Preservation 4

PRESERVATION BY LOW TEMPERATURE (COLD)

- **Refrigeration process means extraction of heat from a body and thus cooling it to a temperature below the surrounding atmosphere either by chilling or freezing .**
- **Appearance, weight and flavour of the meat are altered to a little extent and no substance is added or extracted from it.**
- **The failure of bacteria to grow at or below freezing depends mainly on the removal of the available water as ice; about 70% is removed at 3.5°C and 94% at –10°C. Also in the case of flesh foods low temperature inhibits the action of natural autolytic enzymes.**
- **The surface growth of mould on meat is controlled not only by the temperature but also by the relative humidity of the atmosphere. For the prevention of mould the temperature and relative humidity must therefore be kept as low as possible.**
- **The organisms that grow well at low temperature are referred to as *psychrophiles. Eg.* Pseudomonas, *Achromobacter, Flovobacterium, Alcaligenes, Micrococcus* and others.**

FACTORS CONTROLLING EFFICIENCY OF CHILLING

- Higher temperatures are less effective in preservation and shrinkage is also high.
- The rate of chilling-quick chilling being superior in both keeping quality and sensory qualities and shrinkage is also lesser as well.
- Air velocity is directly proportional to rate of chilling.
- Initial chilling of warm carcasses, sides, or quarters is carried at 7°C and the mean air speed of 0.75m/s, while in the terminal stages of chilling temperature must be maintained between -1°C and 2°C, with mean air speed of 0.5m/s.

- Air circulation rates of up to 70-110 volumes of the room per hour are maintained in quick chilling to rapidly lower the temperature.

- Relative humidity of the chilling room.

- The recommended rail spacing in a chiller or freezer room should be 0.9m for beef, 0.7 m for pork and 0.5 m for lambs and the minimum space between carcasses on these rails should be 0.3 to 0.4m.

PHYSICAL CHANGES IN CHILLED MEAT

Shrinkage

- Shrinkage or loss of weight occurs as a result of evaporation of water from meat surface. (usually 1.5 to 2.0% of weight by evaporation during the first 24 hours of hanging.)
- evaporation is inhibited by membranes such as the pleura and peritoneum and in well nourished carcass, by the solidification of the superficial fat and drying of the connective tissue.

Sweating

- Denotes condensation of water vapour on meat brought from a cold store into ordinary room temperature.
- The condensation occurs because of the cold refrigerated carcass lowers the temperature of the air to below the dew point.

Loss of bloom

- Bloom is defined as the colour and general appearance of the carcass surface when viewed through the semitransparent layer of connective tissue, muscle and fat, which form the carcass surface.
- Loss of surface bloom in beef carcasses may be caused by dehydration or undue oxidation.

CHEMICAL CHANGES IN CHILLED MEAT

- There is a slight degree of breakdown of muscle protein by endogenous enzymes or by those of the microorganisms, which is due to the chemical changes that take place after slaughter.
- The meat odour becomes progressively more marked but never disagreeable
- The condition of the fat determines the length of storage, the changes in fat may render the meat repugnant and unmarketable
- While the lean muscle of a carcass may be still improving in flavour.
- Rancidity is most likely in the kidney fat and in hot weather
- Rapid cooling is necessary to prevent spoilage around the lymph nodes deep in the carcass (referred to as *bone souring*).
- Meat must be chilled after post-mortem inspection and must be held at a temperature of not more than +7 ^{o} C for carcasses and cuts in case of red meats, +4 ^{o} C for poultry and +3 ^{o} C for offals.
- Cutting plants must have cooling equipment to keep meat at constant internal temperature of not more than +7 ^{o} C.
- The temperature of the cutting rooms should never exceed +10 ^{o} C during cutting.

COLD SHORTENING

- Cold shortening is an undesirable change associated with quick chilling, when pre- rigor muscles, (i.e. while the pH of muscle was still above 6.2 and Adenosine Tri-Phosphate (ATP) was still present) were subjected to a temperature of below 10°C

- A pH of above 6.2 and presence of ATP is a pre-requisite for cold shortening to occur.

- The phenomenon of cold shortening was first encountered in New Zealand when rapid cooling schedules for lamb freezing were first introduced.

- Cold shortening is not an important concern in the pork or poultry industry as white muscles are less prone to cold shortening.

- Cold shortening occurs due to the inability of the sarcoplasmic reticulum to sequester Ca^{++} at low temperatures (0°C - 5°C) and a decreased binding ability of mitochondria to bind Ca^{++}. The inability of sarcoplasmic reticulum and mitochondria to bind Ca^{++} results in its spillage into the sarcoplasm and cold shortening ensues much in the same fashion as Ca^{++} triggering muscle contraction.

- This is not a serious problem in white muscles as they possess a rather better developed sarcoplasmic reticulum, in comparison to red muscles and possess fewer mitochondria than red muscles.

- It can be avoided by delaying the start of chilling, e.g. for 10-12 h when the pH will be below 6.2 and the rigor will have taken place with the complete disappearance of ATP from the muscle or not chilling below 10°C in less than 10 h.

- Cold shortening can also be prevented by the use of electrical stimulation, which advances the onset of rigor, tender-stretch method of suspending carcasses and by ageing.

ELECTRICAL STIMULATION

- Electrical stimulation refers to the passing of high voltage electricity through the carcass immediately after slaughter, the current causing the muscles to contract and thereby use up glycogen, ATP and creatine phosphate.
- A number of muscle contractions are made to occur in a short time, thereby accelerating the onset of rigor.
- The process of rigor mortis is advanced and the pH is brought down to less than 6.0 within 2-3 hours of slaughter.
- Hence rigor passes off and thus cold shortening does not occur even when the temperature of the carcass is brought down to less than 10 ^{o}C within 10 hours of slaughter.
- High voltages have been found to be more effective especially if electrical stimulation is delayed. But electrical stimulation must be carried out within half an hour of slaughter for best results.
- Electrical stimulationis also said to improve muscle colour and brightness.

REFRIGERATED MEAT TRANSPORT

- Meat may be transported by road in properly insulated and refrigerated vehicles or in insulated or non-insulated non-refrigerated vehicles.

- Solid carbon dioxide is sometimes used, either as solid blocks or crushed, and provides a temperature of 0-10ºC.

- The van cooler is provided with a fan, which blows the cool air over the CO_2 and load.

- A thermostat switches off the fan when the desired temperature is reached and a microswitch ensures that the unit does not operate when the vehicle doors are open.

- The maintenance of the internal temperature is influenced by the difference between the inside and outside temperatures, the number of times the doors are opened and closed, loading temperature of the cargo, capacity rating of the refrigerating system, respiration rate of the product, etc.

- Urethane foam sprayed between inner and outer linings forms an efficient insulating medium.

- While construction of transport vehicles is normally suitable for hanging quarters of beef, lamb carcasses, packaged meat, etc., the same does not hold for offal, which is not in cartons.

- It is important that for the retail delivery of meat and offal there should be good handling facilities and offals should not be placed in an unwrapped state on dirty floor.

FREEZING

- Freezing of meat involves the reduction of the internal temperature of meat below its freezing point of, -1.5 ^{o} C and further storing it at temperatures of less than its freezing point.

- It is generally recognised that lower temperatures are more satisfactory since they reduce the deterioration of carcass meat, and temperatures no higher than -18 ^{o} C and even -30 ^{o} C are recommended.

  - Beef quarters -frozen within 36 hours, temperature of -7 ^{o} C or below.
  - pig sides - frozen at -30 ^{o} C to temperature -15 ^{o} C or below.
  - Frozen storage for beef must be at a temperature of -17 ^{o} C and at -20 ^{o} C for pork.

- The meat must be wrapped in a polythene pack of at least 0.05 mm thickness and in stockinette.

- Special blast freezers with temperatures around -34 ^{o} C, air speeds of about 3-5m/s and holding times of up to 25 hours are used.

- Wrapping in moisture proof packaging can offset water losses.

- Freezing of any type or by any method does not destroy bacteria completely.

METHODS OF FREEZING

slow freezing	quick-freezing
cabinet freezer-	blast freezers
72 hours	completed in 30 minutes
freezing proceeds slowly from the exterior to the interior.	
Extracellular water freezes more rapidly than intracellular water due to its lesser solute concentration.	Numerous small ice crystals with filament like appearance are formed both intra- and extracellularly at approximately the same speed.
Long periods of crystallisation exist in slow freezing, producing numerous large extracellular masses of ice crystals that are easily lost as drip during thawing.	Most of the water inside the muscle fibre freezes intracellularly, so drip losses during thawing are considerably lower than in slow frozen meat.
Slow freezing also might result in mechanical damage to muscles, due to volume changes, associated with formation of large ice crystals	In addition, smaller and numerous ice crystals formed in quick freezing reflect more light from meat surfaces, resulting in lighter colour than in slow frozen meat.

METHODS OF FREEZING

Still Air Freezer

- The medium of heat transfer is air in a still air freezer. In this method heat transfer is entirely based on convection, as air is a poor conductor of heat. freezing is very slow. Eg Cabinet or desk freezers or freezers of home refrigerators
- The temperature range -10^{o}C and-30^{o}C.
- Their capacity to freeze unfrozen meat, is poor

Plate freezers

- The medium of heat transfer is metal in a plate freezer. In this method heat transfer is entirely based on conduction and hence freezing rates are slightly faster than still air freezers.
- Meat as such or packed in trays is directly placed in contact with freezer plates or shelves.
- The temperature range of -10^{o}C and-30^{o}C. Commercially restricted to freezing thin pieces of meats such as steaks, chops, fillets and meat products such as patties.

Blast freezers

- This is the most commonly used commercial Method

- Method for freezing meat and is either undertaken in rooms or tunnels in which cold air blast is provided.
  The medium of heat transfer in a blast freezer is also air, but air is forced to circulate rapidly by means of fans, hence rate of heat transfer and thus freezing rate is markedly increased.

- The temperature range of commercial blast freezers fall between -10^{o}C and-40^{o}C, while the air velocities range from 0.5 m/sec to about 18m/sec. High air velocities increase the cost of freezing and also the risk of freezer burn.

Freezing by Liquid Immersion and Liquid Spray

- This is the most commonly used commercial method for freezing poultry, though some fish and meat products are frozen by this method.The medium of heat transfer is the freezingliquid used, in this method. In this method heat transfer is entirely based on conduction and hence heat transfer rates are rapid than blast freezers, and hence higher temperatures can be used.

- Liquids used for freezing either for immersion or for spray must possess low viscosity, freezing points, high heat conductivity and must also be non – corrosive, relatively inexpensive and non-toxic.

- Sodium chloride brine (Corrosive in nature), glycerol and glycols such as propylene glycol are commonly used for freezing

Cryogenic freezing

- Cryogenic freezing is very low temperature freezing accomplished with condensed or liquefied gases by direct immersion of the product to be frozen in the liquid, or spraying the liquid over the product to be frozen, or by circulating the vapour of the cryogenic liquid over the product to be frozen. The agents usually used are either liquid nitrogen or carbon – di – oxide, and rarely liquid nitrous oxide is also used.
- Direct immersion of large pieces of meat is rarely used due to extensive shattering or cracking of products. So, generally liquid nitrogen is usually evaporated in a freezing chamber and the great cooling capacity, as it changes to nitrogen gas is used to freeze meat products.
- Liquid nitrogen or carbon – di – oxide released as snow, combined with conveyor systems, are used to rapidly freeze meat products of small size such as patties, diced meat, fish and shell- fish. Meat products frozen by this method have excellent sensory qualities.

PHYSICO-CHEMICAL CHANGES DURING FROZEN STORAGE OF MEAT

Alteration of the state of proteins

- The physical state of the muscle plasma (globulin and albumen proteins) is altered.
- When meat is frozen below –2°C the formation of ice crystals so raises the concentration of these proteins that they become insoluble and do not regain their solubility when the meat is thawed.

Weep or drip

- Weeping denotes the presence of a watery, bloodstained fluid, which escapes from frozen meat when thawed and consists mainly of water, together with salts, extractives, proteins, peptides, amino acids, lactic acids, purines, vitamins of B-complex and damaged blood corpuscles.
- It is caused partly by the rupture of the muscle cells and tissues by large crystals of ice, and partly by the permanent irreversible change in the muscle plasm, which prevent frozen muscles from reabsorbing water on thawing.
- meat which has a high pH prior freezing has a low drip when thawed, and a useful diminution of drip from butcher's cuts can be brought about when pH of meat beforefreezing is 6.1 – 6.3.

Rancidity

- Oxidative process in general is slowed, but in case of prolonged storage of meat in freezer, oxidative changes occur, with fat breaking down into free fatty acids and glycerine.

UNDESIRABLE CHANGES IN FREEZER STORAGE OF MEAT

Freezer burn

- Surface desiccation associated with freezing. The meat or offals have a brown withered discolouration
- It occurs on the outer surface of imported frozen offals, like kidneys livers.
- Freezer burn is attributed to loss of moisture from the outer tissues; it may be seen where a carcass is stored close to opening of a cold air duct.
- This can be prevented by using suitable packaging.

Bone darkening

- Bone darkening is a condition, which develops when young poultry is frozen and thawed as more haemoglobin is present in the bone marrow of young, rapidly growing birds. Incomplete calcification of the bones allows the haemoglobin to escape from the marrow cavity and stain the surrounding tissue dark.

Recrystallization

- It may take place during frozen storage, resulting in translocation of water and consolidation of the unfrozen soluble water molecule tend to migrate from small to large crystals.

Thaw rigor

- When prerigor meat is frozen, a severe type of rigor mortis ensues during thawing.
- The shortening so produced may be 60 to 80% of the original length of the unrestrained muscle.
- Although shortening is less in a muscle attached to skeleton, the condition results in tough meat and heavy drip losses.

EFFECTS OF FREEZING ON MICRO-ORGANISMS AND PARASITES

- Freezing destroys some bacteria but the temperature is merely inhibiting their growth and multiplication until conditions favorable to their growth appear.

- Freezing is a valuable method for the treatment of certain parasitic infestation and pork affected with *Cysticercus cellulosae* can be rendered safe if held for 4 days at -10.5 to -8˚C.

- Carcass of beef affected with *Cysticercus bovis* can be rendered safe by holding for 3 weeks at a temperature of not exceeding -6.5˚C or by holding for 2 weeks at a temperature of not exceeding -10.5˚C.
- *Trichinella* cysts in pork are destroyed by holding the carcasses for 20 days at -15˚C or by quick freezing for 24 hours at -18˚C.