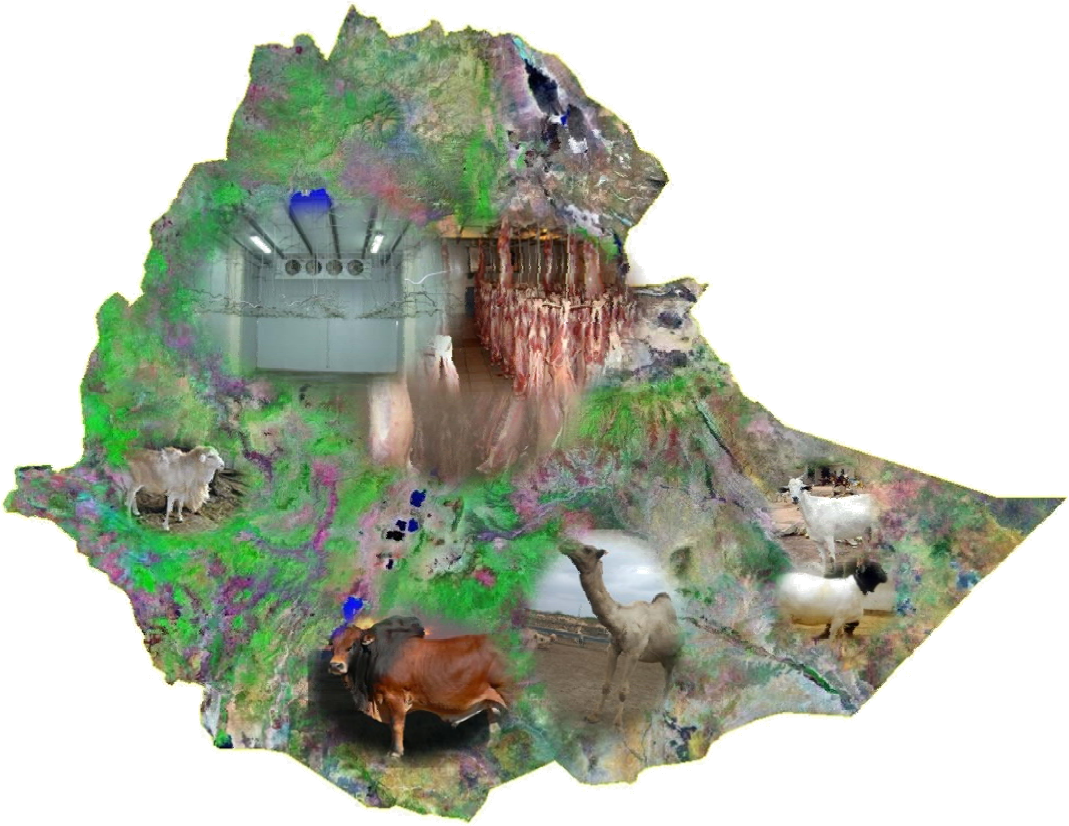
# Ministry of Agriculture and Rural Development
## Animal and Plant Health Regulatory Directorate

# Meat Cold Chain Guideline



**August 2009**
**Addis Ababa**
**ETHIOPIA**

# MEAT COLD CHAIN GUIDELINE

August, 2009

Addis Ababa, Ethiopia

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## List of acronyms

| | |
|---|---|
| ' | foot |
| " | inch |
| % | percent |
| $^{o}C$ | degree Celsius |
| $^{o}F$ | degree Fahrenheit |
| ATP | Adenosine triphosphate |
| Cm | centimeter |
| cm/h | centimeter per hour |
| $CO_2$ | carbon dioxide |
| DFD | Dark Firm and Dry |
| e.g. | for example |
| FIFO | first in-first out |
| FMD | Foot and mouth disease |
| H | hour |
| Hrs | hours |
| ISO | International Standard Organization |
| Kg | kilogram |
| m/sec | meter per second |
| $O_2$ | oxygen |
| PA | Polyamide |
| PE | polyethylene |
| PET/PETP | polyester/polyterephthalic acid ester |
| pH | Potentiel Hydrogène |
| PSE | Pale Soft and Oxidative |
| PVC | polyvinylchloride |
| PVDC | polyvinyliden chloride |
| RVF | Rift Valley fever |
| Shoats | Sheep and goats |
| UV | Ultraviolet |
| VFC | Very Fast Chilling |

## Foreword

This technical document entitled "Meat Cold Chain Guideline" is one of the documents in a series of guidelines and Standard Operating Procedures (SOPs) developed by the Ministry of Agriculture and Rural Development (MoARD) in collaboration with the Ethiopian Sanitary and Phytosanitary and Livestock and Meat Marketing (SPS-LMM) Program. SPS-LMM program is financed by USAID and is implemented by the Norman Borlaug Institute for International Agriculture, Texas A&M University System. The main goal of the SPS-LMM program is to increase exports of meat and livestock to benefit Ethiopian livestock producers and exporters and to promote national economic development.

The guideline is intended to assist abattoir operators, workers and government meat inspectors on simple ways of ensuring hygiene and sanitation of meat and meat products by maintaining the required cold chain and applying routine personal hygiene practices so that Ethiopian meat and meat products remain increasingly competitive in the international markets.

The guideline includes minimum requirements for meat and meat products chilling, temperature and pH measurement, freezing, thawing, cutting and de-boning, vacuum packaging, storing, loading and transporting practices.

At this point, the Animal and Plant Health Regulatory Directorate (APHRD) would like to thank the SPS-LMM program and USAID for developing and publishing this guideline.

Last but not least, I would like also to thank Drs. Nega Tewolde and Wondwosen Asfaw for preparing this guideline and SOP.

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## 1. Introduction

Healthy animals slaughtered hygienically after resting and fasting provide a practically aseptic meat. However, following slaughter, evisceration and dressing operations, microbial contamination occurs especially on the surface of meat, through contact with equipment, tools, hands, clothes, objects, etc.

Due to the chemical composition of meat which is rich in proteins, lipids and water, it is a particularly favorable substrate for the growth of microorganisms. The lipid content of meat also makes it very sensitive to oxidation (the reaction of oxygen with fatty acids) and subsequent production of peroxides. The breakdown products of the peroxides produce the characteristic objectionable odor and flavor of rancid meat.

In general, meat spoilage can be avoided by maintaining the required cold chain, starting from its production until it reaches consumers.

## 2. Scope of the guideline

This guideline sets out minimum standards for controlling and maintaining the cold chain of meat during dressing of carcasses, processing, packaging, handling, storage and transportation. The guideline applies to meat and meat products derived from cattle, sheep, goats and camels.

Apart from this, the guideline highlights personal hygiene for those who produce, store, prepare and handle meat and meat products.

## 3. Definition

***Chilling*** refers to the application of cold to meat to reduce its temperature to 2-4$^{o}$C within 24 hrs. Air temperature of chillers is in the region of 0°C.

***Freezing*** refers to the application of cold to meat to reduce its temperature for preserving meat longer than 72 hrs (acceptable duration for chilled meat). Air temperature of freezers is in the range of -30° to -40°C.

## 4. Cold chain of meat and meat products

Cold chain is a continuum from the time the carcass is skinned and eviscerated and enters the chilling processes, stored, dispatched and transported. This helps to achieve a level at which microorganisms do not grow. If cold chain control is violated at any point, meat safety, quality and hygiene will be compromised.

The factors that control the cooling of a side of meat are the rates at which heat can be conducted from the innermost tissues to the surface and from the surface to the circulating air in the chill room. Air temperature, air velocity, and to a limited extent, relative humidity, are the environmental factors that affect the cooling time of carcass sides. Relative humidity has a greater effect on weight loss than on cooling rate. Cooling rate is also a function of the weight and fat cover of a given side.

In general, the main aim of carcass chilling should focus on the carcass surface temperature because this is where the pathogen contamination is most likely.

There are three areas of primary focus in cold chain management. These are temperature, process flow and contamination control. While temperature control will be dealt here, the other issues are/will be addressed in more detail in other guidelines.

Temperature control does not apply to live animal production but begins at the slaughter process. Temperature control is one of the most effective tools in producing a safe product. Controlling the temperature of carcasses during the slaughter process is a proven method not only to help control microbial growth, but also to assist in creating a quality meat product.

Rapid growth of bacteria occurs between 10 and 50$^{o}$C (50-122$^{o}$F). Therefore, it is imperative that meat should not be allowed to remain at this temperature for very long time.

The goal in meat production should be to get the carcasses into coolers within 40 to 45 minutes after slaughter. For instance, beef carcass takes about 45 minutes to complete rigor mortis. When meat is harvested, it still has ATP or energy stored in the muscles. Enzymes are also still active and these enzymes catalyze the ATP which causes the muscles to contract and relax. This will continue until there is no more energy. Physiologically, the contraction of muscles is caused by calcium while relaxation of muscles is caused by enzyme activity. A decrease in temperature will stop enzyme activity. If a carcass is chilled prior to the completion of rigor mortis, the muscles may go into a state of contraction called cold shortening and the meat will be tough. For beef and lamb, this will be avoided by specifying a minimum air temperature of 10°C for the first 10 h of chilling or by the application of electrical stimulation. A high air velocity during this stage will increase the rate of chilling and reduce the drip loss on cutting.

### 4.1. Chilling

Chilling can be defined as a fundamental operation in applying cold to meat to reduce its temperature quickly. This is done in a cold chamber with intensive air movement. Rapid cooling of the meat surface not only slows and nearly stops the development of surface micro-organisms but also reduces weight loss and discoloration of the surface owing to haemoglobin oxidation. Different systems of chilling are in use but air chilling is the most common.

After slaughter and dressing, the internal temperature of an animal carcass will generally be between 30°C and 39°C. This warm and wet surface provides ideal conditions for growth of food poisoning organisms. Chilling and drying restricts microbiological activity as well as chemical and physical changes that cause deterioration and spoilage of meat.

The time taken to cool product to 0°C in air depends on the temperature of the air, the rate of airflow past the product and the level of insulation provided by the package.

*Normal chilling:* The meat industry has long been attracted by the concept of accelerating the rate of carcass chilling but this has been inhibited by the risk that a rapid drop in muscle temperature can induce a condition known as cold-shortening which can result in unacceptably tough meat. To overcome this detrimental effect on eating quality, criteria have been established for the combination of post-slaughter time, temperature and pH necessary to

avoid cold-shortening. As a general rule, it has been recommended and widely accepted that the temperature of beef and lamb should not fall below $10^oC$ within 10 h of slaughter. Research has shown that, if these time/temperature conditions are met, rigor mortis will have advanced sufficiently to avoid toughening of the meat.

*Very Fast Chilling (VFC):* Recent work has shown that reducing the core temperature of muscle to $0^oC$ in 5 hours *post mortem* produces tender meat. This unexpected result has been attributed to two mechanisms. Firstly, the outer surface of the muscle may be frozen and act as a straitjacket to prevent cold shortening. Secondly, the intense cold releases bound calcium so that the tenderizing enzymes are stimulated. The enzymes break up enough protein chains in the meat to overcome the toughening effect of cold shortening. The relative importance of these two mechanisms is not yet understood. They raise the possibility of using VFC to improve the process efficiency of export abattoirs.

- Slaughter hall shall be fitted with sufficient exhaust fans to avoid hot and humid air in the slaughter area.
- To prevent or even to reduce the deterioration process of meat, particularly microorganism development, chilling has to be carried out quickly (within 40-45 minutes) at the end of the slaughter process and the cold chain has to be maintained until the meat is processed for consumption.
- The dripping area shall be equipped with refrigeration facilities capable of maintaining a temperature of $7\text{-}10^0C$ or less. The mean air speed should be above 0.8-0.9 m/sec.
- The cold chambers where meat chilling takes place must have a low air temperature, a high air speed, a high relative humidity and a high refrigerating capacity.

    - Air temperature of chillers must be in the region of 0°C, with no decrease below -1°C, which could freeze the meat surface and impair its appearance. Meat exposed to circulating air will loose water and moisture constantly. This causes freezer burn of meat which is irreversible and results in changes of color, texture, flavor, and nutritive values. In order to achieve proper cooling, chill coolers should be maintained at $2^0C$. Holding coolers must be maintained at $4^0C$.
    - Air speed should range from 0.25 to 3.0 m/sec. However; for economical reasons, the most common speeds in use are from 0.75 to 1.5 m/sec in the empty section of the cold chamber.
    - Relative humidity during the chilling operation should be kept fairly high to prevent excessive weight loss. The recommended rate is between 90 and 95 percent.

- The surface temperature of carcasses should be $7^oC$ or less after the end of dressing and then the product temperature must continue to go down in continuous manner to $4^oC$ or less as quickly as possible within 24 hrs.
- Chilling should be completed when the warmest point of the carcass (which is the centre of the hind leg) has reached a temperature of about 7°C (3°C for edible offal). With current technology these temperatures can be arrived at in 16–24 hours in small carcasses and in less than 48 hours in large carcasses. Government inspectors should be equipped with meat thermometer to check carcass temperature.

- Chillers should be fitted with thermometer, thermograph, hygrometer and alarm systems. These equipments should be fitted on the external walls of chillers so that the inspectors can easily monitor them.

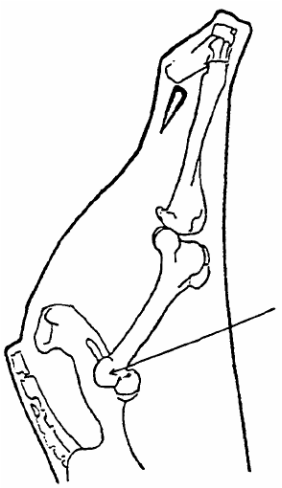

Fig.1. Centre of the hind leg for measuring temperature (drill to the surface of the *Trochanter Major* to measure deep butt temperature of frozen hindquarters)

### 4.2. Measuring pH of meat

The pH of living skeletal muscle is usually just above 7. It may decrease after slaughter from pH 5.4 to 5.7 in normal meat. If initial glycogen is limited, the pH stays high and the meat remains Dark Firm and Dry (DFD), as it is in the live animal. If the pH decline is rapid (affecting muscle proteins while still warm) or extensive (giving a low ultimate pH), the meat becomes Pale Soft and Oxidative (PSE). Thus, the pH of meat has a profound effect on color, firmness and water-holding capacity, as well as subtle effects on taste, tenderness and rate of post-mortem conditioning.

Acidification process due to lactic acid formation in muscle tissue also inactivates (kills) some pathogens including FMD and RVF viruses.

- Meat should be chilled and maturated within 24 hrs. Sample carcasses should be tested for pH in the middle of the Longissimus dorsi muscles in cattle and in the Psoas muscle in shoats and it should be $\leq 5.8$.
- Government inspectors and export abattoirs should be equipped with meat pH meter and these should be calibrated daily.
- Meat pH should be measured in sampled carcasses at 45 minutes and 24 hours post-mortem.

### 4.3. Freezing

The freezing point of a substance is that temperature at which the liquid is in equilibrium with the solid. Because of the physical nature of meat, the method of freezing affects quality and nutrient loss upon thawing. Meat frozen rapidly to 0°C (32 °F) has less drip (nutrient loss due to water loss from cells) when thawed. The speed of freezing is a very important factor as frozen meat quality depends mainly on the size of the ice crystal formed: the lower the speed of freezing the larger the size of the crystals. Slow freezing facilitates the formation of large

crystals and the separation of solution and the migration of water out of the muscle cells. Quick freezing conversely produces many small ice crystals, mainly formed within the muscle cells, and reduces water migration and separation of solution. It is obvious that the latter method will preserve the meat closer to its original quality and, particularly during thawing, moisture loss will generally be lower.

The main problem with frozen storage is deterioration in organoleptic quality. There may be changes in meat texture, fat can become granular and crumble, and there can also be some discoloration of the meat. Fat modification induced by oxygen produces rancidity and acidity, and a disagreeable taste. Microbial enzymes also remain active, especially those that attack the fat.

As in chilled storage, there are also weight losses through evaporation during freezing. This can be seen as freezer burn, i.e. superficial desiccated areas which can occur even in packaged meats when the packaging film is loose and temperature fluctuates inside the chamber.

Weight loss, which can be between 1 and 4 percent in unpacked meat, favors organoleptic deterioration.

- When the preservation period is longer than that acceptable for chilled meat (72 hrs), freezing must be used to minimize any physical, biochemical and microbiological changes affecting quality of meat in storage.
- The freezing speed which is the velocity with which a temperature front moves through the body of the product (cm/h) should be from 2 to 5 cm/h. Slow freezing is considered to be below 1 cm/h and quick freezing above 5 cm/h.
- Air temperatures should be in the range of -30° to -35°C; sometimes -40°C can also be used. Freezing is performed in tunnels or in chambers with intense air circulation called blast chambers.
- Air should circulate at high speed, from 2 to 4 m/sec and up to 6 m/sec.
- The relative humidity should be maintained at 95 percent or above. The higher the relative humidity the better: a range of 95–98 percent prevents meat dehydration. Under the above conditions, half beef carcasses or quarters are frozen in about 16– 20 hours, cut-up meat in cardboard boxes measuring 54×34×16 cm in about four hours and small prepackaged cuts in about one hour.
- Freezer burn due to dehydration should be reduced by method of packaging (with plastic film, usually under cloth or jute fabric). Meat cuts are covered with plastic film, or vacuum-packed in plastic bags; they are placed inside cardboard boxes and usually frozen. Unprotected meat is subject to a constant moisture loss as water is removed through circulating air. Damage caused by freezer burn is irreversible and results in changes in color, texture, flavor, and nutritive values of meat.
- Superficial fat should be eliminated before freezing to reduce the development of rancidity during storage.
- Meats properly frozen should be transferred from the freezer to storage chambers where temperature, relative humidity and air circulation should be adequate and can be tightly controlled. In particular fluctuations in temperature must be kept to a very narrow time interval.
- The freezing temperature should be in the range of -18° to -25°C for periods of preservation of one year or more.

**Table 1. Practical storage life of meat and meat products**

| Products | Practical storage life in months | | |
|---|---|---|---|
| | **-18 °C** | **-25 °C** | **-30 °C** |
| Beef carcass | 12 | 18 | 24 |
| Lamb carcass | 9 | 12 | 24 |

**Table 2. Chilled storage times (days) in temperature range (°C)**

| Type | -4.1 to -1.1 | -1–2 | 2.1–5.1 | 5.2–8.2 |
|---|---|---|---|---|
| Beef | 40 | 34 | 10 | 9 |
| Lamb | 55 | 41 | 28 | |
| Offal | 7 | 7 | 14 | |

### 4.4. Thawing

Thawing is often considered as simply the reversal of the freezing process. Thawing is critical phase in the freezing process as it involves a change from ice crystals to melted water, which in turn is re-absorbed and enhances microbial reactivation. Thawing is used when cold de- boning and cutting of meat.

The majority of the bacteria that cause spoilage or food poisoning are found on the surfaces of meat. During the freezing operation, surface temperatures are reduced rapidly and bacterial multiplication is severely limited, with bacteria becoming completely dormant below -10°C. In the thawing operation, these same surface areas are the first to rise in temperature and bacterial multiplication can recommence.

- Low temperature thawing, below 5°C, reduces the risk of microbial growth and produces a slow thawing rate which guarantees efficient re-absorption of the melted water. It is recommended that carcasses be thawed at 4° to 6°C, in a hanging position and without any covering (plastic or jute is removed), inside a cold chamber with a reasonably low level of air circulation - about 0.2 m/sec.
- Relative humidity must be kept low at the beginning (70 percent) to avoid frost forming on the meat surface, with an increase at the end of the thawing period up to 90–95 percent. In these conditions thawing of beef carcasses lasts about four to five days and of shoat carcasses one to three days.
- Thawing must take place in installations specifically designed for this purpose.
- Thawing should be considered finished when the temperature of the meat is about 0° to -1°C.

### 4.5. Cutting and de-boning

In the meat production cycle, chilled meat is sold, as half or quarter carcasses or in smaller pieces called primals. De-boning is the term used in the industry to process carcasses into smaller primal cuts. In the absence of bone, the meat cuts are less bulky for chilling and freezing to be effected more rapidly and economically. “Cold shortening” can be avoided by de-boning in rooms at 7-10°C and holding the vacuum packed cuts for at least 10 hr at these temperatures.

Maturation of meat to pH <5.8, de-boning and removal of visible lymphatic tissue greatly reduces any FMD viral infectivity and is often used as a risk reducing step when importing beef from countries that are not free from FMD.

- A carcass intended to be cut and de-boned shall be chilled immediately after slaughter of the animal and the temperature of the deepest part of the meat should be reduced to and kept continuously at a temperature not exceeding $7^{O}C$.
- The air temperature within a room or place in which de-boning and cutting is carried out shall be maintained at or below $10^{O}C$.
- Within one hour of being packed, meat de-boned or cut shall be placed in a freezer capable of reducing the temperature of the packed meat to $-15^{O}C$ within 36 hours.
- Cut and de-boned meat must be wrapped or packaged and then chilled to a temperature of not more than 2°C or frozen to an internal temperature of not more than –18°C. These temperature requirements must be maintained during storage and transport.
- If cut and de-boned meat is not used within an hour of being produced, chill it to a temperature no higher than 2°C. If it is not used within 24 hours of being chilled, freeze it to a temperature no higher than -18°C within 6 hours.
- For this reason, slaughtering and dressing of carcasses, preliminary chilling, cutting and de-boning, and prepackaging of small cuts, must be conducted hygienically and by skilled labor.
- Particular care should be taken to keep contamination of the meat to a minimum when cutting and de-boning and packaging.
- In addition, personal hygiene should be ensured and there should be a routine program for cleaning and disinfection of chilling facilities and cutting rooms.
- Carcasses should preferably be cut while hanging or on regularly cleaned surfaces, with tools frequently sterilized during operation and the meat stored in clean containers. The packaging material should be of good quality and cleanliness.

### 4.6. Vacuum packing

Today the most widely used method employed to extend the storage life of fresh meat is vacuum packaging. Vacuum packaging is intended to preserve products from microbial contamination, from dehydration and from environmental factors that affect quality and nutrition. Vacuum packaged meat of normal pH (<5.8) can be stored for 12 to 14 weeks at $0^{o}C$.

- Meat should be packed in gas-permeable plastic laminated bags at 2-4°C and a pH of 5.5-5.8 and stored at between -18°C and 1°C. At this time, residual oxygen is used up and carbon dioxide accumulates. Without air and water, bacterial growth is significantly reduced. The meat regains its red color on re-exposure to air. Under a good vacuum, the package headspace consists of <1% $O_2$ and 10–20% $CO_2$.
- The materials used, besides being specifically for food, must be chemically inert and prevent the transfer of foreign odors or flavors. They must be stable at low and high temperatures, elastic, tear-resistant, and proof against water vapor, oxygen and volatile substances. They must offer protection against light, particularly UV light.
- The following plastics should be used which are compatible with the meat industry for cold storage. Polyamide (PA), polyethylene (PE), polyester (polyterephthalic acid ester) (PET/PETP), polyvinylchloride (PVC), polyvinyliden chloride (PVDC).
- No vacuum-packed product should be loaded out until the meat temperature is at or below 0°C. The optimum storage and transport temperature for chilled meat is the lowest possible temperature at which no freezing occurs. Non-vacuum packed meat commences to freeze at about –1.5°C, and vacuum-packed meat starts to freeze at

about –2°C (depending on meat type and pH). Therefore, the aim should be to reduce the meat temperature to -1°C to 0°C as soon as possible after packaging.

- When meat cuts are prepackaged without vacuum, air pockets must be avoided. A 2-cm space should be left in the upper part of the box to allow for expansion.

### 4.7. Pack off area

The pack off area is where vacuum packaged meat is transported either manually or automatically for boxing.

- The pack off area should be refrigerated to $10^{o}$C or less.
- This area should be separated from the production area by a wall or "pass through" enclosure to maximize sanitation.
- It must have adequate space to accommodate the vacuum packaging machines and limited supply of packaging material (bag and labels).
- Boxes should not be stored in this area.

### 4.8. Packing material storage

- The packaging materials storage room should be adjacent to the pack off area and should house boxes, bags and labels.
- Other non-food ingredients and supplies should not be held in this area.
- The room should be prevented from pests.
- If box assembly occurs in this room, the room must have adequate size to facilitate this process.

### 4.9. Boxed meat blast freezing

- The boxed meat blast freezer should be designed to freeze meat in a $-28^{o}$C with high velocity air movement.

### 4.10. Boxed meat storage

The boxed meat storage room is for boxed meat prior to loading and shipping.

- The room should be temperature controlled to $4^{o}$C for chilled beef and $-18^{0}$C for frozen beef.
- It must have storage racks and an inventory management system.
- Capacity of this cooler should be adequate to handle products equal to 4 days of production.

### 4.11. The cold chain for boxed meat exports

Meat should be transported and exported in fiberboard cartons and the cartons should be packed in refrigerated shipping containers (*reefers*). The guideline outlines techniques for efficient packing of containers and suggests methods to reduce losses through rejection due to damage to cartons.

There are three types of shipping containers that are used to export both chilled and frozen meat. These are 20 foot standard (20’ x 8’ x 8’ 6"); 40 foot standard (40’ x 8’ x 8’ 6"), and 40 foot high cube (40’ x 8’ x 9’ 6").

- All reefer containers should be fitted with integral refrigeration units which allow the temperature to be set to any value between –25°C and +30°C.
- Containers for frozen meat should be set at a temperature of –20°C and for chilled meat at –1.0°C.
- The container refrigeration system is not designed to reduce the product temperature therefore the meat should be at or close to the carriage temperature when loaded.
- Containers should not be pre-cooled before loading. When the doors of a pre-cooled container are opened, warm, moist air condenses on the cold internal surfaces. This condensation will need to be removed by the container refrigeration equipment. Otherwise, it will create ice on the evaporator coil and reduce cooling efficiency at the time when maximum cooling is required.

### 4.12. Loading

- The loading dock should fit to a wide range of meat transport truck sizes.
- The dock should be refrigerated to $10^{o}$C or less and should have dock doors and seals.
- In case of carcasses, the loading dock must have overhead rails leading from each cooler to the dock door and it should be connected to the track refrigerated container to facilitate hygienic movement of meat.

### 4.13. Meat transportation

- Meat should be loaded into refrigerated containers and transported to the port or airport under strict temperature controlled conditions. To maintain the optimal shelf life and quality of beef, sheep and goat meat during transport, the temperature should be maintained at 0°C (±1°C) for chilled and below -10°C for frozen products.
- Throughout transport to the country of destination, container temperatures should be regularly monitored.

#### 4.13.1. Land transport

Refrigerated transport is not designed to reduce the temperature of product but only to maintain the temperature during transport. Trucks generally don’t have the refrigeration capacity to reduce meat temperatures. Thus meat must be loaded and dispatched at 7°C for carcasses or 5°C for meat products. These temperatures relate to the preferred living conditions of bacteria. Different microorganisms prefer different conditions, but the main ones that cause food poisoning generally do not grow at or below these temperatures. So, keeping the meat at or below these temperatures and keeping it clean, will fulfill the required quality and hygiene. All meat processors are required to record the temperature when meat is received, processed as well as the temperature at load out. Temperature of product and the transportation environment should also be monitored and recorded during shipment.

- Meat and carcasses must be transported from the abattoir to the port of embarkation in sealed and specially designed vehicles. Vehicles for transporting meat and carcasses should be considered as an extension of the refrigerated storage.

- Vehicles must be fitted with refrigeration system and minimum and maximum thermometer or another temperature sensing or recording device to monitor cold chain inside the meat container. If the temperature is monitored, it should be documented. The temperature reader should be located in a place where the driver can monitor while driving.
- Refrigeration units should be serviced regularly.
- The cooling unit must be in good repair and operation. Both truck drivers and plant personnel should regularly check the status of the trailer refrigeration unit.
- Meat should hang on rails.
- If stockinet is put on carcasses, it must be clean.
- Meat trucks should not carry anything other than meat.
- Vehicles must be properly cleaned, disinfected out and air-dried before they are allowed to transport meat and carcasses.
- Vehicle body should be sufficiently insulated and be in good repair with no holes in the body that might allow heat, dust, or other adulterants to enter the cargo area.
- Vehicle doors and seals should be securely closed and that there will be no air leaks.
- Vehicles should be free from residues of previous cargoes, cleaning and sanitizing compounds.
- Vehicles should be pre-cooled for at least 1 hour before loading to remove residual heat from the insulation, inner lining and the air of the trailer and it should be capable of maintaining the required temperature of the meat during the journey.
- For pre-cooling, the doors should be closed and the temperature setting of the unit should be no higher than 26°F (-3°C).
- Meat handlers and drivers should apply personal hygiene before handling meat.
- Meat and carcasses must be loaded, transported, unloaded or stored hygienically. In case of flight schedule break downs, it must be unloaded, stored and loaded by maintaining the required cold chain.
- The meat inspecting officer at the ports of embarkation must check and conform that the meat or carcass is certified, transported in sealed and specially designed vehicles and that the minimum and maximum thermometer or other temperature sensing or -recording device reading is maintained at or close to 0°C.

### 4.13.2. Air transport

Although air-freighting of meat offers a rapid method of serving distant markets, there are many problems because the product is unprotected by refrigeration for much of its journey. Up to 80% of the total journey time is made up of waiting on the tarmac and transport to and from the airport. During flight, the temperature is normally maintained between 15 and 20°C. Perishable cargo is usually carried in standard containers, sometimes with an insulating lining and/or dry ice but is often unprotected on aircraft pallets. As a result,

- Insulated containers should always be used to reduce heat gain.
- Meat should always be pre-cooled and held at the required temperature until loading.
- Containers should be filled to capacity.
- A thermograph should accompany each consignment.

### 4.13.3. Sea transport

Historically, it was the need to preserve meat during sea transport that lead to the development of mechanical refrigeration and the modern international trade in foodstuffs.

Developments in temperature control, packaging and controlled atmospheres have substantially increased the range of foods that can be transported around the world in a chilled condition.

- Refrigerated containers should incorporate insulation and have refrigeration units built into their structure.
- The units should operate electrically, either from an external power supply on board the ship or in dock.
- When the containers are fully loaded and the cooled air is forced uniformly through the spaces between cartons, the maximum difference between delivery and return air should be less than 0.8 °C.
- The entire product in a container should be maintained to within ±1.0 °C of the set point.
- For bulk transportation of frozen meat, refrigerated cargo ships should be used.
- Frozen meat should generally be stored and transported at -18 °C or below.

**Table 3. Guidelines for meat shipment**

| Meat | Vacuum pack, 0°C | Vacuum pack, -1.5°C | CO2, -1.5°C |
|---|---|---|---|
| Lamb | 7 weeks | 10 weeks | >12 weeks |
| Beef | 10 weeks | 14 weeks | - |

### 4.14. Air/Sea port cold storage

- Once a meat shipment is accepted by the Federal Meat Inspectors, it should be immediately transferred to the cargo or placed in the air/sea port storage facility. The Inspectors should inspect the storage freezer before storing to assure it is in good working order.
- No substances known to be toxic or harmful should be stored or maintained in the meat storage areas.
- A refrigerated room used for the storage of chilled carcasses, sides, quarters or portions shall be maintained within the range of 1 to $5^{o}$C and the mean air speed over the product shall be maintained above 0.5 meters per second. The relative humidity shall be maintained below 95%. If the product is stored for longer than 72 hours, the relative humidity should be maintained below 90%;
- A refrigerated room used for the storage of offal shall be maintained at a temperature below $-2^{o}$C. If the offal is stored for longer than 72 hours the temperature should be maintained below $-10^{o}$C.
- A refrigerated room used for slow freezing of a carcass or meat shall be operated at temperatures below $-18^{o}$C to freeze such carcass or meat within a period not exceeding 48 hours;
- A blast freezer used to freeze a carcass or meat within a period not exceeding 24 hours shall be maintained at a temperature below $-25^{o}$C and the mean air speed over the carcass or meat shall be maintained at a value exceeding 2.5 meters per second;
- A refrigerated room used for the storage of a frozen carcass, side, quarter or portion, shall be maintained at a temperature below $-18^{o}$C provided that if the storage period is less than 3 months, the refrigeration room shall be maintained at a temperature below $-10^{o}$C.
- Adequate and proper cold air circulation is required for maintaining the desired uniform temperature in all areas of the freezers and refrigerators where meat is stored.

- Proper temperatures in refrigerated and freezer spaces should be Freezer: –30 to –18$^{o}$C (–22 to 0$^{o}$F) or lower; Refrigerator: 4 to 6$^{o}$C (40 to 43$^{o}$F).
- Relative humidity should be maintained at 85 to 90 percent in refrigerated spaces. High humidity in the freezer helps to decrease dehydration of the frozen items.
- The rotation of stock throughout the cold chain should be organized according to the first in-first out (FIFO) rule: the first lots to be stored are the first to be dispatched.

## 5. Personal hygiene

Slaughter and dressing of animals and handling and inspection of meat, presents many opportunities for cross-contamination. Personal hygiene practices should prevent undue general contamination and prevent cross-contamination with human pathogens that may cause food-borne diseases. Persons moving from rooms or areas containing raw meat to rooms or areas used for meat preparations, storage, loading and unloading should thoroughly wash, change and/or sanitize their protective clothing as appropriate, and otherwise limit the possibility of cross-contamination to the lowest level practicable.

### 5.1. Personal cleanliness

Persons who come into direct or indirect contact with edible parts of animals or meat in the course of their work should maintain appropriate personal cleanliness and behavior, and should not be clinically affected by communicable agents likely to be transmitted by meat. Persons who come into direct or indirect contact with edible parts of animals or meat should:

- Maintain an appropriate standard of personal cleanliness;
- Wear protective clothing appropriate to the circumstances, and ensure that non-disposable protective clothing is cleaned before and during work; where necessary, wear clean protective clothing to prevent meat or product contact surfaces from coming into contact with any portion of ordinary clothing, body or hair;
- Only commence work if all clothing and all exposed parts of the body are clean;
- When wearing gloves during the slaughter and dressing of animals and the handling of meat, ensure that they are of an approved type for the particular activity, e.g., synthetic fabric, latex, etc and they are used according to specifications, e.g., washing of hands before use, changing or sanitizing gloves when contaminated, etc;
- Unless wearing protective clothing in accordance with this Standard, no person other than a person authorized by management shall enter the area of the premises used for meat unloading, storage or loading.
- When there is contact with abnormal animal parts that are likely to harbor food-borne pathogens, wash immediately and sanitize hands and protective clothing;
- Store protective clothing and personal effects in locations that are separate from areas where meat may be handled.
- Clean hands thoroughly before commencing work or whenever they become contaminated;
- Do not engage in any activities which may be deleterious to meat or any food products.

### 5.2. Personal health status

The establishment should maintain relevant personal health records of personnel. Persons who come into direct or indirect contact with edible parts of animals or meat in the course of their work should:

- Where necessary, have a medical examination prior to and during employment;
- Not work while clinically affected by, or suspected to be carrying, communicable agents likely to be transmitted through meat;
- Be knowingly free from any infectious disease or skin condition that may be transmitted through handling meat;
- Be aware of and comply with reporting requirements to the establishment operator in respect of communicable agent.
- Be free of any exposed wound or sore. Any dressing or bandage worn shall be clean, waterproof, detectable and secure; cover cuts and wounds with waterproof dressings;

## Annex 1. Providing temperature controlled environments

Different meat products require different temperature levels to ensure their integrity throughout the travel process. Ensuring that meat shipment will remain within a temperature range for an extended period of time depends largely on the type of container that is used and the refrigeration method. Factors such as duration of transit, the size of the shipment and the ambient or outside temperatures are important factors in deciding what type of packaging is required. They can range from small insulated boxes that require dry ice or gel packs, rolling containers, to reefer with their own powered refrigeration units. The major cold chain technologies involve:

- **Dry ice**. Solid carbon dioxide has a temperature of about -80°C and is capable of keeping a shipment frozen for an extended period of time. It is particularly used for the shipping of pharmaceuticals, dangerous goods and foodstuffs. Dry ice does not melt, instead it sublimates when it comes in contact with the air.
- **Gel packs**. Large shares of pharmaceutical and medicinal shipments are classified as chilled products, which means that they must be stored in a temperature range between 2 and 8°C. The common method to provide this temperature is to use gel packs, or packages that contain phase changing substances that can go from solid to liquid and vice versa to control an environment. Depending on the shipping requirements, these packs can either start off in a frozen or refrigerated state. Along the transit process, they melt to liquids, while at the same time capturing escaping energy and maintaining an internal temperature.
- **Eutectic plates**. The principle is similar to gel packs. Instead, plates are filled with a liquid and can be reused many times.
- **Liquid nitrogen**. An especially cold substance, of about -196°C, used to keep packages frozen over a long period of time. Mainly used to transport biological cargo such as tissues and organs which are considered as hazardous substance for the purpose of transportation.
- **Quilts**. Insulated pieces that are placed over or around freight to act as buffer in temperature variations and to maintain the temperature relatively constant. Thus, frozen freight will remain frozen for a longer time period, often long enough not to justify the usage of more expensive refrigeration devices. Quilts can also be used to keep temperature sensitive freight at room temperature while outside conditions can substantially vary (e.g. during the summer or the winter).
- **Reefers**. Generic name for a temperature controlled container, which can be a van, small truck, a semi or a standard ISO container. These containers, which are insulated, are specially designed to allow temperature controlled air circulation maintained by an attached and independent refrigeration plant.

## Annex 2. Setting and organization of cold chains

Moving a shipment of meat across the supply chain without suffering any setbacks or temperature anomalies requires the establishment of a comprehensive logistical process. This process concerns several phases ranging from the preparation of the shipments to final verification of the integrity of the shipment at the delivery point.

- **Shipment preparation**. A key issue here is the temperature of the meat which should already be at the desired temperature. Cold chain devices are commonly designed to keep a temperature constant but not to bring down the temperature of the meat to the desired level. So, they are unable to perform adequately if a shipment is not prepared well ahead of time. The other issue here includes the destination of the meat shipment and the weather conditions for those regions such as if the shipment will be exposed to extreme heat along the transport route.
- **Modal choice**. Several key factors play into how the meat shipment will be moved. Distance between the origin and the final destination (which often includes a set of intermediary locations), the size and weight of the meat shipment, the required exterior temperature environment and any time restrictions of the product all effect the available transportation options. Short distances can be handled with a van or truck, while a longer trip may require an airplane or a truck and a container ship.
- **Custom procedures**. If the freight crosses boundaries, custom procedures can become very important. This is because cold chain tend to be time sensitive and more subject to inspection than regular freight. The difficulty of this task differs depending on the nation (or economic bloc) and the gateways since there are variations in procedures and delays.
- **The "Last Mile**". The last stage is the actual delivery of the meat shipment to its destination, which in logistics terms is often known as the “last mile”. Key considerations when arranging a final delivery is not only the destination, but the timing. Trucks and vans, the primary modes of transportation for this stage, must meet the specifications necessary to maintain the cold chain. The final transfer of the meat shipment into the storage facilities is also important as there is potential for a breach of integrity.
- **Integrity and quality assurance**. After the shipment has been delivered, any temperature anomalies must be recorded and made known. This is the step of the logistical process that creates trust and accountability, particularly if liability for a damaged shipment is incurred. If problems or anomalies that compromise a shipment do occur, an effort must be made to identify the source and find corrective actions.

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