

Introduction to cold chain management

Cold Chain: a network of refrigerators, cold stores, freezers and cold boxes organised and maintained so that agro food products are kept at the right temperature to remain quality transportation, storage and distribution from factory to the point of use/sale. The cold chain is responsible for the preservation and transportation of perishable foods in the proper temperature range to slow biological decay processes and deliver safe and high-quality foods to consumers. Cold chain management has two categories: managing equipment and managing people.

Evaluations of existing means can reveal issues like:

- frequent breakdowns in cold chain (sometimes for a long time) because of the lack of fuel, spare parts and back-up energy source;
- lack of planning for maintenance and cold chain rehabilitation;
- lack of planning for emergencies resulting in organisations not having effective cold chain systems during responses.

These problems slow down improvement in routine vaccination services and hinder efforts to eliminate and eradicate disease. To solve these problems, it is necessary to:

- identify problems in the cold chain and their causes;
- undertake specific actions to remove these causes; and
- strengthen management systems to prevent recurrence of the same or similar problems.

In most developed countries, cold chains are tightly regulated. Refrigeration needs to be applied throughout the entire cold chain, and a HACCP (Hazard Analysis and Critical Control Points) strategy needs to be broadly implemented within the food industry to manage the cold chain and ensure food safety.

It is a significant challenge to maintain the temperature of perishable food in the desired range at all steps of the cold chain. Thus, ensuring the integrity of the cold chain for temperature-sensitive food products involves additional requirements related to proper packaging, temperature protection, and monitoring.

Tools of temperature control: temperature data loggers, RFID labels to monitor the temperature history, electronic thermostats, timers and counters, temperature sensors and transmitters, pressure transmitters, infrared thermometers with USB, a cloud-based control platform Coolit- it is a digital cold chain management system etc.

During the distribution process one should monitor that process until one builds a sufficient data set that clearly demonstrates the process is in compliance and in a state of control. Each time the process does not conform to the process, the event should be properly documented, investigated and corrected so that the temperature excursion do not occur on future shipments.

Notable causes of undesirable temperature increases can include inappropriate precooling of the food, poor performance of temperature control systems, temperature fluctuations caused by on-off cycles of the refrigeration unit, local heat sources in trucks or warehouses, and temperature abuses during truck loading and unloading.

Precooling is critical for removing heat from perishable food after harvesting or production, especially given that refrigeration systems used during transportation are

generally designed to preserve the temperature of the load, and not to remove additional heat. Uniform precooling of food products poses a significant challenge. For instance, during forced-air cooling, the perishable food products near the side of the pallet facing the fan in a precooling tunnel are in contact with warmer air than the products on the opposite side and generally cool down at a slower rate. Consequently, cooling at the pallet surface on the side facing the fan may be insufficient if precooling is stopped based on the measurement of the temperature on the opposite side, or some foods may suffer cold injuries if precooling is performed until the products facing the fan reach the desired temperature.

There are different options on transportation. Land transportation by cars or trucks is the most common mode of food transport. Given the long distances traveled and, therefore, the long duration of land transportation, keeping the temperature of perishable food in the desired range during this step in the cold chain is critical. Transportation of perishable food by air offers considerable advantages for a year-round supply of perishable food in regions that are distant from the harvesting or production site. Yet air transportation of perishable food remains limited because of the high economic and environmental costs of this mode of transportation. As an example, in the U.K., it is estimated that less than 1% of food is transported by air, while air transportation accounts for 11% of the CO₂ emissions associated with food transportation. Sea transportation is much slower than transportation by air and may thus not be appropriate for perishable food with a short shelf-life. Nevertheless, sea transportation may be more cost-efficient than air transportation and is an important mode of transportation for fruits, vegetables, dairy products, meats, and fish products that are produced at a location far from the market and whose shelf-life exceeds the transportation time. Sea transportation is generally performed in specialized vessels or refrigerated containers. rail transportation is used mainly for long distances (exceeding approximately 400 km) and for delivery times greater than 2 d between markets that are connected by a railroad system. As such, rail transportation is a minor component of perishable food transportation. Perishable food can be transported in 3 types of train cars: insulated cars, ice-cooled cars, and mechanically refrigerated cars

After harvesting or processing, perishable food is generally transported to 1 or multiple distribution centres to be sorted and shipped to a retailer that is selected based on product demand and a predetermined management system. Given that the perishable food can be stored at the distribution centre for multiple days proper refrigeration is required.

On arrival at the retailer, perishable food is generally placed in a display cabinet or rotated between a display cabinet and a refrigerated storage room. Studies have reported a wide range of perishable food temperatures during display at retail. These contrasting results may be explained by several factors, a significant one being the heterogeneity of the temperature according to the position inside the display cabinet. Very important is to ensure required temperature for all products.