



doi: <https://doi.org/10.20546/ijcrar.2020.802.005>

Optimum Temperature Maintenance in Cold Storage for Storing Meat Products

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Abstract

Storing of meat products in cold storage is one of the techniques for preserving and storing of products. To construct this type of cold storage, we must take in account of various parameters like temperature of supplied meat products, quantity of meat products, freezing time period, respiration heat. Freezing is an excellent way to preserve most fresh foods. The frozen meat products are good in quality, texture, colour, flavour. Meat is the one of the good protein source of food. Those who are Handling the meat products in cold storage can monitor the temperature of preservation. This paper aims to overview the optimal temperature maintenance of meat products. The awareness of optimal maintenance of temperature can help to preserve the meat products in safe conditions, until they reach to customer.

Article Info

Accepted: 04 January 2020

Available Online: 20 February 2020

Keywords

Storing of meat, cold storage, Optimal Temperature, moisture loss in meat, protein.

Introduction

Cold chain sector is one of the supply chain management system and it has been established for maintenance of low temperature for food products. It is temperature – sensitive and perishable food can preserve (Kuo and Chen, 2010). Especially the cold chain is used to preserve the dairy, meat, fruits and vegetables and flowers. Hence, above items are maintained in good condition at specific environment (Shabani *et al.*, 2012).

The cold supply chain system involved the storage and transportation process, where the low temperature is maintained from suppliers to the customers to withstand the quality and safety of the food products (Rai *et al.*, 2013). Refrigeration is a process of extraction of heat from the food material. The moisture in meat products is up to 75%. Freezing is one the more common processes

for the preservation of meat. This type of preservation technique used several years back. Due to low temperature, the deactivation of microorganism happens, thus preventing the deterioration of food products is blocked. The ice crystallization is formed in the surface of the product. The refrigeration is the only means of preserving food in its original freshness. It may note that when food is to be preserved by refrigeration, the refrigerating process must begin very soon after harvesting or killing of animal and must be continuous until the food is finally consumed.

There is some limitation in freezing and most of the methods are available stated by Ramaswamy and Tung (1984). The preservation of perishable foods by refrigeration involves the use of low temperature as means of eliminating or retarding the activity of spoilage agents. The low temperature are not as effective as high

temperature in bringing about the destruction of spoilage agents. The storage of perishable foods at low temperature provides a practical means of preserving perishable foods in their original fresh state for longer periods of time. The degree of low required for adequate preservation varies with the type of product stored and the length of time the product is to be kept in storage. Thermal imaging method is used for studying the heat transfer in meat muscle. It is a technique that converts the radiation emitted by a body surface into temperature data (Vadivambal and Jayas, 2011).

The application of refrigeration for preserving foods is common in domestic refrigerators, commercial refrigerator and cold storages. Water freezes when the molecules have slowed down enough to develop bonds upon collision. The rate at which freezing occurs is governed by nucleation and growth. Nucleation is the formation of small solids in a liquid.

The clusters of solids are called the nuclei. The rate at which new nuclei form (number of nuclei per second) is the nucleation rate. Once the nuclei have formed, they become the landing sites for other molecules to attach onto. The growth rate is the rate at which the radius of a nucleus grows after formation. The solidification rate is determined by the combination of nucleation and growth rates. To predicting cooling and freezing times for refrigeration requirements for freezing systems and design the necessary equipment for effective processing (Lal Basediya, *et al.*, 2013). The size of crystals formed during solidification is determined by the nucleation/growth processes. For identifying food's stability during storage and suitable condition for processing (Rahman, 2008).

A solidification process with fast nucleation rate and/or slow growth rate will result in many small crystals forming. Larger crystals form from slow nucleation rate. Most liquids decrease in volume upon solidification. Water, however, has a rather unique property of expanding during liquid-to-solid transformation. This property comes from the hexagonal structure of ice crystals; water molecules form a hexagonal crystal structure, which actually takes up more volume than if the molecules were freely slipping past one another. Consequently, ice cubes float in water. Freezing consists of lowering the temperature of a food to -18°C or below which crystallizes some of the water and solutes.

Characteristics of cold storage

Cold storage is one modern food preservable system and it use from farm to customer (Elansari *et al.*, 2019).

Salvadori *et al.*, 1987) gave a graphical method to estimate freezing times of foods with a high water content and it is widely accepted. The products can preserve from chilling to frozen state. It is system for bulk handling and easy of marketing without wastage of food products and decrease the financial loss to farmers, because the products can store for longer time by controlling the temperature and humidity. The storage practices involve temperature control, relative humidity control, air circulation, and maintenance of space between containers for sufficient ventilation (Rahman *et al.*, 2017).

Refrigeration is a process of decreasing the temperature and supporting it in a given space for chilling foods, preserving the food products. Refrigeration system decreases the both bacterial growth and enzymatic reactions that happen in the normal atmosphere (Akdemir, 2008). The cold chain extended shelf life to reduce food waste for those consumers and increase the shelf life. The meat products preservation can start from slaughter house, packaging, chilling, frozen, distribution, marketing and end user. During the period, the product has to maintain the nutrients, decrease the growth of microorganism, texture throughout the shelf life. The process of food respiration, enzymatic reaction and microbial deprivation, carbohydrates, proteins, and nutrients are interrupted down into simpler compounds. So, the quality is reduced.

Principle of Refrigeration system

Vapour compression refrigeration system is improved type of air refrigeration system in which a suitable working substance termed as refrigerant, is used. It condenses and evaporates at temperature and pressure close to the atmospheric conditions. The refrigerants usually used for this purpose are ammonia, carbon di oxide, and sulphur di oxide.

The refrigerant used does not leave the system, but is circulated throughout the system alternately condensing and evaporating. In evaporating, the refrigerant absorbs its latent heat from the brine, which is used for circulating it around the cold chamber.

While condensing it gives out its latent heat to the circulating water of the cooler. The vapour compression refrigeration system is therefore a latent heat pump from the brine and delivers it to the cooler. The vapour compression refrigeration system is now used for all purpose refrigeration. It is generally used for all

industrial purposes from a small domestic refrigerator to a big air-condition plant.

Mechanism of vapour compression refrigeration system

Compressor

The low pressure and temperature vapour refrigerant from evaporator drawn into the compressor through the inlet or suction valve A, where it is compressed to a high pressure and temperature. This high pressure and temperature vapour refrigerant is discharged into the condenser through the delivery or discharge valve B.

Condenser

The condenser or cooler consists of coils of pipe in which the high pressure and temperature vapour refrigerant is cooled and condensed. The refrigerant while passing through the condenser, gives up its latent

heat to the surrounding condensing medium which is normally air or water.

Receiver

The condensed liquid refrigerant from the condenser is stored in a vessel known as receiver from where it is supplied to the evaporator through the expansion valve or refrigerant control valve.

Expansion valve

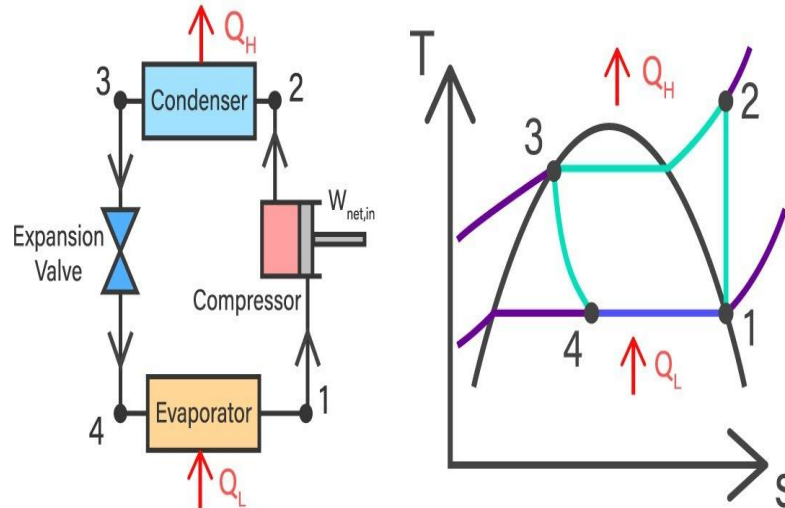
It is also called throttle valve or refrigerant control valve. The function of expansion valve is to allow the liquid refrigerant under high pressure and temperature to pass at a controlled rate after reducing its pressure and temperature. Some of the liquid refrigerant evaporates as it passes through the expansion valve, but the greater portion is vaporized in the evaporator at the low pressure and temperature.

Table.1 Recommended storage condition of Meat products

S. No.	Food products	Short term storage	Long term storage	Air circulation	Forced air circulation	Freezing point in °c Celsius	Composition in % water	Maximum storage period
1.	Poultry (fresh)	-2.2 to -1.1	-2.2 to -1.1	84	87	-2.8	74	10 days
2.	Poultry (Frozen)	-9.4 to -6.7	-17.8 to -15	85	85	-2.8	74	10 months
3.	Pork (fresh)	1.1 to 3.3	-1.1 to 0	80	85	-	57	15 days
4.	Pork (smoked)	4.4 to 7.2	-2.2 to -1.1	80	85	-	57	15 days
5.	Beef (fresh)	1.7 to 4.4	-1.1 to 0	84	87	-2.8	68	3 weeks
6.	Fish (fresh)	1.1 to 3.3	-1.1 to 0	85	85	-2.2	70	15 days
7.	Fish (frozen)	-9.4 to -6.7	-15 to -12.2	80	80	-	70	6 months
8.	Sausage (fresh)	1.7 to 4.4	-6.1 to -2.8	80	85	-3.3	65	15 days

Fig.1 Working principle of refrigeration

VAPOR COMPRESSION REFRIGERATION



Evaporator

An evaporator consist of coils of pipe in which the liquid vapor refrigerant at low pressure and temperature is evaporated and changed into vapor refrigerant at low pressure and temperature. In evaporating the liquid vapor refrigerant absorbs its latent heat of vaporization from the medium (air, water or brine) which is to be cooled.

Facilities in Cold Storages

The cold storage should be effective storage system and it is developed for storing variety of food products, quantity of product, time period. The storage system as several aspects to be considered, Now days cold chain industry has lot of modern construction structure (PEB), material handling equipment's, insulated panel technology, mechanized cold room, chamber doors, temperature controllers, water management systems, heat recovery systems, use of renewable energy systems, storages racks, web based platforms, project management software, warehouse management systems, bar coding systems, modern electrical and electronic systems, IoT in cold logistics and energy monitoring, online food delivery platforms, dry and wet fire safety systems.

These applications will help and improve quality and reliability and reduce wastage in cold chain sector, include total capacity, number and size of rooms, refrigeration system, storage, and handling equipment and access facilities. The design of storage facilities is to maximize the use of space, minimize the distance of movement, facilitate proper location and recovery of stock and to maintain the quality of the food products. Proper relative humidity with the temperature and regular sanitation is required.

Inventory management

Inventory management is an important aspect of cold chain industry, and its starts in warehouse. In the warehouse, the meats products are obtained from the slaughter station and placed in proper packaging material. After the meat products moved to chilling, freezing and frozen stages in cold storage.

An inventory control system is used to keep inventories in a desired state while continuing to adequately supply customers, and its success depends on maintaining clear records on a periodic or perpetual basis.

Inventory management software often plays an important role in the modern inventory control system, providing

timely and accurate analytical, optimization, and forecasting techniques for complex inventory management problems. Typical features of this type of software include.

Inventory tracking and forecasting tools that use selectable algorithms and review cycles to identify anomalies and other areas of concern inventory optimization purchase and replenishment tools that include automated and manual replenishment components, inventory calculations, and lot size optimization

lead time variability management

safety stock calculation and forecasting

inventory cost management

shelf-life and slow-mover logic

multiple location support

Mobile/Moving Inventory Support

A warehouse management system (WMS) is a set of policies and processes intended to organise the work of a warehouse or distribution centre, and ensure that such a facility can operate efficiently and meet its objectives.

The core function of a warehouse management system is to record the arrival and departure of inventory. From that starting point, features are added like recording the precise location of stock within the warehouse, optimising the use of available space, or coordinating tasks for maximum efficiency.

The control of inventory involves managing the physical quantities as well as the costing of the goods as it flows through the supply chain. In managing the cost prices of the goods throughout the supply chain, several costing methods are employed:

FIFO (First in First Out) method

LIFO (Last in First Out) method

Challenges in cold chain industry

In the one aspect, there is more viable opportunities in cold chain industry. But in real practice, some challenges are focussed. Initial cost of construction of cold storage

is more, Land requirements in suitable location, insufficient market surveys, Lack of power supply, non – availability of adequate water with proper quality, Lack of road infrastructure, Lack in refrigerated trucks, non – availability of skilled labours, Global warming through refrigerated usage, Damaged and spoilt produce disposal. Cold chain sector is storing the optimal temperature of meat products and reach the customer without anydeterioration. The preservation of meat products can done through packaging material, after they can store in - 18⁰c by stepping from chilling, freezing and frozen state. Because of cold chain sector, the food wastage is reduced and there is chance of exporting the remaining products. Refrigeration process is one of the low cost effective of preservation compare to processing (i.e value added products).

Due to that frozen meat can utilize for various time period, during the non – availability product. The frozen meat is free from microbes, good quality of meat for longer period, proper texture, colour are maintained during the storage. Hence, initiative have taken to spread the knowledge of cold storage for public to maintain the temperature of meat and proper time period for reducing the food wastage. Because of reduction in wastage, the meat product are available for nutrients deficient peoples. This type of preservation is not end – up in storing, it will continue, till the meat reach to customer at good quality condition. Hence, freezing temperature has to maintain through the refrigerated trucks during the distribution of product in retail markets. So, the maintenance of low temperature is not short phenomenon, we have to travel in long trip from slaughter house to home freezers.

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How to cite this article:

Velayudham, G. 2020. Screening Optimum Temperature Maintenance in Cold Storage for Storing Meat Products. *Int.J.Curr.Res.Aca.Rev.* 8(2), 41-46. doi: <https://doi.org/10.20546/ijcrar.2020.802.005>