



General Queries on Cold-chain Development

1. Food Loss and Waste - India vs. World

CIPHET (Central Institute of Post-Harvest Engineering & Technology) published a report in 2015, which estimated losses in India range from 4.58% to 15.88% in selected fruits and vegetables.

This was a follow-up to an earlier study conducted by CIPHET during 2005 to 2007 (report published in 2012), which had reported that the losses in fruits and vegetables ranged from 6% to 18%. Both studies were based on sample surveys in 120 selected districts.

NCCD submitted observations that the study did not evaluate losses incurred during transportation from producing region to consumption centres. It was also observed that measures were disconnected and not for the same product load at each evaluation point. Further, the losses indicated in the study, do not differentiate between those within or without the cold-chain. Hence, a comparative assessment of losses directly attributed to lack of integrated cold-chain could not be ascertained.

FAO's (HLPE Report 8) study of June 2014 evaluated that 115 Kgs per capita per annum food is lost in South & South-eastern Asia before reaching consumer.

In this region, an additional waste of 11 kgs/capita/annum is assessed at consumption point. The loss translates into an estimated 2,700 lakh tons of food produced in this region. Worldwide, the report suggests losses incurred are in the range of 30% of harvest. However, these losses include all whole food (grains, meats and fruits and vegetables, etc.) and does not differentiate losses occurring within or without a cold-chain.

Summation - Food Losses

There is no comprehensive study at hand that differentiates between losses within the cold-chain and outside the cold-chain. However, pragmatic reports from established operations indicate that the majority of losses can be mitigated through use of cold-chain connectivity. Experienced stakeholders inform that in well managed cold-chain systems, the losses incurred are minimal (~5%), provided that the intervention promotes continual supply linked to markets, and shelf presence is maintained well within the extended holding life of the produce or product.

2. What are the good harvest and post-harvest handling practices?

In case of perishable food handling systems, good harvest and post-harvest practices will incorporate specific (crop or product particular) interventions. On a broad level, these will include:

- i. Timing of harvest (linked to availability of logistics, market linked for desired holding life).
- ii. Pre-harvest irrigation control - to suit curing practice or minimise moisture related diseases.
- iii. Harvesting practices should cause as little mechanical damage to produce as possible.
- iv. Close proximity to pre-conditioning centers – preferably within a 2-4 hour radius.
- v. Use of post-harvest handling carriers to mitigate transport damage to pre-conditioning centre.

Careful harvesting, aggregation and transporting of fruits and vegetables to pack-houses are necessary to preserve product quality, taking care to avoid dynamic road stress due to loose stowage/stacking,



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dumping, over-stacking on farm-gate transport. Post-harvest handling leads to receipt of produce at a pack-house, wherein organised operations and cold-chain management commences.

Before the large energy application phase in the cold-chain, the following practices are undertaken, especially for fruits and vegetables (sequence may vary for produce types):

- vi. Assorting of produce by market value (sorting by market destination).
- vii. Curing of certain crops, root & tuber crops (eg. Red chillies, potatoes, cassava, yams, onions).
- viii. Washing or cleaning (to wash off field residues, pesticide or treat with fungicides). For some crops, other specialised treatment maybe a market requirement.
- ix. Drying in case of washing undertaken. In certain cases, the washing includes pre-cooling.
- x. Segregation of produce for logistics handling (grading by size before packaging).
- xi. Palletisation of load for unitised handling – minimise handling operations.

Thereafter, temperature and environment control practices are normally commenced:

- xii. Undertake Rapid Pre-cooling of total package – for most fruit and vegetable crop types. For crops such as onion or potato, a slow cool down period is undertaken.
- xiii. Undertake Rapid Chilling or Blast freezing of harvested animal product - meats or milk.
- xiv. Short term storage prior to onward dispatch to market centres or for long term storage.
- xv. Dispatch on reefer modes of transport to destination points, to vacate farm-gate pre-conditioning centres.
- xvi. Palletised stowage on reefer transport and destination storage.
- xvii. Using appropriate of palletised material handling equipment to avoid box handling until dispatch to retail points.
- xviii. Divert low value or non-marketable surplus to value addition facilities (food processors).
- xix. Recordkeeping for maintaining traceability (farm-coding) for all food handled.
- xx. Maintaining temperature and humidity parameters throughout the logistics chain.
- xxi. Maintaining living (breathable and disease free) environment for fruits and vegetables, throughout the logistics chain.
- xxii. Follow guidelines to avoid incompatibility, cross-contamination or tainting of produce.

Best practices in managing food products in cold-chain, will also include following:

- xxiii. Implement and regularly revisit HACCP in the logistics chain.
- xxiv. Maintain personal and facility hygiene.
- xxv. Undertake efficient and periodic pest control measures.
- xxvi. Treat, replace and recycle water used in pack-houses.
- xxvii. Packaging Containers, chemicals used etc. must be food grade quality.
- xxviii. Keep people and product flow separate in operations and in facility design.
- xxix. Follow FEFO instead of LIFO or FIFO – intelligent inventory management.

Above Practices relate to product care and market compliance. The following can be incorporated for energy efficiency and environment safeguards:

- xxx. Steps to aid in cooling:
 - Harvest in the morning when it is cool; keep the product out of direct sunlight.
 - Move the product to the pre-conditioning facility as soon as possible.



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- Select appropriate precooling technique for crop type cooling– Forced air cooling, Hydro cooling, Top Icing, Vacuum cooling etc.
- xxxi. Time chamber air replenishments during cool periods or use heat recovery systems.
- xxxii. Use refrigerant recovery equipment to prevent leakage of ODP/GWP refrigerants.
- xxxiii. Inspect and repair insulation of cold rooms or transport.
- xxxiv. Use program logic controls for automation of refrigeration system.
- xxxv. For transport, leave air gaps when storing fresh produce for long travel. Keep frozen goods away from peripheral walls.
- xxxvi. Do not load product at higher than compliance temperature into cold room or transport unless excess refrigeration capacity is designed and available.
- xxxvii. Minimise door opening to least, use air curtains or strip curtains.
- xxxviii. Design facility with suitable ante-rooms, dock shelters and ramps to minimise energy leakage.

The above list of best practises is merely indicative and a comprehensive SOP should be created by each operator depending on the activities undertaken, product handled and other parameters.

3. What are the components of good infrastructure for transportation, storage, cooling, processing and marketing

The mechanisms that promote best practices and promote safety would be considered as “components of good infrastructure”. Systems that have a lower negative impact on environment – ecofriendly refrigerants and energy efficient operations would also be considered to be good. Broadly, the components of good infrastructure have been categorized as follows:

- i. Natural or Low ODP/GWP refrigerants.
- ii. Program logic controls to improve the energy efficiency.
- iii. Equipment with high MTBF (mean time between failures).
- iv. Improvement in reducing external heat ingress.
- v. Variable and step-less controls in refrigeration.
- vi. Sensors and alarm components that enhance safety of the refrigeration plant.
- vii. Infrastructure designs with built in equipment redundancy and safe guards.

4. What are the components of well-designed cold-chain system

A cold-chain that is designed to integrate the entire set of activities needed to transfer the harvested or produced value from source to consumer, while ensuring all climate controls for the value under its care. Such a system would also safeguard the environment, be efficient in managing waste and comply with food safety standards.

A cold-chain is a modern agri-logistics system and therefore must, at a minimum, incorporate the following infrastructure components:

- a. Modern pack-house at (or in proximity) to farm-gate.
- b. Transport from pack-house to next stage in the supply chain.
- c. Cold storage (hub) in proximity to market
- d. Cold storage (bulk) when storing at farm-gate
- e. Ripening units (in case of select produce only)



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- f. Merchandising platforms (last mile retail units)
- g. Kitchen storage (domestic fridges, deep freezers – optional depending on product).

A well-designed cold-chain system will incorporate synergy in the throughput capacity to maintain seamless connectivity. A cold-chain system will also maintain links with food processing and non-food processing facilities to divert capacity and extract maximum value for the produce owners. It may be noted, globally the various infrastructure components are usually delinked from single operational ownership and the operational or business processes fully integrate the value chain.

Attention is also drawn to the following documents:

- i. Mission for Integrated Development of Horticulture (MIDH)-Operational Guidelines-Variou missing links in the total supply chain and components that alleviate some of the pain points to holistic development have been considered and included in the MIDH Operational Guidelines.
- ii. Guidelines & minimum System Standards for Implementation in Cold-chain Components- This document defines & describes the concept and application of cold-chain components supported under MIDH and allied agencies and provides remarks & recommendations for the users.

5. How can it reduce food loss

Cold-chain systems reduce food loss by ensuring that the perishable produce finds an avenue or physical access to consumption centres. Food loss occurs primarily because food perishes before being brought into consumption. This happens because access to market is beyond the normal lifespan or marketable holding life of the food item. Cold-chain applies technology to first extend the holding life of the produce, and secondly by providing a mode to transfer to market within this extended time period. In a few cases, where the food item or crop is hardy and its life span can be extended over months, temperature controlled storage allows for “commodity-like” time arbitrage, while drip feeding the market in that duration.

Perishable fruits and vegetables have a limited life span in normal conditions. However, unless the selling cycle will fall within this natural period, cold-chain intervention is required to mitigate food losses when markets are concentrated over distance.

Cold-chain does not preserve food, but extends life for a predetermined duration, within which period the food must reach shelves for consumption. Food preservation is the domain of food processing, wherein a new food product is prepared, and the harvested produce does not remain in its original whole format.

The cold-chain not only extends the marketable life span of whole produce, it also brings organisation and standardisation to post harvest food handling. This ensures that fresh produce is packaged to withstand road stress or damage, allows for modern material handling practices to reduce damage, provides relief from damage due to uncontrolled exposure and safety from external diseases. All of this allows for a larger quantum to reach consumers, thereby mitigating food loss.



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6. How does cold chain system maintain the safety and quality of produce at the desired level?

- i. Organised handling to structure and bring compliance with food safety standards.
- ii. Reduced exposure to external microbial load with packaging and controlled ambient.
- iii. Grading by size enables for safe handling practices.
- iv. Use of dock levellers promotes good practices of palletised or unit load handling in cold-chain.
- v. In case of inanimate or post-mortem foods, cold-chain maintains the correct temperature to minimise decomposing influence of bacteria and other enzymatic activities.
- vi. In case of living fresh produce, cold-chain manages living condition (humidity, replenishes air, monitors & controls degenerative gases), segregates to avoid tainting between living tissues, and maintains optimal temperatures. All of this helps to maintain the quality of fresh produce.

7. How does cold-chain increase the productivity and income of farmers?

Farm productivity is a direct result of production processes, which include quality planting material, farming practices, INM/IPM, irrigation/fertigation, mechanisation, and other farming aspects. Cold-chain does not directly increase productivity of farmers.

However, cold-chain helps farmers to directly expand their selling radius by connecting with more distant markets. This extension of their market radius, leads to greater market capture, which in turn leads to more gainful productivity. Therefore, cold-chain has an immediate, though indirect, impact on farm level productivity. This is evidenced in case of grapes and can be explained as follows-

- i. Cold-chain counters produce perishability and directly addresses the otherwise inherent inability to connect perishable produce from farm-gate to consumers, across long distances.
- ii. Cold-chain provides the option of temporarily extending the produce life cycle, which is utilised to handle and increase marketing range of the perishable food items.
- iii. By empowering farmers with the ability to capture a larger buyer base, cold-chain results in an increase in market footprint and the total volume of sales of produce. Not merely, extending the reach of farmers market across geographies, the cold-chain also serves as the custodian of quality and the value of the farmers produce.
- iv. This in turn, feeds and justifies efforts to increase productivity. Without market reach, the higher productivity results in food loss, as has been periodically evidenced.

Physical access to more markets, adds to the revenue options of the producer, and this in turn substantiates greater and gainful productivity and production. In case of processed foods, cold-chain also links manufacturer to buyers, but farm productivity in this case is a factor of the capacity of the production lines.

8. How does cold-chain add value and to what extent?

Cold-chain does not directly add value to the produce, but merely safe-guards the value under its custody. Cold-chain is a market linkage mechanism and protects the value entrusted in its care.

Value addition occurs at production end of the food chain. A farmer produces value by converting raw inputs (water, fertilizer, labour, energy, etc.) into a final product. This is akin to the value created by



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any manufacturer of marketable goods. For this purpose, cold-chain activities are not subject to value-added-taxes.

Nevertheless, since cold-chain extends the marketable life of the produce under care or assists to maintain the sell-by/expiry life of a processed product, in general terms it is considered as a market linking set of activities, that brings value to the producers.

The extent of empowerment depends on the business and delivery mechanism involved. The intangibles can be qualified as follows:

- i. Through effective and efficient market linkage, perishable produce from horticulture is able to maximize its potential, by not only expanding market footprint, but also by providing cause to farm more quantities, produce better yields and use more resourceful technologies.
- ii. Establishes end-to-end delivery systems to connect farm-gate value directly with consumption points. This also helps streamline market feedback and market linked agriculture.
- iii. Multi-modal transport options is supported in the perishables logistics chain, especially as speed and safe handling are equally critical to reduce risk, damage and losses.
- iv. Cold-chain enhances the produces' usable life, retards loss of freshness, sustains nutritional value to the maximum and contributes enormously by extending the value chain system beyond traditional regions and limitations.
- v. Standardisation of handling, packaging and equipment is critical to smooth operations and to minimize operational wastage with the storage aspect taking a back seat.
- vi. Depending on market demand, ripening chambers are used to manipulate the life extension due to the cold-chain, by adjusting or tweaking the maturity cycle of the produce.

For all purposes (legal, taxation and domain terms), cold-chain does not add value to the product but only empowers the producer/owners to connect with more markets and increases their ability to capture greater value for their produce/product.

9. How does cold-chain support the development of diversified food industry?

- i. Cold-chain is a specialized logistic system that serves as a conduit to carry and safeguard value, which was either manufactured or harvested, from source to end consumers.
- ii. The modern Pack-house, is the nerve centre for cold-chain and initiates multiple market routing or value realisation opportunities.
- iii. A pack house unit allows to selectively channelize the following market destinations:
 - Direct to local market channels, packaged or non-packaged.
 - Localized storing of selected produce for off-seasonal supply.
 - Channelize into cold-supply-chain for distant markets or cold stores.
 - Selected produce routed to food processing units (value-addition).
 - Management of waste by routing to non-food processing uses.

All of these market destinations is a point of gainful value realization, and helps optimize upon the harvest. Depending on quality, food can be throughput in organized fashion to local consumers, distant consumers, value-adding processing units, or to other non-food processing or other uses. A



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diversified food industry would optimize upon all such uses and cold-chain is probably the only logistics sector that becomes the root cause of such industry specific development.

10. What are the new technologies in cold-chain management system for perishable food in India?

Cold-chain involves preconditioning, transport, warehousing, distribution and retail and hence a list of technologies would be varied. Technology is primarily needed in cold-chain to manage activities involving the Product Life Cycle, Packaging, Labelling Cooling, Transport, Storage, Distribution, Monitoring, FEFO, Atmosphere, Vibration, Refrigeration, Energy, Food safety and Trade Processes.

Besides the commonly understood technologies of mechanical refrigeration, electric motors, insulation, etc., the following list is of certain technologies and applications that help manage and improve operational concerns in cold-chain management. These technologies are not necessarily new:

- i. Warehouse management system (WMS)
- ii. Transport or Fleet management system (TMS)
- iii. Food Traceability system (FTS)
- iv. Thermochromatic inks
- v. Photo-catalytic equipment
- vi. MAP packaging
- vii. Organic packaging
- viii. Dynamic racking
- ix. Portable CA Tents
- x. Multi-modal transport
- xi. PLC / Automation
- xii. Alternate Cooling (Mag-lev, Vapour Absorption, Thermal banks, etc.)
- xiii. Various Hybrid application in energy sourcing

This list is not comprehensive and the technologies may be deployed across the various equipment or infrastructure components in the cold-chain.

11. Its comparison with the other Asian countries namely, Bangladesh, China, Indonesia, Nepal, Pakistan, Sri Lanka, Thailand, Vietnam.

Technology adoption is business linked and also linked to government support on basis of strategic national agenda. It is expected that most of the governments, would promote adoption of technology that safe-guard environmental commitments. A global focus on nutritional security and food safety would also be reflected in technology uses. However, validated information is not available.

12. The current status of Cold-chain systems in these other countries?

According to 2014 Global Cold-chain alliance (GCCA) and International Association for Refrigerated Warehouse (IARW) report the refrigerated warehouse capacity for the following countries is:-

- a) India- 131 mill m³



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- b) China- 76 mill m³
- c) Indonesia- 12 mill m³
- d) Bangladesh- 0.49 mill m³
- e) Nepal- 0.26 mill m m³

Cold chains of Bangladesh, India, Pakistan and Nepal are primarily concentrated for Potatoes. The countries with effective market links have a large component of transport components, including multi-modal containers. Thailand and China are also reported to have large number of pack-houses.

China has also reported implementing refrigerated transport on rail to Europe as well as “Green Corridor”, an agricultural transport network that facilitates the transportation of fresh agricultural produce, including fresh vegetables, fruits, aquatic products, livestock, meat, eggs and milk. China is reported to have about 66,000 refrigerated vehicles.

There is no ready report to compare the cold-chain systems of the mentioned countries. However, a ready reference on the status of the cold-chain can be more easily drawn from the quantity of export of perishable commodities from each country.

13. Categories of Cold-chains?

Cold-chain may be broadly classified on the basis of storage temperature and total holding life into:-

- a) Chill- (0 °C to 10° C) - temperate Fresh fruits & vegetables, fresh meats, milk, butter, etc.
- b) Mild Chill (10° C to 20° C) - Sub-tropical Fresh fruits & vegetables, chocolates and seeds and some milk products.
- c) Frozen (below-18° C) - frozen ingredients, processed fruits & vegetables, Ice Cream, frozen meats (fish, poultry, livestock), etc.
- d) Normal (>20° C) - Whole Onion, Dehydrated Foods, Pickle, Jams and Oils and extracts.

Cold-chain may also be categorised on the basis of infrastructure, such as:-

- a) Static– Cold storages, pack-houses, Ripening Units etc.
- b) Mobile- Mobile Precooling, Reefer Vehicles, containers.

14. Major Cold-chain infrastructure Components?

Major cold-chain infrastructure components have been highlighted in the MIDH guidelines and AICIC study and are namely:-

- a) Modern Pack-house- At farm gate for fresh Produce preconditioning
- b) Long Haul Transport- Transport from Pack-house to Mandi/wholesale buyer
- c) Cold Storage Hubs – Close to consumption/ distribution centre
- d) Cold Storage Bulk- At farm-gate/food processing premises
- e) Ripening Chamber- Close to consumption/distribution centre
- f) Last Mile Transport- Within distribution city
- g) Retail/Front end – Last mile Merchandising
- h) Kitchen or consumer level – domestic fridges



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15. Role of other Ministries?

Ministry of Commerce and Industries, (through APEDA resp.) promotes development of cold-chain for agricultural produce. APEDA promotes cold-chain for purpose of export (agricultural produce is defined as per the Finance Act). Similarly MPEDA has also been supporting certain needs of marine produce exporters.

Ministry of Agriculture & Farmers Welfare also provides support to cold-chain development, through DAHDF and MIDH. DAHDF provides support to Animal Husbandry, Dairy & Fishery sector while MIDH promotes cold-chain for horticultural produce.

Ministry of Food Processing Industries (MoFPI) also supports cold-chain creation for both agricultural produce and for processed products. However, besides cold-chain, MoFPI also incorporates support for developing infrastructure exclusively used in value-addition and preservation activities (scheme supports cold-chain sector and value addition & preservation industries).

Ministry of Finance through DEA also supports PPP ventures in cold-chain. Besides this, tax and duty exemptions to support cold-chain are supported through this Ministry.

Due to certain commonality in the use of refrigeration systems, there is a resultant overlap between cold-chain and food processing technologies.

16. What is the cold-chain infrastructure requirement vs availability in India?

This information is a matter of scientific research and answers cannot be expected from general opinion based enquiry. The "All India Cold-chain Infrastructure Capacity (Assessment of Status & Gap)" report by NCCD-NABCONS is the only comprehensive study. The published report may be reviewed for understanding and information on requirement and availability.

17. Can energy requirement for cold-chains be reduced by use of superior technology, alternative energy sources, etc.?

All technology based applications can help reduce energy load in the cold-chain. At first step, the insulation is an important barrier to heat load. Secondly, the type of refrigeration can reduce energy load. Technology that hastens operations and minimize breaches in thermal integrity like dock shelters also reduce energy consumption. Similarly, various thermal barriers, automation and efficient facility designs also reduce energy requirement. It is to be noted that the energy to counter field heat, and respiratory load cannot be reduced. Good operational and design practices can reduce energy leakage.

On the other hand, alternate energy sources cannot reduce the energy requirement. Instead, they only replace the energy source. Usually dual energy sources are used for cold stores and diesel based systems for periodic and/or transport based systems.

It may also be understood that in the complete chain, the production end and the transport leg are the most energy intensive. Keeping risk to product and continuity of refrigeration in mind, assured power is important in the cold-chain. Technologies such as large capacity fuel cells, when fully developed may find suitable use. At the moment, hybrid systems that deploy solar thermal, solar photo voltaic, geothermal energy, grid and generator based electricity serve as energy sources.



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18. Are the railways and ships part of the cold-chain infrastructure?

Cold-chain has essentially developed worldwide as a multi-modal transport system. Therefore, all modes of logistics are part of cold-chain and best practices in cold-chain necessitate designs that incorporate roadways, railways, airways, and waterways.

19. Will Retail outlets be considered part of the cold-chain?

Provided that product handled in the cold-chain requires a controlled ambient for gainful end-use, all handling of finished product would be part of the cold-chain. This therefore means merchandising platforms (point of sale cabinets, vending platforms, humidity controlled shelving) are a part of cold-chain. Ministry of Agriculture & Farmers Welfare has included financial support for temperature controlled outlets including street vending carts. In fact, considering Indian consumers' buying patterns, retail outlets are more important in the frozen product segment than fruits & vegetables.

It may be differentiated that the equipment (even if at retail outlets), used to process the goods into a new food product, such as grinders, mixers, cookers, ice-flake makers, fryers, dicers, etc., would not be considered a part of cold-chain. These would be part of the kitchen or processing industry.

20. What are the best practices in cold-chain management systems in India?

In terms of cold-chain management, best practices in India can be evidenced in the grape export systems. Similarly good practices are evidenced in meat (beef & fish export), ice cream and milk distribution. Good practices can also be witnessed in businesses that have centralised kitchens for cross-geography markets (eg. Dominos and McDonalds). In case of cold warehousing, innovative practices are also evidenced in case of potato and dried chilly storage.

Good practices in the cold-chain must incorporate HACCP systems, meet compliance of food safety regulations, minimise damage to the environment, manage risk to inventory, result in avoiding food loss, prevent leakage of energy, support upkeep of machines and equipment, whilst facilitating streamlined and faster movement to end-consumer.

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Above answers to general queries are to share information, provoke thought and inputs from general public and other experts. Readers and NCCD members may provide further comments to NCCD.India@gmail.com