Recent Trends in Cold Chain Management

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Abstract: India is one of the largest producers and a leader of various agricultural products. But due to fledgling cold supply chain there is a heavy loss of food and other resources. These losses have been stated to be as high as US$8 to 15 billion per annum from the agriculture sector alone. There is a need to develop cold chain sector to avoid these problems. Cold supply chain involves the transportation of temperature-sensitive products. It is a supply chain which takes place through thermal and refrigerated packaging methods to protect the integrity of the products in shipments. The cold chain sector is combination of surface storage and refrigerated transport. The cold chain industry has been growing at a CAGR of 20% for the last three years i.e from 2014 to 2016. The cold chain market in India is anticipated to reach Rs 624 billion (US$13 billion) by 2017. Cold stores are the major revenue contributors of the Indian cold chain industry. But still lacks proper infrastructure as India have capacity below 1,000 MT of products. However, lack of proper and adequate food storage, processing and cold chain logistics remains a serious challenge. Though, the Indian government is one of the driving forces in developing the cold chain industry and supports private participation through various subsidy schemes and grants. Investment in cold chain in India was also opened under the automatic route for 100% FDI participation.

Key: Cold chain, Supply, Infrastructure, Food storage, Logistics.

1. INTRODUCTION

India has seen a phenomenal growth from last decades in production of horticulture produce, dairy and meat products over the last decade. Presently, India occupies a position amongst the top three in production of a host of commodities including spices, fisheries, poultry, milk, fruits and vegetables. But even with such large production volumes, India’s present share in global farm trade is still very small. India is the second largest producer of fruits and vegetables in the world with production of 81.3 million MT (Metric Tonne) and 162.2 million MT respectively but its share in global export of fruits and vegetables is around 1.4% only[1]. Approximately, 18% of fruits and vegetables get wasted in the country. This is mainly caused due to lack of cold chain infrastructure which includes both storage and transportation facilities.
The cold chain industry in India is still at a nascent stage. Although, there is a large production of perishables but still the cold chain potential remain untapped due to certain reasons like high share of single commodity cold storage, high initial investment (for refrigerator units and land), lack of enabling infrastructure like power & roads, lack of awareness for handling perishable produce and lapse of service either by the storage provider or the transporter leading to poor quality produce. However, increasing urbanization and growth of organized retail, food servicing and food processing sector are boosting the growth of cold chain industry in India. The trend is shifting towards establishing multipurpose cold storages and providing end to end services to control parameters throughout the value chain.

As FAO (Food and Agricultural Organisation) estimates that a 70% increase in food production and availability will need to be achieved by 2050. It is to ensure adequate food supply to over 9 billion inhabitants by 2050 which would be a huge challenge for the world[2]. Thus, it is vital to explore every possible means of achieving progress, particularly the reduction of post-harvest losses. Losses of perishable foods are most important in developing countries where over 80% of the global population lives, and where about one quarter of production is lost due to a lack of an incomplete cold chain.

These losses represent more than 400 million tons per year. Large post-harvest losses affect food security to the rural economies by markedly widening the gap between consumer prices and the amounts the producers are being paid at the end. They make products less affordable for consumers, and reduce farmers’ income, thus discouraging them from producing and supplying markets. Following table(Table:1) shows the range of temperature of the food product storage:

<table>
<thead>
<tr>
<th>Food product Storage</th>
<th>At optimum cold temperature</th>
<th>Optimum temperature + 10°C</th>
<th>Optimum Temperature +20°C</th>
<th>Optimum Temperature + 30°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Fish</td>
<td>10 days at 0°C</td>
<td>4-5 days at 10°C</td>
<td>1-2 days at 20°C</td>
<td>A few hours at 30°C</td>
</tr>
<tr>
<td>Milk</td>
<td>2 Weeks at 0°C</td>
<td>7 days at 10°C</td>
<td>2-3 days at 20°C</td>
<td>A few hours at 30°C</td>
</tr>
<tr>
<td>Fresh Green Vegetables</td>
<td>1Month at 0°C</td>
<td>2 weeks at 10°C</td>
<td>1 week at 20°C</td>
<td>Less than 2 days at 30°C</td>
</tr>
<tr>
<td>Potatoes</td>
<td>5-10 months at 4-12°C</td>
<td>Less than 2 months at 22°C</td>
<td>Less than 1 month at 32°C</td>
<td>Less than 2 weeks at 42°C</td>
</tr>
<tr>
<td>Mangoes</td>
<td>2-3 weeks at 13°C</td>
<td>1 week at 23°C</td>
<td>4 days at 33°C</td>
<td>2 days at 43°C</td>
</tr>
<tr>
<td>Apples</td>
<td>3-6 months at - 1 °C</td>
<td>2 months at 10°C</td>
<td>1 month at 20°C</td>
<td>A few weeks at 30°C</td>
</tr>
</tbody>
</table>

Source: Adapted from Kitinoja (2013) [3]
The impact of poor food preservation on global food supply is thus undoubtedly far greater than the observed food losses alone. It is also noteworthy that the loss of hundreds of millions of tonnes of foodstuffs involves wasting of the scarce or non-renewable resources required to produce and transport them which exerts an additional effect on global warming. The costs of the cold chain, both economic and environmental, can often be more than offset by the economic and environmental benefits due to reduced post-harvest losses (Fig.1) [4].

2. GLOBAL IMPACT OF COLD CHAIN

Cold chains are being pushed towards globalization. It is due to the increased interest of consumers in healthful food, demands in higher-end products that travels extended distances and a growing capacity of expenditure of the middle class ensuring freshness as well as quality.

Doug Harrison, president and CEO of Versa Cold, a Vancouver, B.C.-based cold chain third-party logistics (3PL) provider said that the food is traveling around the world as more manufacturers manage their supply chains globally. These manufacturing plants are becoming more specialized to a specific product or label, and they ship their goods more widely.

According to Tim Smith, executive vice president, sales and business development for Lineage Logistics, a cold chain 3PL based in Colton, Calif told that the demand for fresh food is growing, and that requires increased innovation to overcome capacity and infrastructure constraints, and mitigate disruption risks to ensure quality delivery, meeting these demands without driving up inventory or cost places added pressure on each element of the supply chain [5].

In the food industry, to win and to get the repeat business of fickle and demanding consumers, manufacturers must focus on quality, health, and integrity. This trend has been increasing day by day. Maintaining cold chain is a big challenge though it can avoid the changes in texture and taste that may occur when a shipment strays outside recommended temperatures, as well as may decrease the amount of processing for proteins in case of fish etc or for any cold chain products.

Cold chain is now recognized as a sunrise sector in India. Our country ranks first in milk production in the world and second in fruits & vegetables production. It also has substantial production of marine, meat & poultry products. So, our country needed a fully developed cold chain sector and the current scenario reveals that there is a tremendous scope for the development of cold chain facilities (Table 2).
Cold stores form the heart of the cold chain. The cold storage industry in India indicates that the cold stores have been established initially from the beginning of twentieth century but with very slow development. Earlier, the units were designed mostly for storage of potato and were located in areas like UP, West Bengal, Punjab, and Bihar etc. During sixties, the idea of multiproduct, multi-chamber cold stores were introduced and Maharashtra took the lead [8].
Cold chain top market report ITA 2016

<table>
<thead>
<tr>
<th>Segment</th>
<th>Size (Million Tonne)</th>
<th>Key products</th>
<th>Expected Growth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy Products</td>
<td>121</td>
<td>Value-added Milk, Butter, Cheese</td>
<td>8</td>
</tr>
<tr>
<td>Fruits &amp; Vegetables</td>
<td>233</td>
<td>Raw Fruits &amp; Vegetables, Pulp, Canned Food</td>
<td>7</td>
</tr>
<tr>
<td>Meat and Poultry</td>
<td>11</td>
<td>Poultry, Beef</td>
<td>18</td>
</tr>
<tr>
<td>Seafood</td>
<td>8.4</td>
<td>Seafood Products</td>
<td>7</td>
</tr>
<tr>
<td>Packaged Products</td>
<td>Rs 8,000 crore</td>
<td>Ready-to-eat &amp; Ready-to-cook</td>
<td>8</td>
</tr>
</tbody>
</table>

*Source: www.trade.gov/topmarkets [9]*

<table>
<thead>
<tr>
<th>Production (in Million MT)</th>
<th>2010-11</th>
<th>2011-12</th>
<th>2012-13(Prov.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable</td>
<td>146.55</td>
<td>156.32</td>
<td>159.51</td>
</tr>
<tr>
<td>Fruits</td>
<td>74.87</td>
<td>76.42</td>
<td>77.70</td>
</tr>
</tbody>
</table>

*Source: FNBnews.com, 2016 [10] (The total production of fruits and vegetables in the country during the last three years)*

The cold storage sector is still undergoing a major metamorphosis, with the government focusing on food preservation (Table3). The cold chain sector is combination of surface storage and refrigerated transport. The cold chain industry has been growing at a CAGR of 20% for the last three years i.e from 2014 to 2016 [8]. A lot of stress is being laid on energy efficiency as the cold stores are energy intensive. With the advent of newer materials / equipments, every part of a cold chain renders itself amenable for improvement and are witnessing changes for eg. the type of construction, insulation usage, refrigeration equipment, type of controls managing cold chain etc. for effectiveness [11].

4. USAGE OF COLD CHAIN SYSTEM

4.1. Ripening Units: There has been considerable interest in scientific ripening and storage of food like banana, mango etc. where cold chain system are being used for the perishable food products. In recent
years the units are being established at a number of places. It can be seen in the South, Gujarat & Maharashtra (Table 4).

4.2. Distribution Centres: With the growth of cold chain in the country, the food distribution centres are also being established here. The first such unit was constructed in Navi Mumbai region. Further, growth is expected in this sector as number of smaller centres have been set up by the food retail sector.

A cold chain can most readily be defined as a series of warehousing and distribution activities that is designed to ensure ideal storage and transportation conditions for temperature-sensitive products. Cold chain services can add benefit in improving quality of life for billions of people around the world. This system is high in demand, especially in less developed economies that suffer from malnutrition, high rates of food spoilage and chronic disease.

4.3. Export-Import Purposes: Cold chain systems have now become important for the growth of global trade in perishable products and to the worldwide for availability of food and health supplies. As every year, billions of tons of fresh food products and millions of dollars’ worth of exports are lost due to poor cold chain systems in developing markets and has been reflected in the World Economic Forum lists where food crises lies as fourth on its top global risks of highest concern for the next 10 years. Globally, billions of dollars are spent on improving agricultural processes to create higher food yields, but the fact that nearly half of all food never makes it to a consumer’s plate which is largely ignored[4](Cold Chain Top Markets Report, 2016 ITA).

4. METHODS FOR MANAGING COLD CHAIN

The series of warehousing and distribution activities that comprise a cold chain system are designed to ensure ideal storage and transportation conditions for temperature-sensitive products. Cold chain services that support perishable food distribution globally are estimated to be valued at nearly $250 billion. Asia alone contributes to $1.2 billion in growth. The compound annual growth rate (CAGR) of cold chain markets is anticipated to reach nearly 16 percent into 2019[12].

The United States is a world leader in developing the technology and processes necessary to develop and manage cold chain systems efficiently. Therefore, the U.S. is well positioned to capture a large share of the global market for cold chain development. According to the Global Cold Chain Alliance, an industry association comprised of the many industries that make up cold chain services, global refrigerated warehouse capacity which has been increased by 20 percent from 2012 to 2014[12].

Fresh foods, like fruits, vegetables, meat, poultry and dairy, require an uninterrupted cold chain due to their perishable nature. Cold chain service providers can increase the product life of fresh foods for days,
weeks or even months by controlling parameters of temperature, humidity and atmospheric composition, along with utilizing proper handling procedures. These services allow fresh products to hold their value longer, increasing their transportability and providing opportunities that expand their market reach.

Each cold chain varies by the region, location and temperature requirements of specific place. However, cold chain maintenance starts for agricultural products at the farm itself. Produce often goes through pre-cooling at the harvest location and is then loaded onto a truck or other transportation unit. It has been designed to keep the produce protected from the sun and held within a desirable temperature range, as it travels to a processor facility or a temperature controlled warehouse.

The transportation in less developed locations are carried out either on covered trucks or smaller carts whereas in more developed locations, these transportation solutions can include insulated reefer trucks. The product are being treated according to the type of product and its ultimate destination. A cool dry storage facility protects the product and keeps it from high temperature fluctuations and humidity. A cold storage facility is required for products that require a lower temperature to remain fresh reducing the chance for bacterial introduction.

5. MAJOR COLD CHAIN TECHNOLOGIES

The major cold chain technologies in providing a temperature controlled environment during transportation may involve [13]:

Dry ice: It is solid carbon dioxide, is 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 and in refrigerated unit load devices for air cargo[13]. Dry ice does not melt, instead it sublimates when it comes in contact with air.

Gel packs: There are some pharmaceutical and medicinal shipments which have been classified as chilled products, which must be stored in a temperature range between 2 and 8°C. For providing this temperature gel packs are used, also for packages that contain phase changing substances that can go from solid to liquid and vice versa to control an environment[13]. 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: Eutectic plates are known as "cold plates". The principle eutectic plate is similar to gel packs. Plates are filled with a liquid and can be reused many times. These have a wide range of
applications, such as maintaining cold temperature for rolling refrigerated units[13]. They can also be used in delivery vehicles to keep temperature constant for short periods of time, a process that can be suitable for deliveries in noise sensitive areas or for night deliveries.

Liquid nitrogen: It is the cold substance, of about -196°C, used to keep packages frozen over a long period of time. It is mainly used to transport biological cargo such as tissues and organs[13]. Though, it is considered as a hazardous substance for the purpose of transportation.

Quilts: Quilts are 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[13]. It is also used to keep temperature sensitive freight at room temperature while outside conditions can substantially vary in different weather conditions.

Reefers: This is the generic name for a temperature controlled transport unit, which can be a van, small truck, a semi trailer or a standard ISO container. These units, which are insulated, are specially designed to allow temperature controlled air circulation maintained by an attached and independent refrigeration plant[13]. A reefer is able to keep the cargo temperature cool and even warm.

Refrigerated Containers: Refrigerated containers, reefers, etc. are the refrigerated cargo being transported around the world. The reefer has become a common temperature-controlled transport unit which can be used to insure load integrity. It can accommodate a wide range of temperature settings and accordingly a wide range of temperature sensitive products[13]. It is a versatile unit able to carry around 20 to 25 tons of refrigerated cargo and is fully compatible with the global intermodal transport system, which implies a high level of accessibility to markets around the world. The refrigeration unit of a reefer requires an electric power source during transportation.

It is important to underline the refrigeration units as they are designed to maintain the temperature within a prefixed range. The shipment must be brought to the required temperature before being loaded into a reefer, which requires specialized warehousing and loading / unloading facilities.

A new generation of reefers is coming which will be equipped with an array of sensors monitoring the temperature effectively and shutting the cooling plant when not needed and is unnecessary to use. This may improve the reliability of temperature control as well as can extend the autonomy of the reefer.
6. OTHER FACTORS FOR MAINTAINING COLD CHAIN

Shipment/Delivery Preparation of the Products: There are various parameters for transporting a temperature sensitive product assessing its characteristics. A key issue concerns the temperature conditioning of the shipment, which should already be at the desired temperature. Weather conditions is another concern to be taken care of, for the shipment and for those regions which is likely to get exposed to extreme cold or heat along the transport route[13]. Using a reefer with its own power unit usually mitigates such concerns.

Transportation Option: Several key factors are considered for the transportation of the shipment. For example, distance between the origin and the final destinations, the size and weight of the shipment, the required exterior temperature environment and perishability of the product etc.will effect the available transportation options. Short distances can be handled with a van or a truck, while a longer trip may require an airplane or a container ship[13]. The cost / perishability ratio also becomes one of the factor.

Inspection during Custom Procedures : There are few barriers which come in the way like custom procedures since cold chain products tend to be time sensitive and more subject to inspection than regular freight [11]. The procedure itself is a hindrance and likely to get delayed. So, it becomes difficult sometimes to retain cold chains.

The "Last Mile": This term is used for actual delivery of the shipment to its destination in the last, which is often known as the "last mile"[13]. As timing of the delivery is as important as reaching of the product to the right destination where the warehouse space must be available.

Integrity and quality assurance: This step of making temperature recording made known is the logistical process that creates trust and accountability, particularly if liability for a damaged shipment is incurred[5]. If any problem arised , an effort must be made to identify the source and must find out the corrective actions.

7. CHALLENGES AND BARRIERS

Cold chain expansion is one of the greatest challenges that too to operate this business in any international environment. There is lack of infrastructure in a developing market for sustenance of cold chains. Maintaining transportation systems is really a cumbersome task for transporting refrigerated products in a timely manner. It adds further costs and complications due to lack of reliable power for cold warehouses,
power hookups for reefer trailers at ports and transportation hubs, and providing adequate facilities at the final customer locations.

Globalization has made the relative distance between regions of the world much smaller, the physical separation of these same regions is still a very important reality. Freight can be damaged in transport operations due to greater physical separation. Some goods can be damaged by shocks while others can be damaged by undue temperature variations. For a range of goods labeled as perishables, particularly food (produces), their quality degrades with time since they maintain chemical reactions which rate can be mostly mitigated with lower temperatures. It takes time and coordination to efficiently move a shipment and every delay can have negative consequences, notably if this cargo is perishable. To ensure that cargo does not become damaged or compromised throughout this process, businesses in the pharmaceutical, medical and food industries are increasingly relying on the cold chain.

8. SUGGESTIONS

The cold chain involves the transportation of temperature sensitive products along a supply chain through thermal and refrigerated packaging methods and the logistical planning to protect the integrity of these shipments. There are several means in which cold chain products can be transported, including refrigerated trucks and railcars, refrigerated cargo ships as well as by air cargo. Though, improvements in insulation are increasing but onboard fleet management systems may deliver even bigger savings. As there would be less responsibility on drivers for setting up of the temperatures. There would be no need for the drivers to turn off the reefer to save fuel, so fuel utilization would be improved and conditions can be controlled remotely. The system would now decrease claims and issues such for the lost of the sales.

9. OPPORTUNITIES

Cold chain systems require trained industrial designers and engineers to develop efficient warehousing and storage systems. There is a big trend in the food industry which is mainly focussing on quality, health, and integrity[5]. There is a need to develop refrigeration units also for transportation vehicles and networks. Engineers and industrial design teams take into account what type of product will be stored in a warehouse facility, how much processing will be done within the facility, the quantity of items to be stored and the product’s specific handling requirements. Many facilities hold varying types of product sizes and handling requirements, and the design of these warehouses will often take into account the need for flexibility in cooling and handling conditions. A cold warehouse and storage system may cost several million dollars to design and build[13].
Temperature control in the shipment of foodstuffs is a component of the industry that has continued to rise in relation with international trade. As a growing number of countries focus their export economy around food and produce production, the need to keep these products fresh for extended periods of time has gained in importance for commercial and health reasons. The cold chain is also a public health issue since the proper transport of food products will reduce the likeliness of bacterial, microbial and fungal contamination of the shipment.

Following is the data provided by Yes Bank Report, 2014[14] regarding production and the requirement for cold chain:

**Potato**
- Potato production – 2.5 million MT of which currently approx 20% is processing variety being cultivated for specific players. New technologies for storage of processing grade potato will be required as companies expand their procurement from Gujarat[14].

**Fish**
- Fish production – 788,500 MT
- Large export oriented units have plans for expansion and modernization of current Cold chain infrastructure for processing units, cold chain (storage and reefer transport) for domestic market for expansion and modernization of current processing facilities[14].

**Milk & Milk Products**
- Milk production – 10.3 million MT • Highest share of approx. 21% of India’s dairy output • Prevalence of cooperative model
- Well established cold chain Low cost technology for chilling milk at farm level required[14].

### 10. CONCLUSION

Innovations in packaging, fruit and vegetable coatings, bio-engineering (controlled ripening), and other techniques reducing the deterioration of food products have helped shippers extend the reach of perishable products. For food products such as fruits and vegetables, time has a direct impact on their shelf life and therefore on the potential revenue a consignment may generate. Concomitantly, new transport technologies have permitted the shipment of perishable products over longer distances.

Various parameters have been recognized by the Indian government and 100% FDI in the cold chain has already been permitted country needs to ensure that their production does not go waste and returns fair value to producers and consumers. There must be a better linkages and way of transportation between growers, storage and customers. There is absence of a single dedicated perishables gateway or fast track corridor for perishable cargoes. Consumer food retail sector is the fastest growing in the country, worth
around 15 billion USD 40% of fresh produce is wasted due to lack of satisfactory handling in the supply chain Indian cold chain business is fragmented in a big way [15].

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