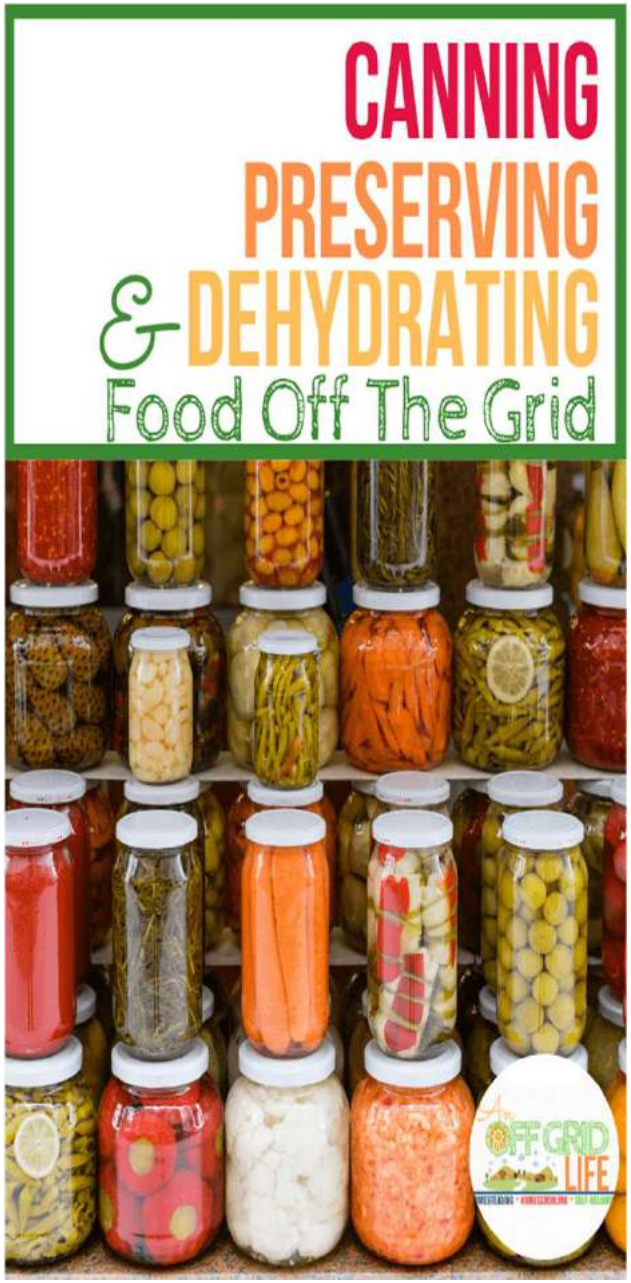


Sterilization (Retorting)

It is another form of thermal processing which unlike pasteurization utilizes comparatively higher temperature . Sterilization is the process of killing microorganisms that are normally heat resistant. Unlike pasteurized products where the survival of heat resistant microorganisms is accepted, the aim of sterilization is the destruction of all microorganisms including inactivation of enzymes. Heat treatment of such products must be severe enough to inactivate/kill the most heat resistant bacterial microorganisms. Food products filled in sealed containers are exposed to temperatures above 100°C in pressure cookers. Temperatures above 100°C, usually ranging from 110-121°C depending on the type of product, must be reached inside the product. However, most food products cannot be submitted to such intensive heat stress without suffering degradation of their sensory quality or loss of nutritional value (destruction of vitamins and protein components). Not much significant in food preservation.

Canning

Canning is a method that sterilizes food by heat in airtight containers(cans) to achieve a commercially sterilized product, which allows food to be stored at room temperature while maintaining food safety and organoleptic quality for months or even years. There are two typical forms of canning: in-container sterilization (i.e., retort processing) and out-of-container sterilization (i.e., aseptic processing). In-container sterilized food heats packed product in containers such as metal cans or glass jars using a retort process, such as steam, until the center of the product reaches protocol temperatures for sterilized product. Accordingly, both the package (i.e., can) and product are sterilized together. Retort processing can be applied to all types of foods. Out-of-container sterilized food refers to separate sterilization of food and product and then packing/filling and sealing under specific aseptic conditions. Aseptically processed food is limited to liquid foods.



DRYING/DEHYDRATION

Both are one of oldest methods of preservations. They are means of removal of water/moisture to stop the growth of bacteria, yeasts and molds that normally spoils food. Slows down but does not completely inactivate enzymes.

Drying- Removal of water from food by non-conventionl energy sources like sunlight and wind.

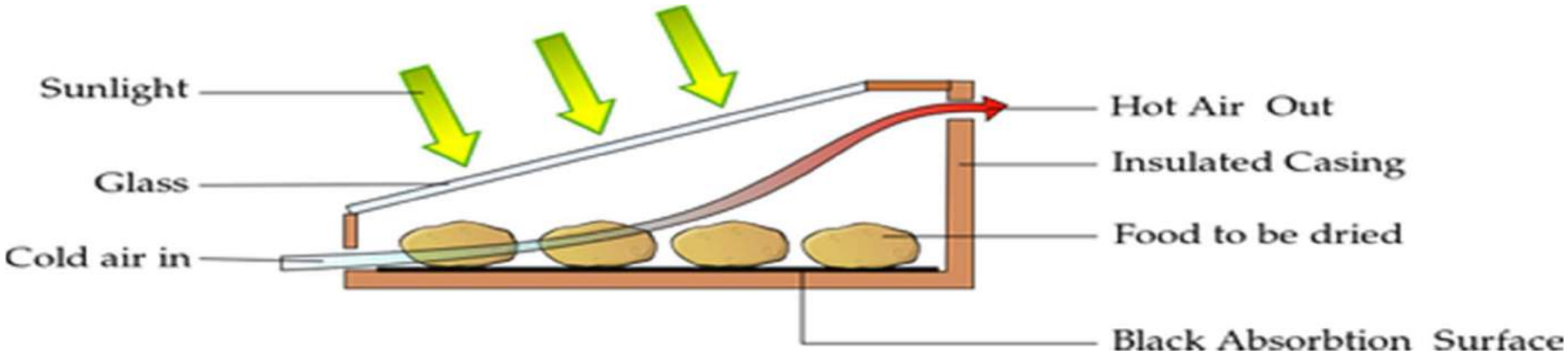
Dehydration- The process of removal of water from food under controlled conditions like temperature, relatve humidity and air flow etc. Dehydrated foods are shelf stable(safe for storage at a room temperature).

Preservation of food by drying is based on the fact that microorganisms and enzymes need water in order to be active. The moisture content has to be lowered to a point where the activity of food spoilage and food poisoning organism are inhibited. Dried foods said to be low moisture foods(**LM)** have maximum moisture content of 25% and aw between0.00-0.60.Freeze dried foods too are in this category. Another category of shelf- stable foods are said to be intermediate moisture foods**(IM**) those that contain moisture between 15-50% and aw between 0.60-0.85.easiest drying means is sun drying where pests may contaminate the food. Thus various types of development of drying equipments are underway and even in operation

DRYERS

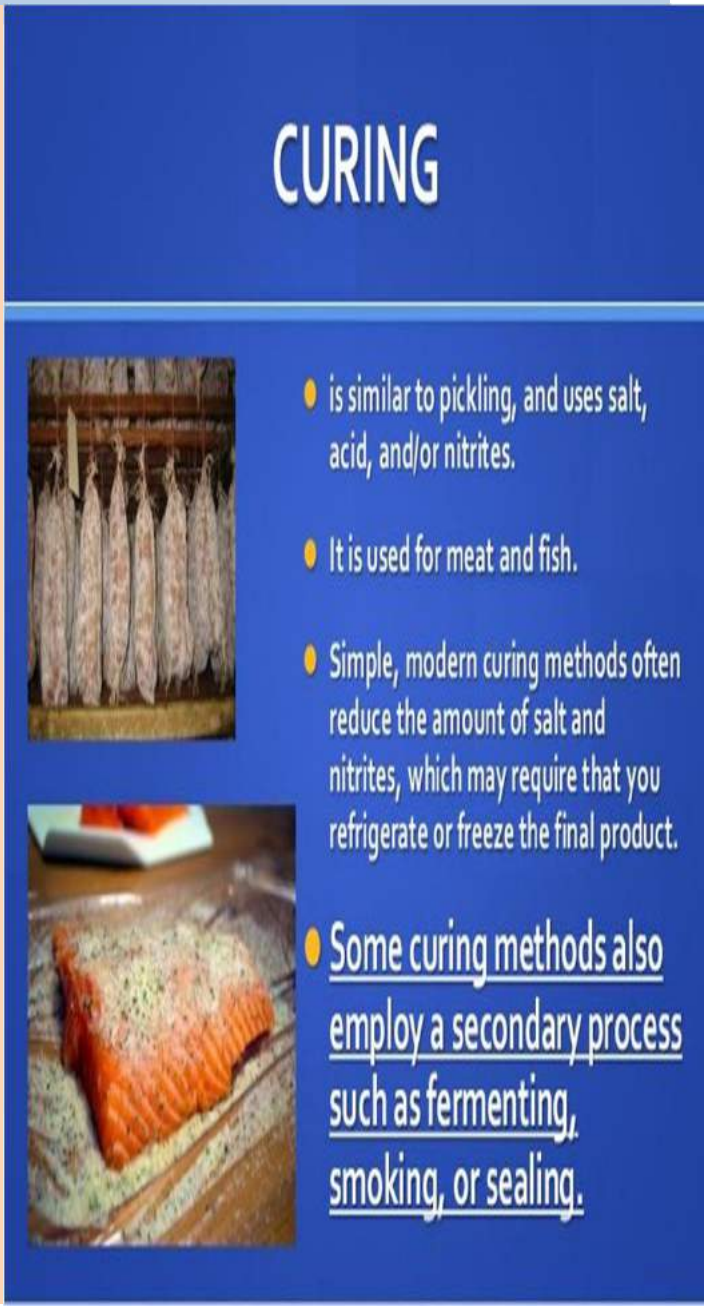
Heat transfer mode

Convection	Conduction	Radiation	Dielectric	Combined modes
Flash dryer Spray dryer Fluid bed dryer Cabinet dryer Tunnel dryer Rotary dryer Spouted bed dryer	Drum dryer Agitated pan dryer Rotary dryer Trays dryer	Infrared shelf dryer Sun dryer	Microwave oven Microwave tunnel Radiofrequency dryer	Microwave convective dryer Microwave spouted bed dryer Infrared convective dryer Radiofrequency assisted heat pump dryer



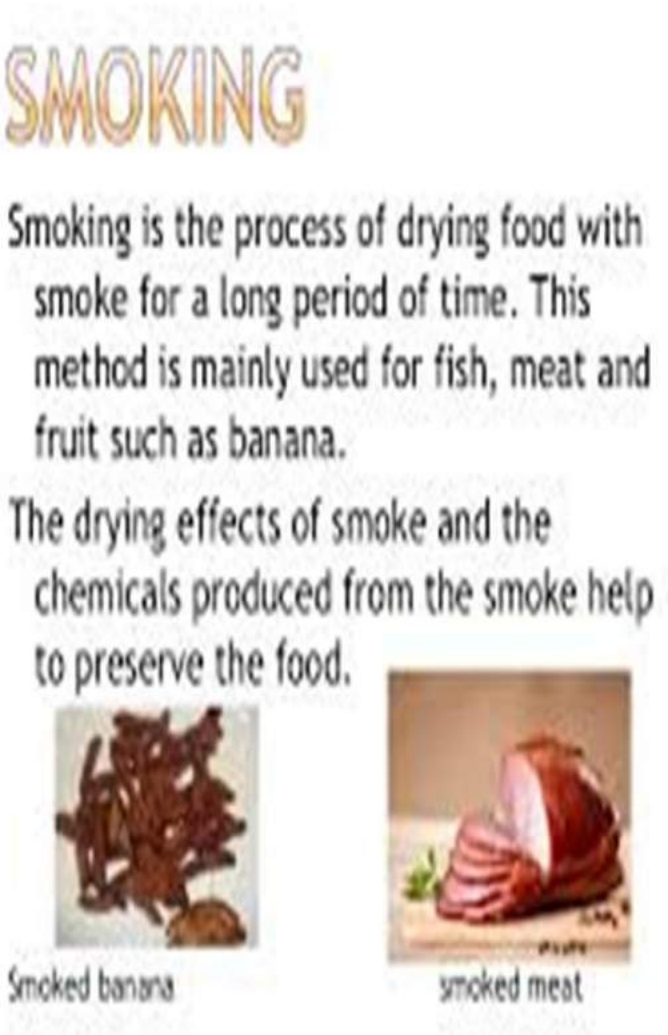
CURING

❖ **Curing** is done in foods like meat ,fishes and vegetables to reduce moisture content by osmosis process, subsequently killing or retarding microbial growth. It is done by adding salt, sugar, nitrates and nitrites which can dehydrate the food. Salt has capability of slowing oxidation process resulting in slow oxidation of fat thus avoiding rancidity. Nitrite has ability to inhibit spore forming bacteria. **The mechanism of its action is** poorely understood due to the complexity of interaction of several factors such as pH, salt content, nitrite and heat processes. Curing of meat utilizes nitrate and nitrite salt in addition to sodium chloride. Nitrate becomes an effective curing agent only after reduction to nitrite. Usual pH range of meat processing is 5.0-6.5; under such conditions nitrite forms nitric oxide (NO) which binds to myoglobin. The NO-Myoglobin pigment is heat stable and bestows a red curing color to meat. In meat matrix nitrite is oxidized to nitrate and acts as an oxygen scavenger or as antioxidant compound. By this action nitrite gets reduced and thus do not form carcinogenic N-nitrosamine upon thermal processing. Raw aged meat products may contain traces of various various N-Nitrosamines.



Smoking

Usually done in meat ,apart from preserving imparts an appealing sensory property. **It has three preservation mechanisms**: 1)heat, 2)chemical, 3) surface dehydration. Smoke heat kills the contaminating microorganism ,depending on temperature and time used. Wood smoke has some chemical compounds having antimicrobial effect



Pasteurization

- The process of pasteurization **(physical preservation technique**)was named after **Louis Pasteur**(1860s)who applied heat treatment to extend shelf life of wine .Today it is widely used in dairy industry and various food processing industries.
- Pasteurization literarily means heating food to a certain temperature for some time followed by rapid cooling.It is application of mild heat (range 60-80 °C) or below 100 C upto few minutes.
- The heat treatment and cooling processes are designed o inhibit a phase change of the product. The acidity of food determines the parameters (time and temperature)of the heat treatment as well as duration of shelf life. It requires adequate holding time to assure the thermal destruction of pathogens and microbes accountable for food spoilage, without any changing in the nutritional qualities. However it does not affect the nutritional value and taste.
- This conventional pasteurization process employs continuous heat transfer. The Purpose of pasteurization is to increase milk safety and other beverages for the consumer by destroying disease causing pathogenic microorganisms that may be present by destroying spoilage microorganisms and inactivating enzymes that contribute to the poor quality and shelf life of milk and beverages. Milk is a food product that is pasteurized worldwide.
- Originally, the temperature-time combination for pasteurization was based on amount of heat treatment required to destroy *Mycobacteriun tuberculosis var.bovis*, causing tuberculosis. This was considered the most heat stable pathogen in milk at that time.Currently , the temperature time setting is based on thermal death time studies (at which the nutritional other qualities like taste and palatability of milk are retained for most heat-resistant pathogens found in milk, *Coxiella burnetii* which causes Q fever. At dairy industries, routinely milk is pasteurised at 62.8°C for at least 30 minutes or at 71.7°C for at least 15 seconds usually.

Purpose of Pasteurization

Its primary intention is to make microbe free food which may cause health issues. The mode of heat treatment and resulting extension of shelf life are determined mostly by pH of food. In low acid foods(pH>4.5) ., the purpose is destruction of pathogenic bacteria, and below pH4.5 destroys spoilage microorganism or enzyme inactivation. Table-IShows different pasteurization conditions for food. Unlike sterilization pasteurization is not intended to kill all microorganisms in food; instead it aims to achieve 'log reduction' in a number of viable organisms, reducing their number so that they are unlikely to cause disease(conditioned that pasteurized product is refrigerated and consumed before expiry date).commercial scale sterilization is not common, as it negatively affects the quality and taste of product.

Pasteurization of carbonated juices needs only to be conducted at such temperature and time that destroys molds and yeasts. Yeasts are killed at 60-65°C,resistant molds can be heated upto 80°C.Juices of high acidity may be pasteurized at lower temperature of 0-65°C.

Processing containers of food with low pH as pickles, fruit juices is similar to **canning.** In acidic product(pH 4.0-4.5) yeasts , mold and some bacteria grow(thermophilic and mesophilic). The main risk of spoilage is from aerobes- *Clostridium pasteurianum, C. thermosaccharolyticum* among the anaerobes. In high acid foods (phL<3.9) such as pineapple juice , spoilage is caused by non-spore forming bacteria(*Lactobacillus* and *Leuconostoc*), yeasts and molds. Fruits with low pH contain enzyme system as catalases, peroxidase, pectin, esterase etc in addition to spoilage organisms. Unless inactivated these enzymes likely causes undesirable changes in canned products. Peroxidases , have higher heat resistance than spoilage organisms and have been evaluate in thermal processing of canned fruits.

Food	Main Purpose	Subsidiary Purpose	Minimum Processing Conditions
pH < 4.5			
Fruit juice	Enzyme inactivation (pectinesterase and polygalacturonase) (yeasts, fungi)	Destruction of spoilage microorganisms	65°C for 30 min; 77°C for 1 min; 88°C for 15 s
Beer	Destruction of spoilage microorganisms (wild yeasts, *Lactobacillus* species) and (residual yeasts, *Saccharomyces* species)	—	65°C–68°C for 20 min (in bottle); 72°C–75°C for 1–4 min at 900–1000 kPa
pH > 4.5			
Milk	Destruction of pathogens: *Brucellaabortis*, *Mycobacterium tuberculosis*, *Coxiella burnetti*	Destruction of spoilage microorganisms and enzymes	63°C for 30 min; 71.5°C for 15 s
Liquid egg	Destruction of pathogens *Salmonella seftenburg*	Destruction of spoilage microorganisms	64.4°C for 2.5 min; 60°C for 3.5 min
Ice cream	Destruction of spoilage microorganisms.	Destruction of pathogens	65°C for 30 min; 71°C for 10 min; 80°C for 15 s

TABLE –I Purpose of pasteurization for different food (ref- google)

Methods of pasteurization

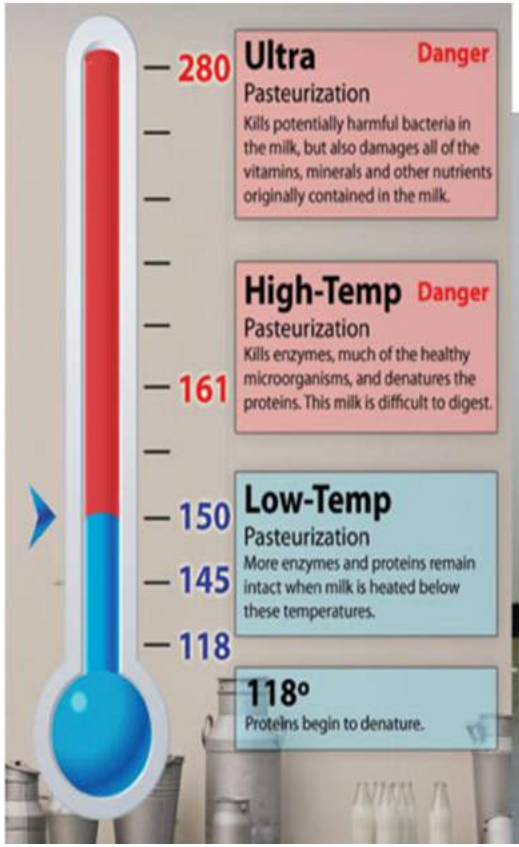
On the basis of temperature and heat exposure, pasteurization can be categorized into three types:
Low temperature long time (LTLT) --63 to 65°C over 30 minutes or 75°C over 8 to 10 minutes.
High temperature short time (HTST) HTST method involves temperature of 71.7°C for about 15 seconds in case of milk pasteurization and grape wines are generally pasteurized for one minute at 81 to 85°C.
Ultra high temperature (UHT) method (Rapid, high or flash pasteurization involves temperatures of 85-90°C or more and time in order of seconds).

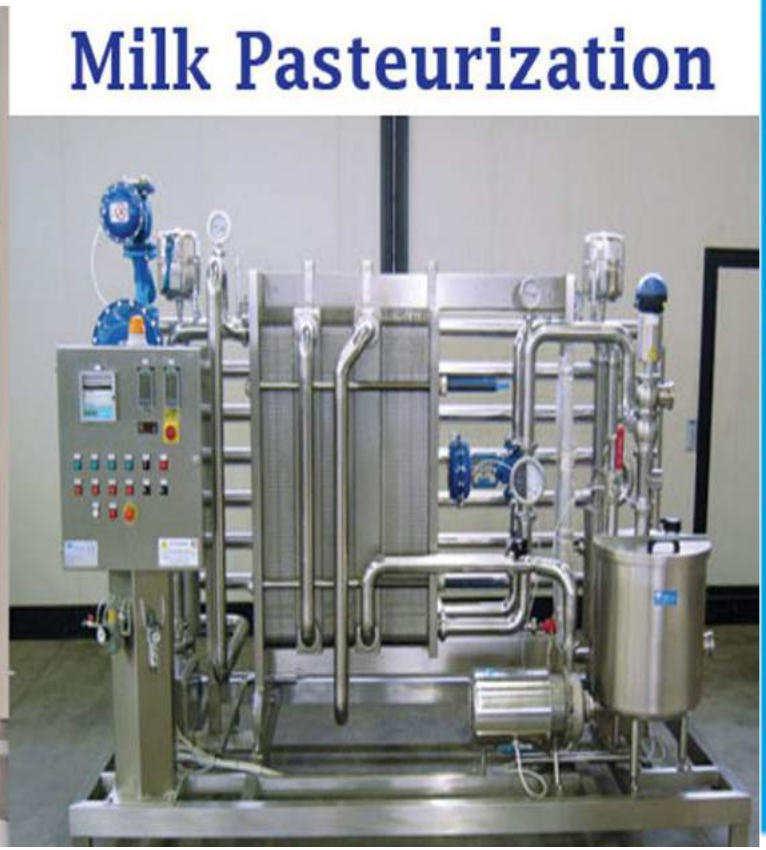
Other variable types of pasteurization :

In-package pasteurization –inside packages, heating to sterility level is not required.
Pasteurization prior to packaging; preheating process for goods sensitive to high temperature gradients.
Batch pasteurization: low temperature short time process e.g; In case of milk.
Continuous pasteurization : high temperature short time process. Here plate heat exchangers, tubular heat exchangers, and scraped surface heat exchangers are used, depending on the viscosity of fluid food material.
In addition to the mentioned conventional processes, alternate methods exist which are not regarded as true pasteurization.

Commonly pasteurized products

Canned foods
Beer
Dairy products
Juices
Low alcoholic beverages
Syrups
Wines
Vinegar
Water etc.





Products That Can Be Pasteurized	
Foods	**Liquids**
Butter	Milk
Cheese	Honey
Cream Cheese	Vinegar
Sour Cream	Fruit Juices
Yogurt	Cider
Ice Cream	Lemon Juice
Nuts	
Sauerkraut	
Eggs	
Lobster meat	
Crab meat	

Thanks