Meat Preservation Techniques

- Meat is a highly perishable commodity due to nearly neutral pH, high moisture content and rich nutrients.
- Contamination with spoilage organisms is almost unavoidable which makes the preservation of meat more difficult than most other foods.
- Unless proper preservation methods are adopted, deteriorative microbial activity, enzymatic and chemical reactions along with physical changes are bound to occur.
- Efforts should be made to attain asepsis by avoiding contamination as much as possible.
- However, once meat is contaminated with micro-organisms, their removal is difficult.
- Hence, preservation of meat is usually accomplished by the use of low temperature, high temperature, moisture control, direct microbial inhibition, etc.

Various methods employed to prolong the shelf-life of meat are:

1. Chilling/refrigeration
2. Freezing
3. Curing
4. Smoking
5. Thermal processing
6. Canning
7. Dehydration
8. Irradiation

Chilling/Refrigeration

- This is the most widely used method of preservation for short term storage of meat as chilling/refrigeration slows or limit the spoilage rate at temperature below the optimal range can inhibit the microbial growth, enzymatic as well as chemical reactions.
- Storage of fresh meat is done at a refrigeration temperature of 2 to 5°C.
- Chilling is critical for meat hygiene, safety, shelf life, appearance and nutritional quality. Carcasses are first hanged in chilled coolers (15°C) to remove their body heat, and are then passed on to holding coolers (5°C).
- It is essential to maintain proper spacing between carcasses so as to allow throughout air circulation.
- It is employed by two methods: (a) immersion chilling, in which the product is immersed in chilled (4°C) water and (b) air chilling, in which the carcasses are misted with water in a room with circulating chilled air.
- Refrigeration of meat begins with the chilling of animal carcass and continues throughout the entire channels of holding, cutting, transportation, retail, display and even in the customer household before the ultimate use.
- The relative humidity is generally kept at 90% in order to avoid excessive shrinkage due to loss of moisture.

- The refrigerated storage life of meat is influenced by species of origin, initial microbial load, packaging and temperature as well as humidity condition during storage.
- Irrespective of species of origin, maximum care should be taken during handling of meat in order to check further microbial contamination.
- Refrigerated temperature favors the growth of psychrophilic organisms causing spoilage of meat in due course of time.
- Generally, fresh meat remains in good condition for a period of 5-7 days if kept at refrigerated temperature of 4 ± 1°C.
- Cold-shortening and toughening may result from ultra-rapid chilling of pre-rigor meat.
- It is emphasized that the processed meat should be stored under refrigerated condition till they are finally consumed.
- The well preserved meat has enhanced shelf life as compared to fresh meat.

Freezing

- Freezing is an ideal method of keeping the original characteristics of fresh meat.
- Meat contains about 50-75% by weight water, depending on the species, and the process of freezing converts most of water into ice.
- It stops the microbial load and retards the action of enzymes.
- The most significant advantage of freezing is the retention of most of the nutritive value of meat during storage, with a very little loss of nutrients occurring in the drip during thawing process.
- It is important to wrap fresh meat in suitable packaging film before freezing otherwise meat undergoes freeze burn.
- This abnormal condition occurs due to progressive surface dehydration resulting in the concentration of meat pigments on the surface.
- The quality of frozen meat is also influenced by its freezing rate.
- In slow freezing, there is formation of large ice crystals, which may cause physical damage to muscular tissue, giving it distorted appearance in the frozen state.
- In fast freezing, numerous small ice crystals are formed uniformly throughout the meat tissue. The freezing rate is increased with decreases in temperature, almost 98% of water freezes at -20°C and complete crystal formation occurs at -65°C. Thus, problem of muscle fiber shrinkage and distorted appearance is not there in meat tissue.
- The drip losses during thawing are considerably low as water freezes within the muscle fiber itself.
- Numerous small ice crystals on the surface of the fast frozen meat are also important as they give a desirable light color as compared to slow frozen meat.
- Microbial growth stops at -12°C and total inhibition of the cellular metabolism in animal tissues occurs below -18°C.
- However, enzymatic reactions, oxidative rancidity and ice crystallization will still play an important part in spoilage.
- During freezing, about 60% of the viable microbial population dies but the remaining population gradually increases during frozen storage.

- Currently, meat for industrial processing is usually frozen in the form of carcasses, quarters, or boned - out primals in 25 – kg cartons.
- It is not unusual for meat to be frozen twice before it reaches the consumer.
- During industrial processing, frozen raw material is often thawed or tempered before being turned into meat - based products (i.e., pies, convenience meals, burgers, etc., or consumer portions, fillets, steaks, and so on).
- These consumer - sized portions are often refrozen before storage, distribution, and sale

The effect of freezing and thawing on meat quality

There is a general view that fast freezing offers some quality advantage (ice crystal size).

Tenderness and texture
The texture of frozen meat generally fixed by what happened to the meat during the primary chilling of the carcass. Toughness (in meat) is caused by three main factors—advancing age of the animal, "cold rigor" (the muscle fiber contraction that can occur during chilling), and unfavorable meat acidity (pH). However, ageing (also known as conditioning, maturation) improve tenderness of meat.

Drip production
When meat is frozen, its water-hold capacity is reduced. This in turn gives rise to increased "drip". Drip loss occurs throughout the cold chain. During fluctuation of temperature during frozen storage drip loss occurs.

Odor and flavor
There is no evidence that freezing and thawing has any effect on meat flavor. However, meat flavor can alter during frozen storage. This is principally caused by lipid oxidation, also referred to as oxidative rancidity, which results in unacceptable off flavor.

Color and appearance
The appearance of meat at its point of sale is the most important quality attribute. Changes in color of the muscle and blood pigments (myoglobin and hemoglobin, respectively) determine the attractiveness of fresh meat, which in turn influences the consumer's acceptance meat products.
The color of frozen meat varies with the rate of freezing. There is a direct relationship between freezing rate and muscle lightness; the faster the rate, the lighter the product.

Freezing systems for meat

Heat transfer can only occur by four basic mechanisms: conduction, radiation, convection, and evaporation/condensation.

Conduction requires a good physical contact between the meat to be cooled and the cooling medium, and this is generally difficult to achieve with carcasses and other irregular meat cuts.
Radiation does not require any physical contact, but a large temperature difference is required between the surface of the meat being cooled and that of surrounding surfaces to achieve significant heat flow. In primary freezing, radiation is only important in the initial stages of the

process in a system where the meat is not surrounded by other product. Again, in the initial stages of the freezing of cooked meat products (e.g., pies, pasties, joints), radiant heat loss can be substantial if the products are surrounded by cold surfaces.
Evaporation from a meat surface reduces yield and is not desirable in most meat refrigeration operations but can be useful again in the initial cooling of cooked meat products.
Convection is by far the most important heat transfer mechanism employed in the majority of meat refrigeration systems. In most cases, refrigerated air is the transfer medium; however, in some cases water, brine, or a cryogenic gas can be used.

Air freezing methods
Air is by far the most widely used method of freezing meat, as it is economical, hygienic, and relatively noncorrosive to equipment. The big advantage of air systems is their versatility, especially when there is a requirement to freeze a variety of irregularly shaped products or individual products.

Contact freezing methods
Contact freezing methods are based on heat transfer by contact between products and metal surfaces (which in turn are cooled by either primary or secondary refrigerants) or direct immersion in a refrigerated liquid.
Contact freezing offers several advantages over air cooling — for example, much better heat transfer and significant energy savings. However, disadvantages are the need for regularly shaped products with large flat surfaces with plate systems, and the need to wrap and wash off the immersion liquid in immersion systems.
Cryogenic freezing is essentially a subset of immersion freezing, in that it directly uses cryogenic refrigerants, such as liquid nitrogen or solid carbon dioxide. The method of cooling is essentially similar to water -based evaporative cooling, where cooling is brought about by boiling off the refrigerant, the essential difference being the temperature required for boiling. As well as using the latent heat absorbed by the boiling liquid, sensible heat is absorbed by the resulting cold gas. Due to very low operating temperatures and high surface heat transfer coefficients between product and medium, cooling rates of cryogenic systems are often substantially higher than other refrigeration systems.

Frozen storage systems for meat
Three factors during storage — the storage temperature, the degree of fluctuation in the storage temperature, and the type of wrapping/packaging in which the meat is stored —are commonly believed to have the main influence on frozen storage life.

Storage Temperature
It is generally accepted that lowering the frozen storage temperature of meat extends the storage life.

Temperature fluctuation
Generally, fluctuating temperatures in storage are considered to be detrimental to the product.

Packaging
Packaging has a large direct effect on storage life, especially in fatty meats and meat products, and in extreme cases, indirectly due to substantially increasing the freezing time. Without

wrapping, freezer burn may occur, causing extreme toughening and the development of lipid oxidation as the surface dries, allowing oxygen to reach subcutaneous fat in the affected area. Wrapping in a tightly fitting pack having a low water and oxygen permeability (such as a vacuum pack) can more than double the storage life of a product. Waterproof packing also helps to prevent freezer burn, and tight packing helps to prevent an ice buildup in the pack.

Thawing and tempering systems for meat

Frozen meat as supplied to the industry ranges in size and shape, although much of it is in blocks packed in boxes. Thawing is usually regarded as complete when the center of the block has reached 0 ° C, the minimum temperature at which the meat can be filleted or cut by hand. Lower temperatures (e.g., - 5 to - 2 °C) are acceptable for meat that is destined for mechanical chopping, but such meat is " tempered " rather than thawed. The two processes should not be confused because tempering only constitutes the initial phase of a complete thawing process. In practice, tempering can be a process in which the temperature of the product is either raised or lowered to a value that is optimal for the next processing stage.

There are two basic methods of thawing: thermal and electrical.
Thermal methods are dependent upon conventional heat conduction through the surface. Electrical methods, on the other hand, employ heat generation inside the product.

Thermal thawing/tempering methods

		Advantages	Disadvantages
Conduction systems	Air	Easy to install: can be adapted from chill rooms Low velocity systems Retain good appearance	Very slow, unless high velocities and high temperature are used When there can be weight loss, spoilage and appearance problems
	Water	Faster than air systems	Effluent disposal Deterioration in appearance and microbiological conditions Unsuitable for composite blocks
	Vacuum heat	Fast Low surface temperature Very controllable Easily cleaned	Deterioration in appearance High cost Batch size limited
	High Pressure	Fast	Not commercially

		Reduce Microorganisms	available at present
Electrical systems	Microwave/Infrared	Very fast	Problems of limited penetration and uneven energy absorption Can cause localized cooking
	Resistive	Fast	High cost Problems of contact on irregular surfaces
	Ultrasonic	Fast	Not commercially available at present

Shelf life of meat

- Properly packed refrigerated meat can be stored for 72 hours.
- Ground meat at refrigerated temperature can be stored for one day.
- Vacuum packed meat at refrigerated temperature can be stored for three weeks.
- Cured, vacuum packed meat at refrigerated temperature can be stored for three montsh.
- Frozen meat can be stored for one year.