PRESERVATION OF MEAT: CHILLING AND FREEZING

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Objective of meat preservation is to discourage the growth of microorganisms by controlling temperature of and / or moisture content in meat. The nutrients in meat are ideal media for the growth and propagation of spoilage microorganisms and pathogens. Holding temperature, atmospheric oxygen, endogenous enzymes, moisture content, light and microbial load influence the shelf life of meat and meat products. All these factors, either alone or in combination, cause detrimental changes in the color, odor, texture and flavor of the products. Carcass and meat contamination is inevitable though control measures are applied during slaughter operations. Low temperature holding of carcasses or meats is essential to control and reduce the levels of microorganisms in meats.

The following aspects will be studied in this topic.

1. Microbial contamination and decontamination
2. Chilling
3. Freezing
4. Thawing
5. Freeze dehydration
6. Changes in meat quality

1. MICROBIAL CONTAMINATION AND DECONTAMINATION

Animal health, hide, viscera, feces, oral microflora and carcass handling are all potential sources of cross contamination of sterile muscle during dressing operations. Washing the animal prior to slaughter reduces the number of contaminants. Scalding treatment applied to pig during dressing minimizes bacterial contamination. Pig carcass dehairing introduces bacteria from contaminated circulating water. Evisceration also contaminates through spilling of fecal matter on skinned carcass. Skill of operators during skinning and evisceration is more important than processing plant physical facilities or the type of animal slaughtered.

Washing and use of chemicals help decontamination of carcasses. Dilute solutions of organic acids and / or their salts, hydrogen peroxide, chlorine and chlorine dioxide are used as antibacterials for washing of animals. Hot water washing is also adopted commercially as a cheaper alternative. Application of steam for a few seconds (pasteurization) reduces microbial load on carcasses.

2. CHIILLING

Chilling is a process of cooling meat above its freezing temperature. Well – designed and controlled chilling process is critical to producing meat of satisfactory quality. Chilled carcasses and / or primal cuts are transported to other processing plants for further processing. Important source of microbial contamination of processed meat products include detritus accumulated in inaccessible parts of equipment. In cooled work environments, cold tolerant (Psychrotrophic) pathogens can flourish. Low temperature and low pH due to rigor are the only two hurdles to slow bacterial proliferation in fresh meats. Meat temperature should not exceed 7 ºC to prevent pathogenic mesophiles from proliferating. Storage and transport of meat at chilled temperatures lower than 7 ºC is regarded as safe. Growth of psychrotrophs can be better controlled by lowering the temperature of packed meat to – 1.5 ºC without ice formation. Although chilled temperatures inhibit microbial growth, pathogens may survive for prolonged periods in meats.

Low temperatures retard microbial growth, enzymatic and chemical reactions, which are responsible for deterioration. The temperature of chilling of meat is generally 0 - 4 °C. Fresh meat is retailed in the form of prepackaged cuts. The shelf life of fresh meat under chilled condition is 72 h in the present marketing conditions. The maintenance of low temperature at all stages of operation and particularly during display is important to secure 1 - 3 days stable life.

The different methods of chilling are:

Mechanical chilling: Meat is stored in chill room where cold air is constantly blown on its surface thereby bringing down the temperature of meat quickly. This method of chilling is quite faster and the time required to chill the meat is very less. The temperature of air is 3 °C and chilling loss is only 2 - 3 %. The bloom of meat is enhanced by this method. In quick chilling, the temperature should not be too low. High air circulation is avoided. Otherwise, it leads to cold shortening resulting in tough meat.

Cooling by ice: Meat is kept in insulated boxes containing ice and salt for cooling. It is a slow process and the surface of meat becomes moist and unattractive. Discoloration of meat starts during long storage.

3. FREEZING

Freezing is a process of removing heat by converting water in meat in to ice. Freezing is superior to other methods of preservation due to the following reasons:

(i) Lowering of temperature retards or stops most reactions including bacterial activity,

(ii) Water in ice form is not available for bacteria for their biological functions and growth and

(iii) There is complete immobilization of the system, thereby reducing spread of organisms by convection.

Meat preserved by freezing retains its original quality attributes without significant reduction or modification.

Freezing of meat covers essentially three aspects, *viz.*,

(i) Freezing process,

(ii) Frozen storage and

(iii)Thawing.

The quality of the product is affected to varying degree by several factors involved in these three operations.

Freezing point: Meat starts freezing only after its surface temperature drops below the initial freezing temperature of meat. Meat will start freezing from outside towards inside. The surface layer freezes first and then the frozen layer will become thicker. The inner boundary of the frozen layer is known as frozen front, which moves gradually inwards toward the center of the meat. Once the freezing temperature front has started moving, the temperature of the unfrozen region will usually have dropped to the freezing temperature of meat.

Freezing process: The freezing operation has to be carried out in "freezers" at specified time temperature conditions. The frozen meat is then transferred to "frozen storage" immediately to ensure quality of the product. Fresh meat contains 75 - 80 % of water. The duration with which the conversion of water to ice takes place has a significant role on the quality of the frozen product. Slow freezing causes cell damage due to the formation of large ice crystals in intercellular space. This leads to drip loss and deterioration of texture. In quick freezing, on the other hand, the ice crystals formed are small and uniformly distributed in intra - cellular space, causing less damage to the structure. The product should cross the temperature of - 1 °C and - 5 °C, within 1 - 2 h. This process is called fast - freezing, as major portion (75 %) of the water in the meat gets frozen within a short time.

Methods of freezing and types of freezers: Two types of freezers, *viz.*, (i) Air - blast freezer and (ii) Contact plate freezers are in operation in commercial practice. The blast freezer (or tunnel freezer) (Fig. 1) operates on the principle of cooling the carcasses / meats by a blast of cold air sweeping over them, circulated in a closed system. The working temperature of most blast freezers is in the range of - 40 °C to - 45 °C with air velocities around 2500 ft per minute. The main advantage of this method is that large size objects of assorted shape and dimensions can be frozen simultaneously. However, moisture loss and weight reduction of carcasses occur due to the high velocity air circulation, if not well protected by packaging,

In surface contact plate freezers, the freezing of material takes place by contact with a cold metallic surface such as plates, belts, drums or shelves. The plate freezers are the most common in use. They may be vertical, horizontal or rotary and may be manual or automatic in operation. The horizontal plate freezers (Fig. 2) require a product packed into trays of uniform depth, with minimum air spaces. Vertical plate freezers do not require trays and the product may be top - fed between the plates. The main advantage is that the plate freezers produce frozen blocks of uniform thickness. The use of plate freezer is usually limited to meat pieces which are relatively thin (*e.g.* steaks), deboned and pre - packed meat and minced products (*e.g.* hamburger patties).

Cryogenic freezing: Recent development is the use of liquid nitrogen, carbon dioxide or freon (chlorofluorocarbon compounds). These freezants are directly sprayed on to the material to be frozen. Freezing takes place due to removal of heat as heat of evaporation needed by the liquefied gases. This kind of freezing is "Cryogenic freezing". The evaporated gas is discharged to the atmosphere. This process is expensive, although the initial installation cost is relatively less as compared to the conventional systems.

Frozen storage of meat: The manner in which frozen meat is stored influences more the quality of the product than the process of freezing itself. The main factor is the temperature of storage. The ideal temperature for each kind of product is dependent on the fat content, lower temperatures being preferred for more fatty materials. Temperature range of - 18 to - 23 °C is ideal for the storage of meat and meat products. It is desired to have the product temperatures immediately after freezing as close to the storage temperature as possible. A properly packed meat, poultry or their products may remain in sound conditions for several months at such storage temperatures.

The comparison of cost of freezing is given below.

Freezing cost (comparative)

Method	Unit cost
Horizontal plate freezer	X
Vertical plate freezer	X
Batch air blast	1.5 X
Continuous air blast	1.5 X
Liquid fluorocarbon freezing	3 X
Liquid nitrogen	6 X

Shelf life of variety frozen meat products held at - 18 to – 23 °C is given below:

Lean meat	5 - 6 months
Pork products	3 - 6 months
Dressed chicken	5 - 6 months
Processed products	
e.g. Sausages	3 months
Cooked products	1 - 3 months

4. THAWING

Correct thawing prior to cooking ensures the nutrient retention of meat and meat products. Thawing, the reverse process of freezing, involves the melting of ice in the frozen product, by absorption of heat from external source. Under practical conditions, thawing of frozen meat is a very slow process and poses serious operational problem in commercial practice. The normal procedure is to thaw in cold or warm air or circulating water. Recently, microwave energy has been extensively used both for home and commercial thawing of frozen products. Quick thawing minimizes drip loss and surface growth of microorganisms to a large extent.

5. FREEZE DEHYDRATION

Freeze dehydration can be achieved by the removal of water from meat by sublimation, while thermal dehydration is done by evaporation. Sublimation is a process where a solid turns into a gas without going through a liquid stage.

Freeze dehydration incorporates plates to enhance heat exchange during initial phase of sublimation and to supply heat to them to aid drying during the second phase. This process is also called as accelerated freeze drying (AFD).

The advantages of freeze drying are:

(i) Process of dehydration is faster,

(ii) Avoids translocation of salts,

(iii) Formation of honey comb texture by the direct sublimation of ice from the minute interstices of the tissue,

(iv) Least damage to meat proteins and

(v) Meat quality almost resembles fresh meat.

6. CHANGES IN MEAT QUALITY

When meat is chilled to temperature below 10 ºC while its pH is still above 6.2, the muscle will contract. This cold contraction results in to toughening of meat. If the muscle pH is below about 6.0, it can be cooled rapidly without contraction. Chilling must be slow to prevent cold contraction. Holding of carcass / meat at chill temperature (also called as ageing of meat) tenderizes meat. This is caused by the activity of proteolytic enzymes (enzymes affecting proteins) that are already present in muscle. These enzymes breakdown muscle proteins resulting in to tender meat. Ground meat or

minced meat has lower keeping quality due to increase in the surface microbial load and also incorporation of oxygen from air. This leads to discoloration and quick spoilage. This can be minimized by using vacuum package to minced meats.

At the frozen storage, microbial activity is almost nil. However, chemical deterioration, especially rancidity development of fat due to autoxidation, will continue. Again, in a frozen tissue the water is never completely frozen and there is a concentration of solutes in the remaining unfrozen phase. Most of the solutes are minerals and their concentration tends to denature the protein, thereby affecting the texture of the meat. Another major problem in frozen - stored meat is the "Freeze burn". “Freeze burn” or “Freezer burn” refers to a bleached (whitish or amber colored patches) appearance on the frozen meat surface caused by dehydration. Freezing and thawing do not have much adverse effect on cooked color, flavor, odor or juiciness of meat. Most nutrients are retained during freezing and subsequent frozen storage. Some soluble proteins may be lost during thawing, but the fluid loss is similar to the amount of fluid lost when fresh meat is cooked.

Rehydration of freeze - dried meat only with water may produce meat with slightly higher toughness than fresh unfrozen meat. Rehydration with aqueous solution of proteolytic (tenderizing) enzymes, such as papain, helps minimize this adverse effect of freeze drying on tenderness.

CONCLUSION

Carcass and meat contamination is inevitable though control measures are applied during slaughter operations. Low temperature holding of carcasses or meats is essential to control and reduce the levels of microorganisms in meats. Chilling is a process of cooling meat while the meat remains above its freezing temperature. Low temperatures retard microbial growth, enzymatic and chemical reactions, which are responsible for spoilage. Chilling of meat is achieved by mechanical chilling (blowing cold air on meat in a room) or by placing packed meat in contact with ice and salts. Freezing is a process of removing heat so that the water in meat is converted in to ice. Air - blast freezer and contact plate freezers are commercially used for freezing meat. In cryogenic freezing, the liquid nitrogen, carbon dioxide or freon (chlorofluorocarbon compounds) are used as freezants by directly spraying on to the meat to be frozen. Temperature range of - 18 to - 23 °C has been recognized as ideal for storage of meat and products. Thawing, the reverse process of freezing, involves the melting of ice in the frozen product, by absorption of heat from external source. Removal of water from meat by sublimation is referred to as freeze dehydration.

Holding of carcass / meat at chill temperature (also called as ageing of meat) tenderizes meat, which is caused by the activity of proteolytic enzymes present in muscle. Discrete ice crystals formed in meat during freezing can cause mechanical damage to cell membranes and the concentration of solutes in to unfrozen portion of the meat during the freezing process. These changes will denature proteins resulting in to greater drip loss during thawing, which is unattractive to the consumers. Freezing and thawing do not have much adverse effect on cooked color, flavor, odor or juiciness of meat. Most nutrients are retained during freezing and subsequent frozen storage. Some soluble proteins may be lost during thawing.

Fig. 1. Air blast freezer

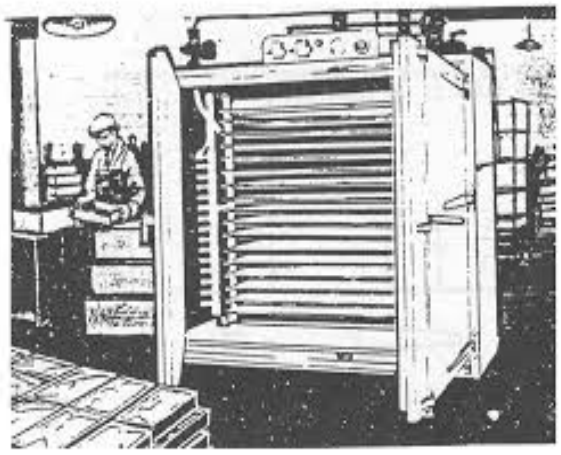

Fig. 2. Horizontal plate freezer

Source: Google search for images of meat freezers (in February 2016)