

A Low-Cost Cold Chain Suggestion for Indian Fruit and Vegetable



Vardan Parashar, Abid Haleem and J. A. Usmani

Abstract India produces a massive amount of fruit and vegetables. However, the contemporary fruit and vegetable cold chain are not as per the requirements, which lead to a high decay rate and significant constraint for the fruit and vegetable industry. Fruit and vegetables cold chain are a special supply chain, must keep the appropriate low temperature during the processing, storage, transportation, distribution and retail for maintaining the quality and reduce the loss as far as possible. Temperature management is an essential factor to improve the shelf life of perishable products. This paper tries to study the issues faced by the Indian cold chain of fruits and vegetables and further gives low-cost solutions to maintain the low temperature at different stages of the cold chain. The paper discusses different low-cost techniques for controlling the temperature like pre-cooling, ice cooling and free cooling techniques. These are the methods applied to maintain the temperature of food lower than ambient to improve the shelf life.

Keywords Cold chain control · Fruits and vegetables · Shelf life · Temperature control

1 Introduction

After harvesting, the most important thing is to maintain food products at desirable controlled temperature environment during storage and transportation. A substantial loss of shelf life happens during loading and unloading during transportation and warehousing. So, it is imperative to reduce the harvest losses and transportation losses during entire cold supply chain. In India, more than 40% of the total production of food becomes waste from harvesting to the eating plate, and this is mainly just because of the weak cold chain.

Due to lack of cold chain after harvesting and during storage and handling of agriculture crops, occurring high losses are big challenge for small farmers. More

V. Parashar (✉) · A. Haleem · J. A. Usmani
Jamia Millia Islamia, New Delhi, India
e-mail: vardan.parashar@gmail.com

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than 30% fruits and vegetables wastage become a burden for this community. Result of that retailers struggles to maintain the quality without disturbing the finance of agribusiness in Indian scenario.

Cold chain is an integrated approach, and throughout the distribution network, the important issue is of quality assurance from the point of origin to the point of consumption along with the maintenance of predetermined ambient parameter. The planning, execution, traceability, controls and monitoring play an important role towards maintaining the quality and integrity of the products. The food industry in a developing country like India faces enormous challenges during a cold chain, precisely due to the operational difficulty like economic challenges for refrigeration, and energetic changes of customer need new rules and lower life cycles.

To control the temperature, fruits should be away from out of the sunlight and away from any source of heat, properly ventilated and maintain humidity. During loading, unloading, handling and storage of costly food items, a skill labour requires reducing the wastage. A sustainable cold chain consists of distribution marketing strategy, inventory control, network planning, outsourcing and distribution planning to retain the quality in market.

Due to the limited shelf life of food product, its cold supply chain becomes more difficult as compared to the supply chain of perishable items. There is a need to develop low-cost cold chain logistics in India. A better cold chain provides new method to temperature control along with food quality improvement. Foods stuff are dependent on time and temperature, and they need to be adequately taken care of concerning storing, preparation, packaging, transportation and handling during the cold chain [1]. Fruits in India have a poor cold chain, especially in the local market just because of not only the desired temperature condition but also the lack of awareness of the quality and potency of products. Here fruits and vegetables can be easily visually inspected and sorted by quality appearance.

Adopting suitable low-cost cold chain in Indian scenario has certain issue as lack of infrastructure of transport medium, roads and continuous electric power supply in rural areas. Even farmers are not able to maintain cold chain parameter after having high rates of borrowed money for producing the agriculture crops.

The temperature rise of fruits directly affects its quality, because of the increased microbial growth during respiration and transpiration. It decreases the fruit quality, increases spoilage and the increase of the risk of food poisoning [2]. Loss and damage to perishable goods during storage and transportation are a substantial global issue which can be further reduced by managing the temperature of agriculture products during the supply chain to improve shelf life. Most of the fruits increase in shelf life to provide refrigeration effect, and the same can achieve by some simple tradition techniques as free open-air cooling, ice cooling, cooling by Peltier effect, etc.

2 Need for Cold Chain Logistics

In order to have quality food product with maintain organic parameter, every cold chain parameter must keep in mind from source to consumption point. By receiving and emitting heat, a mass moves from one place to another connected with airflow in the refrigerator system. A significant issue for maintaining the proper cold chain is not only the high cost but also the lack of awareness of desired temperature range during storing, transportation, loading and unloading the fruits in cold chain logistics in India. During transportation, the orientation of food also has high significance for maintaining the desired temperature. To maintain the freshness of food temperature control and time management is also a primary task during the cold chain.

Refrigerated transportation is almost non-existent in rural India. The farmers mostly use open trucks to transport their product, and this leads to a high percentage loss. Indian retail sector has a market of about \$180 billion, but the organised sector represents only a 2% share of this market [3, 4]. Temperature and humidity monitoring data play a vital role in identifying product quality risks in the cold supply chain. Understanding the environmental conditions and the product's susceptibility to heat, cold and humidity is required to maintain product quality throughout the cold chain [5].

More than 20% of food gets wasted due to lack of effective cold chain, and this amount is more than the food subsidies provided by the Indian Government. Only post-harvest losses exceed 10% of total food production which is equal to Australia's annual food production. India produces a wide range of fruits and vegetables, but 25% of these wastes is due to wrong handling of these products and does not maintain a desired temperature throughout the entire cold supply chain. As per the IIR, 2009 report, worldwide global food losses are more than 25%. The losses of fruit and vegetable losses exceed 40% in developing country due to lack of refrigeration, infect developed country and maintain the loss of fruits and vegetables up to 15%. To fill this considerable difference, a proper and low-cost logistics cold chain is to be developing in India. Table 1 relates to the technical investment and economically based opportunities during the cold chain of a perishable item. Critical part of food chain includes handling, storing, distribution to cold storage, transport and temperature control warehousing, retail marketing and food service operations are to be processed and monitored. The cold chain is to plan, execute and manage the desired temperature of products to reduce the waste by proper handling and storing [6].

A temperature maintain supply chain (cold chain) is to be used for decrease the losses after harvesting of fruits and vegetables. The improved cold chain can be developed by identifying the issue and challenges during storing, transport, retailing and final consumption. Strategies required for planning and implementation develop an economic, improved and develop a practical, low-cost cold chain for domestic users. Essential to building a fresh system, farmers can afford and operate in an area far away from the city, processing fruits and vegetables at low temperature after harvest. In order to follow the transportation of domestic fruits and vegetables, the need is to speed up the researchers in the new direction of application of energy and

Table 1 Predicted shelf life of perishable at optimum temperature

Food product	Storage potential			
	At an optimum cold temperature	Optimum temperature + 10 °C	Optimum temperature + 10 °C	Optimum temperature + 10 °C
Fresh green vegetables	1 Month at 0 °C	Two weeks at 10 °C	One week at 20 °C	Less than two days at 30 °C
Potatoes	5–10 months at 4–12 °C	Less than two months at 22 °C	Less than one month at 32 °C	Less than two weeks at 42 °C
Mangoes	2–3 weeks at 13 °C	One week at 23 °C	Four days at 33 °C	Two days at 43 °C
Apples	3–6 months at 1 °C	Two months at 10 °C	One month at 20 °C	A few weeks at 30 °C

Source DGCIS Annual Export [7]

develop user-friendly and low-cost refrigerated technology. The government should provide support in policies and develop a better cold chain of fruits and vegetables.

3 Temperature Management in Food Cold Chain

As same to control the temperature of food products for having the improved shelf life, management and monitoring also play an essential role for the better cold supply chain. Lack of maintaining the recommended proper temperature is the cause for rusting and crumbling of fresh fruits. Strongly recommend maintaining the proper temperature for fresh fruits having potency and maintaining freshness also [8]. The preferable condition for storage of food items varies concern temperature requirement of different foods. Even temperature variation for a short period affects the shelf life and decreases the quality. For avoiding such condition, management of temperature range is done carefully after harvesting, storing and transportation [9].

Temperature management is an important factor for supply of fruits and vegetables because color, taste and potency of fruits and vegetables are depends on it [10]. Different products during cold chain after harvesting to final consumption have different preferable temperature range. Table 2 shows predetermined temperature environment during storage and transportation for fruits and vegetables.

All the types of perishable food with different temperature control should be maintained from the point of supply to the point of consumption, through the process of storage and distribution. The freshness and safety of food must be maintained by the value and quality to make happy to customers. Table 2 shows preferable temperature condition for vegetables and fruits. Thus, it is necessary to have suitable storage temperature in the cold chain.

Different temperature standard levels to endure the quality during the cold chain are “cool” (13 °C), “chill” (2 °C), “frozen” (−18 °C) and “deep frozen” (−29 °C),

Table 2 Preferable temperature condition for vegetables and fruits

1–4 °C	5–9 °C	More than 10 °C
Apple	Bean (French)	Lemon
Berry fruits	Black grapes	Fruit mango
Cheery	Capsicum	Pineapple
Grape	Cucumber	Potato, tomato
Broccoli	Mandarin, orange	Banana
Mushroom	Potato	Pumpkin

Source Zhang [3]. Cold chain management

each related to specific product groups. Any diversity will cause high damage; product result loses market value or utility [11].

4 Methods to Develop a Low-Cost Cold Chain

To develop an improved cold chain, following methods can help the farmer, retailer and the consumer to improve and sustain the shelf life of food with the help of cold chain so to improve the potency and quality. By pre-cooling, a farmer can choose the simple method for agriculture crops to reducing temperature such as using direct ice or flow the cool air from an open chamber, wash the crops by running water time to time (If recommended), by forced air flow, hydro-cooling and vacuum cooling. Few more advanced techniques for refrigeration effect can produce by a chamber for the free cooling process to control the temperature and humidity through Peltier effect and any other methods. For storage and transport, options are small cold room and large-scale commercial refrigerator warehouse. They are most commonly used for costly products but are not able to use for products having meagre cost like fruits and vegetables. Some low-cost conditioning techniques can use for small cooling units with the help of chillers, blast freezing, dry ice, gel packs, eutectic plates, etc.

Cold chain logistics can use information management system to ensure the quality, increase costumer satisfaction and improve integrity and transportation of products in the right direction. Relevant information about control temperature leads to initiate new researcher to develop the low-cost technology of cold chain logistics. Radio-frequency identification (RFID) technology is a monitoring system for cold chain logistics to trace the vehicle during transportation of perishable products. This system is developed and implemented to identify all location of the moving vehicle of interest and continue the supply without a break. Supportive policies in finance and taxation need to be introduced and effective implementation be supported. Local government should plan the rules and see that the technique is appropriate for the particular type of fruit or vegetable. Demand, supply and market order can be developing on the same platform to have transmissibility in the cold chain by local government.

5 Providing Temperature Controlled Environments

The success of the cold chain depends on the methods adopted for temperature control during transportation and storing. Temperature requirements in cold chain vary from $-10\text{ }^{\circ}\text{C}$ to $12\text{ }^{\circ}\text{C}$ for different types of fruits (and vegetables) to maintain the improved shelf life. The integrity of the product also plays an important role to maintain the potency of fruits. The integrity of fruits should also be maintained during the packaging of food.

Dry ice (solid carbon dioxide) has a temperature of about $-80\text{ }^{\circ}\text{C}$ and used for freezing the food environment for extended periods of storing especially for storing pharmaceuticals items. The phase change of products during transportation can maintain the required temperature by gel packs that maintain the temperature between $2\text{ }^{\circ}\text{C}$ and $8\text{ }^{\circ}\text{C}$. Refrigeration effect produces for a short period by Eutectic plates.

Liquid nitrogen is used at about $-196\text{ }^{\circ}\text{C}$, to keep package store frozen for long period of time. The cell is storing products for an extended period at a liquid nitrogen environment. During summer and winter, insulated pieces are placed to maintain the temperature constant. To maintain the proper air circulation, a 15 cm clearance must be provided between the fruit palates. Convection heat by fruits also causes an increase in temperature of cargo. Solar energy and another ambient parameter may also increase the temperature of cargo. So, proper cold air circulation should be maintained to reduce the heat generation inside the cargo during transportation of fruits and other food stuff.

6 Results and Discussion and Future Course of Action

Farmers and small mandi retailers are the major part of Indian population deals with agriculture product, and they cannot afford the traditional cooling method to maintain the suitable cold chain. They are only dependent on the low-cost cold chain methods like evaporative coolers, cool chambers, cooling by phase change materials and economically developed temperature controlling methods. If these temperature control low-cost cold chain techniques will be adopted by the major rural population, then it will affect to reduce the rate of waste agriculture products and support the farmers and small retailers to stable financially also [12, 13].

In this paper, we have identified the present scenario of the cold chain for food stuff in India. We identified that high loss of agriculture product is because of not maintaining the desirable temperature environment. Losses can somewhat be contained by using low-cost temperature control techniques and educating the domestic retailer and user towards the maintenance of desired temperature range during storing, packaging and transportation throughout the cold chain. As traditional techniques (AC/Refrigerator/Deep Frizer) cannot be used by local retailers so they need a low cost technique for cooling of their agriculture products.

7 Conclusion

India is having a long cold chain in food export in world. The export of fruit and vegetable in India and consumption in India are also on a vast level. As discussed in previous literature that very high losses of fruits and vegetables have in India due to lack of cold chain so it is essential to improve the cold chain for Indian economic development. This paper discusses the benefits of maintaining the better cold chain especially temperature range to reduce the wastage and improve the shelf life of fruits and vegetables. It is necessary to maintain a better cold chain to increase export volume, quality of fruits and increase shelf life from source to origin to consumption.

Thus, it is tough to develop low-cost and appropriate cold chain to reduce the losses and improve efficiency. We are proposing controlling the losses of fruits and vegetables by applying the different low-cost techniques for temperature control and refrigeration. This reduction in the loss of food products helps the agricultural economy of India and supports the fruit and vegetable industry.

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