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Cold Chain Supply in Dairy Industry in India

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Abstract: ***The study provides an overall idea about the development of cold chain in the dairy industry as well as the necessity of having cold chain management in the dairy sector. Cold Chain involvement has been a huge contribution to the dairy sector as it has helped the sector to flourish more as well as to unfold to its maximum potential. Cold chain statistics provides the information to know about the present status of cold chain in the nation. Cold chain in the country is still under development and hasn't been used to its utmost advantages and uses which will be explored in the forthcoming years.***
The reason or challenges encountered by the cold chain while its practice are the major drawback for the lack of cold chain application in the country which also have been tapped upon in the study. The present scenario of the dairy sector with the application of cold chain helped to minimise the losses of the dairy sector by a huge margin.
The application of cold chain in dairy sector is practised in the storage and transportation of milk and its value based products hence government also provides schemes and initiatives for the usage of cold chain supply s it ensures zero wastage, affordable product, accessible product, healthy and nutritious products.
The cold chain supply has essential steps of storage and transportation which have been explained in the study through the considerations of the appropriate design of cold storage based upon the product to be stored. There are various types of cold storage which must be taken into consideration while designing of cold storage.
The cold chain supply of milk and its value added products varies from product to product and it must be ensured for preservation of quality and its shelf life throughout the cold chain supply by inhibiting the product from microbial attack hence the maintenance of the ambient temperature is absolutely necessary throughout the cold chain which is done by various practices in the dairy sector as mentioned in the study.
The study in brief provides with the overview of the cold chain supply in dairy industry along with its challenges, applications, present scenario, statistics and assessment of the dairy sector for milk and its value added products from farm to consumers ensuring that there is no breakage of the cold chain until the product reaches the consumers.

I. INTRODUCTION

Cold chain or in other words cool chain refers to the series of measures taken with the help of equipment or tools to preserve the quality of a product by maintaining a specific low temperature range throughout the chain or series of custody until the product bought by the customer. The cold chain needs to maintain a specified low temperature range from the time of manufacturing of the product until the purchase of the product by the consumer.

An unbroken or uninterrupted cold chain is a clear indication of the preservation of the product as well as the increase of shelf life of the product. A cold chain preserves the products quality and shelf life by maintaining the temperature by keeping it isolated from microorganism to attack as well as by preserving the product throughout transportation by the means of logistics. The logistics plays a key role in cold chain supply because if the temperature is not maintained during transportation of the product even a slightest changes in temperature directly effects the shelf life of the product hence this is of key importance because unlike other commodities the commodities in need of a cold chain supply is highly perishable hence for its outreach to the consumer it is necessary to be stored in required environment as well as transported with the desirable requirements for the product's sustainment.

Cold Chain with respect to dairy products require constant monitoring and specific attention throughout the movement of the chain because dairy products pose a major risk to the consumer if the chain has been broken or hampered in any way. Some cases have been reported prior where microorganism like Listeria attacked ice cream and Salmonella attacked milk hence it is absolutely necessary to maintain the cold chain because if the products aren't kept cold constantly the bacteria cultivated can be very deadly for the consumer. Therefore, it's critical that supply chain managers do everything they can to ensure that the dairy cold chain remains intact.

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II. DAIRY SECTOR COLD CHAIN ASSESSMENT

A. Overview Of Cold Chain In Dairy Sector

India has maintained its apex position in milk production globally which during 2016-17 touched 165.4 Mn MT. India has been the world's largest producer and consumer of milk and dairy products, with 20% share in global milk production since long years and this position of India hasn't changed in decades. Domestic milk production in households had a compounded annual growth rate (CAGR) of 5% 2011-17 and was expected to further grow at a faster rate of 5-6% CAGR in the next 3 years that is 2018-21 owing to increasing yield of in-milk cows and buffaloes. Hence the demand of milk and milk based dairy products have also been on rise in the recent years hence to have zero wastage of any products and to surpass the demand cold chain supply is very necessary.

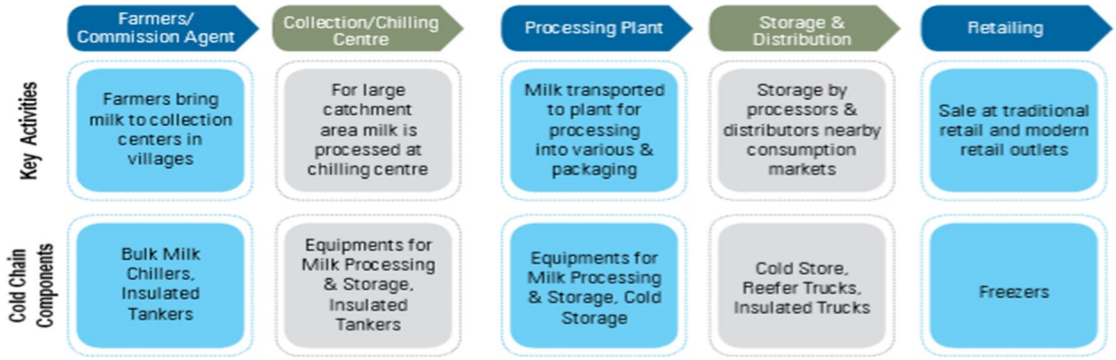

Figure 1: Supply Chain of Indian Dairy Industry with Scope of Cold Chain Components

Source: Yes Bank Analysis

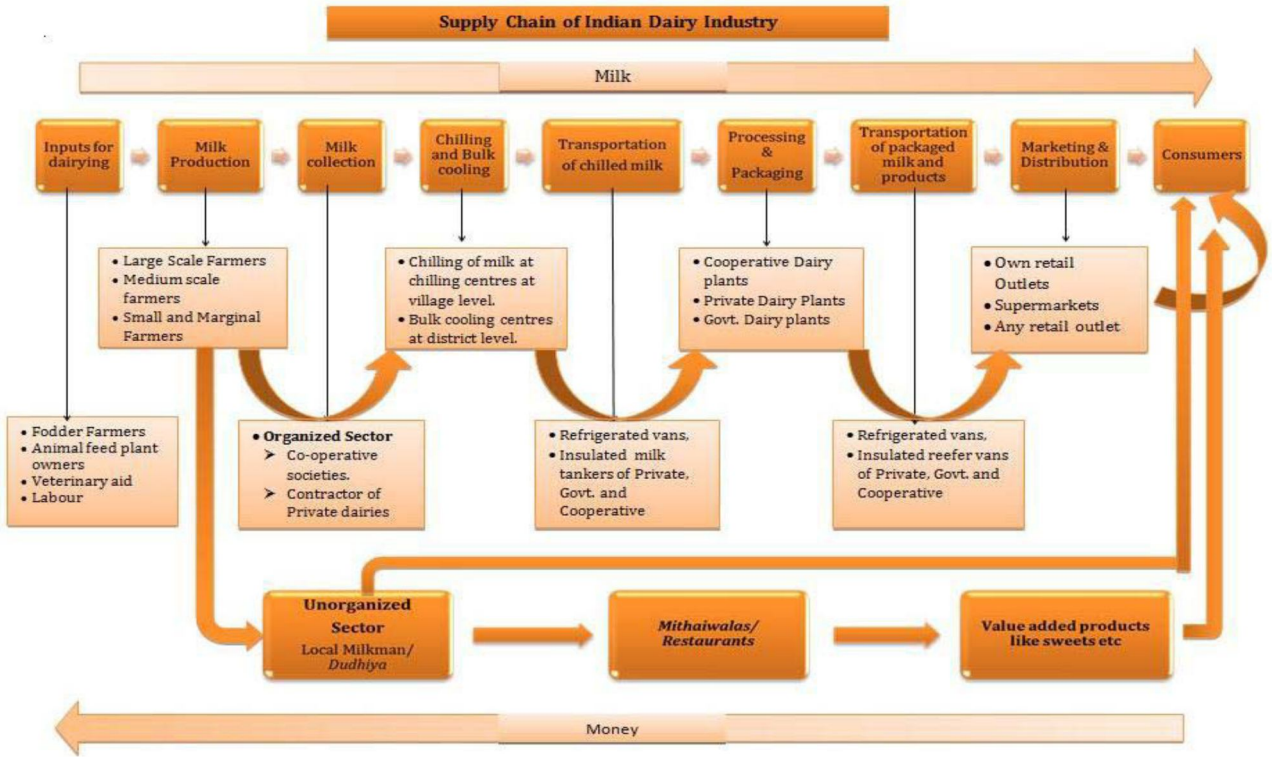

Figure 2: Supply Chain of Indian Dairy Industry

Source: Issues and Challenges of Supply Chain Management with perspective to Indian Dairy Industry.Mr. Purushottam A Petare.

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B. How Cold Chain Supply Chnaged The Dairy Sector

Primarily in India farmers used to rare milking animals which fulfill their milk requirements. Mostly every Indian family owes any kind of milking animal. Those who don't have it, fulfill their milk requirements by the exchange of goods with the milk producers. Production of milk and its selling was not at all a trade at that time. Later by using basic heating techniques people started storing and preserving milk for days. Results in the increase in its trading outside the production zone. But still it was not sufficient.

After when cold storages facility were introduced in India it was primarily used for potatoes and some delegate fruits .One of the oldest multi-chamber cold storage was located in Fruit Research Station at Pune and was supposedly installed in 1932 during the British rule. This was mainly an experimental station with seven cold rooms which worked on a common brine chilling plant.

During the period between '50s and '60s the development of the cold storage industry was mainly confined to the states of UP, Punjab, Delhi, Bihar, West Bengal, MP and Gujarat where cold stores of medium and large sizes were set up, but these were mainly bulk storage units for potatoes. However the major development of the concept of multipurpose cold storage unit happened between 1965 and 1970 when a few units were established for storage of a number of products in Bangalore and Pune. After 1970 to 1996 dairy sector tremendously involved and utilised the cold chain the reason behind it was 'White Revolution'

Hence during transportation to avoid contamination loss artificial cooling system introduced in some vehicles and distribution centres. When private players entered into the segment it boosted dairy sector and eventually improved its cold chain. Now various milk and milk products can be available at any place in country.

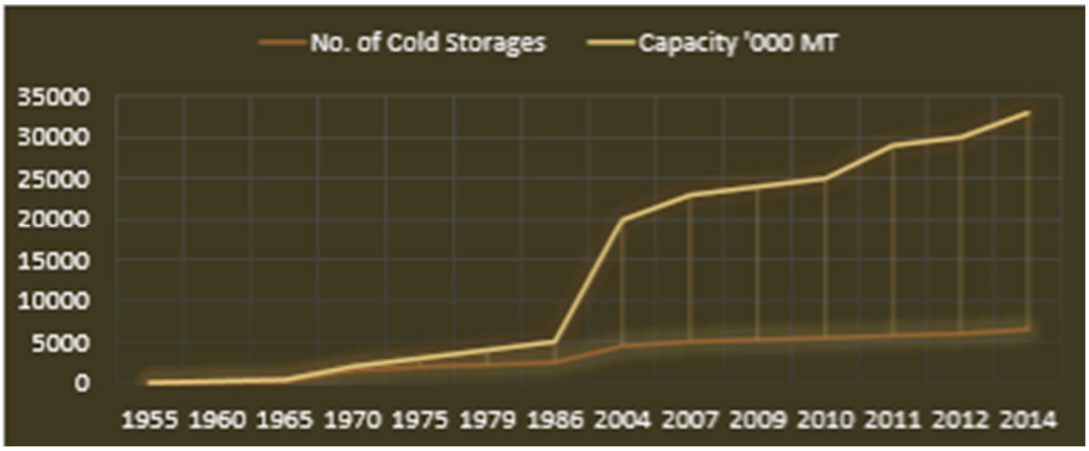

Figure 3: Evolution of cold chain in India

Source: NCCD

But Indian cold chain is still at a nascent stage. Although, there is large production of perishables items such as milk but still the cold chain potential remains untapped due to multiple reasons like high share of single commodity cold storage; high initial investment (for refrigerator units and land); lack of Basic Enabling Infrastructure (roads, water supply, power supply, drainage, etc.); lack of awareness for handling perishable produce and lapse of service either by the storage provider or the transporter leading to poor quality produce.

If we focus on consumption pattern of milk in India then we see it is extremely buoyant. With sustained growth of economy and consequent rise in the purchasing power during the last two decades, more people are now able to afford milk and dairy products. This growing trend in demand is expected to continue with the sector experiencing a robust growth in the short and medium run however, if one of the most important impediment, the cold chain facility left unaddressed, India is likely to face a serious supply demand mismatch and may gradually turn into a net importer of milk and milk products.

III. PRESENT SCENARIO

Presently, India has more than 6,900 cold storage facilities irregularly distributed across the various states of the country, the cumulative capacity of the cold storage is 32 million metric tonnes.

1) India's cold chain sector is estimated at INR 175-177 billion (~USD 2.9 billion) during the time span of 2013-14.

2) 88-90% of market share is with the Temperature Controlled Warehouses (INR 162 billion (USD 2.7 billion); 6500+ stores, 30.4 million MT Capacity)

3) Remaining 10-12% comprises of Temperature Controlled Vehicles (INR 13-14billion (~USD0.2 billion); 8000+ vehicles).
4) It is highly fragmented industry and unorganized sector accounts for an estimated 80-85% Share of the total capacity.
5) Wholesalers and organized retailers are the key user segments of cold chain services with a share of 70-75% and 10-15% respectively.
6) Currently, about 68% of the total cold storage capacity is concentrated in the states of West Bengal, Uttar Pradesh and Bihar, wherein storage of potatoes accounts for 85-90%of the capacity.

Despite this surge in the demand the cold chain industry in India remains nascent and hasn't been explored to its utmost potential these could be due to various reasons some accounted are fragmentation of the market, lack of adequate infrastructure that is road network, Power supply etc.

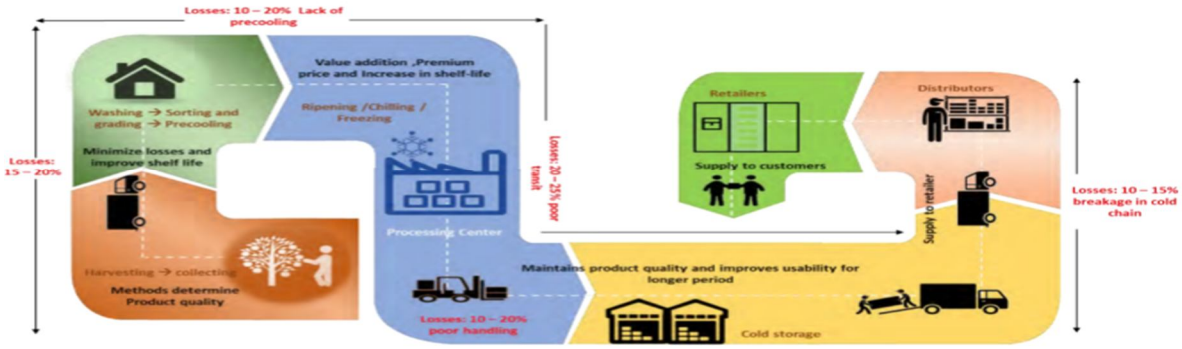

Figure 4: Different stages of product value chain and losses incurred at each stage
Source: Cold Chain Technologies ASSOCHAM May 2017

However, increasing urbanization and development of organised methodology is resulting to the boosting growth of cold chain industry in India. This trend is shifting towards establishing multipurpose and end to end services to control parameters throughout the chain. Annually India faces a loss of Rs.4409 crore due to the improper structure and this loss directly effects the growth of the sector. The loss is encountered over various components of the value chain such as transportation, operations, storage etc. with appropriate and efficient measures these losses can be clearly eradicated and increase the efficiency of the chain and economy of the sector.

IV. COLD STORAGE STATISTICS IN INDIA

The Task Force on Cold chain projects (TFCP-2014) reported that 31.82 million metric tons have been manufactured in the nation out of which 10.58 million tons in cold storage manufactured in the past decade with the guidance of Central Government Assistance throughout the project. The cold store facilities haven't been spread evenly throughout hence Top 5 states in terms of total installed capacity are:

1) Uttar Pradesh (13.6 million MT)
2) West Bengal (5.9 million MT)
3) Gujarat (2.3 million MT)
4) Punjab (2.0 million MT)
5) Andhra Pradesh (1.6 million MT)

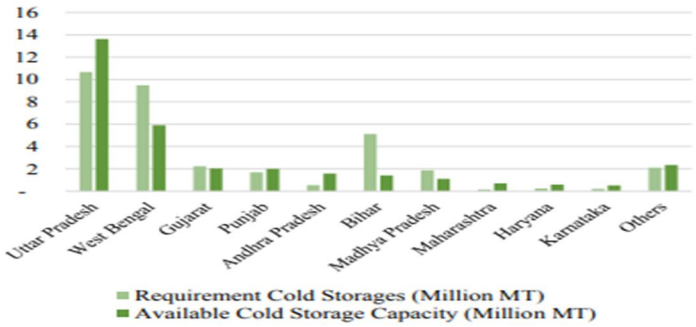

Figure 5: State Wise Cold Storage Distribution in India: 2014-15
Source:NCCD

It is clearly understood through the figure that there isn't proportional distribution of cold stores in the nation as states like Uttar Pradesh, Punjab, Haryana, Andhra Pradesh have more cold stores than the required amount on the contrary states like West Bengal, Gujarat, Bihar don't have cold store facilities until the requirement capacity. States like West Bengal, Uttar Pradesh have high storage capacity which cumulates its average storage capacity more than 6000 MT, whereas states like Karnataka and Maharashtra, though have a high number of cold storages but the average storage capacity cumulative is less than 2000 MT. As the majority of cold stores in India are single purpose warehouses due to the seasonality of produce cold stores remain idle for almost 6 months.

It has also been observed in the NCCD study (2015), that only 75% of installed cold stores are being utilized. Majority of the cold stores in India are under private ownership. In states like Gujarat, Haryana, UP a number of cold storages are owned on partnership basis, whereas storages in AP are predominantly owned by private limited companies. In states like Karnataka, proprietorship basis is also prevalent.

V. CHALLENGES OF THE INDIAN DAIRY COLD CHAIN SUPPLY

1) *Supply Chain Of The Unorganized Market:* The unorganized dairy market is nearly 80% and this the direct supply chain of producer to the consumer hence the need of cold chain supply is absent.
2) *Inadequate Feeding of Animals:* Due to increase in demand of resources the farmers need to meet the demand of their nutrition as well as sustain the nourishment of the milking animal which is difficult for small scale holders.
3) *More Disease Incidence:* Financial constraints in small scale holders generally inhibit these farmers' access veterinary services and the required care of the husbandry which effects the quality of the milk and its value added products.
4) *Low Genetic Potential of Animals:* The milking capacity of the animal depend on its breed hence improper insemination or cross breed effects the quality of the milk and its value added products.
5) *Lack of Chilling Capacities:* The farmers who have animals with high milking capacity don't have access to chilling plant near to the houses hence have to travel a long distance for milk collection making the milk prone to spoilage.
6) *Lack of Trained and Skilled Workers:* There is lack of trained and skilled workers who can handle the milking procedures hygienically as well as the chilling plants or collection units.
7) *Lack of Cold Storage Facilities:* Milk is a highly perishable product hence requires processing or cooling as soon as possible after milking, so as to prevent spoilage and contamination but this facility is not available at village level.
8) *Gap in the Cold Chain and Transport Facilities:* There is a shortage of refrigerated transportation hence there is a development of gap or standstill developed in the cold chain supply of milk and its value added products.
9) *Monitoring and Traceability:* Currently there are very limited initiates in monitoring of reefer parameters in vehicles and traceability in cold chain. This results in spoilage in the value chain. There are no incentives for optimizing operational control in Cold storage and reefer vehicles.

VI. REFRIGERATED TRANSPORT

Refrigerated transport plays a key role in a cold chain ensuring the seamless movement of the materials to various locations. Transportation between farms to processing units then to the retailer followed by the consumer. Vehicles equipped with active refrigeration are especially designed to provide environment controlled carriers to the products that can be broadly classified as:

1) *Reefer Trucks:* The refrigerated trucks are powered by integrated diesel driven motors, independent of the main truck engine, acting as cold rooms on wheels. Smaller vehicles can also be used for the same purpose, by utilizing direct drive systems that are linked to the vehicle engine or battery powered refrigeration units. New age reefer trucks are also incorporated with GPS based location tracking system and data logging temperature and humidity sensors that help in continuous monitoring and check for analysis.

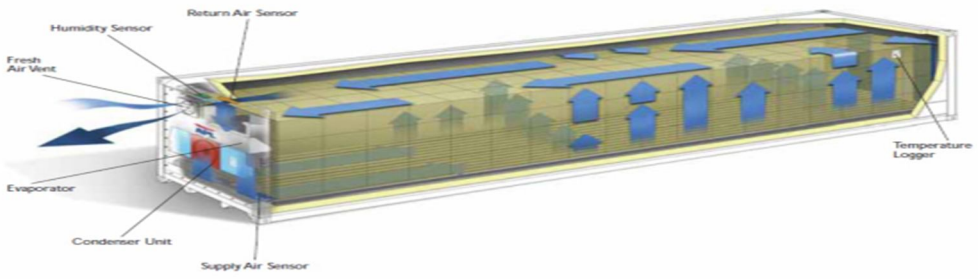

Figure 6: Refrigerated Trucks
Source: Research gate.net

2) *Reefer Containers:* Reefer containers are multi-modal containers with integrated refrigeration equipment, normally used for multi-modal activities where rail-road-sea-air movements are involved in the logistics chain. It sources electric power from a separate generator (power-pack) which is independent of the reefer container. It has temperature control range of -25 to +20°C.

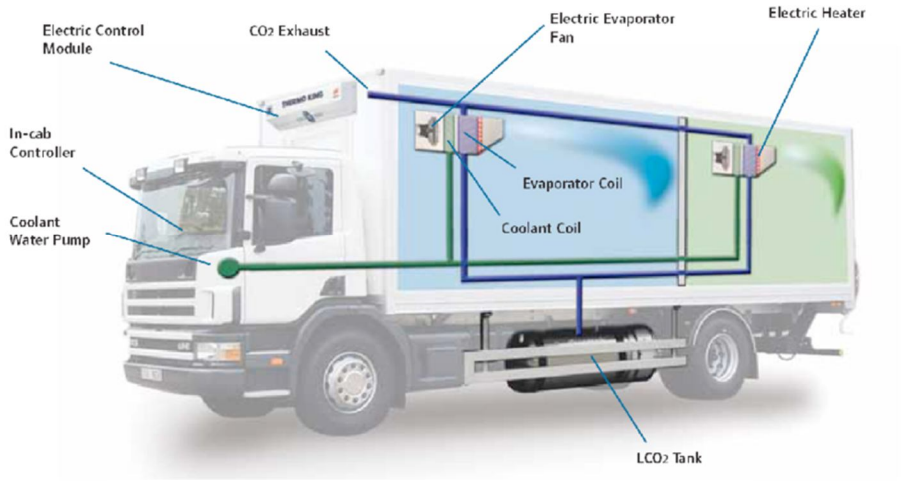

Figure 7: Reefer Container
Source: apl.com

3) *Reefer Vessels/Ships:* Cargo vessel specializing in carriage of goods which are required to be maintain temperature below ambient temperatures. Each cargo carrying space is lined by layers of insulation material. Furthermore, the floor is double skinned to allow even circulation of the cooling air. Usually, perforated wooden/plastic gratings are utilized so as to allow uniform percolation of the cold air. Reefer vessels can carry any frozen or cooled cargo including fruits, vegetables, meat, and fish. Depending on the type of cargo a temperature range of -30 to +12°C can be maintained.

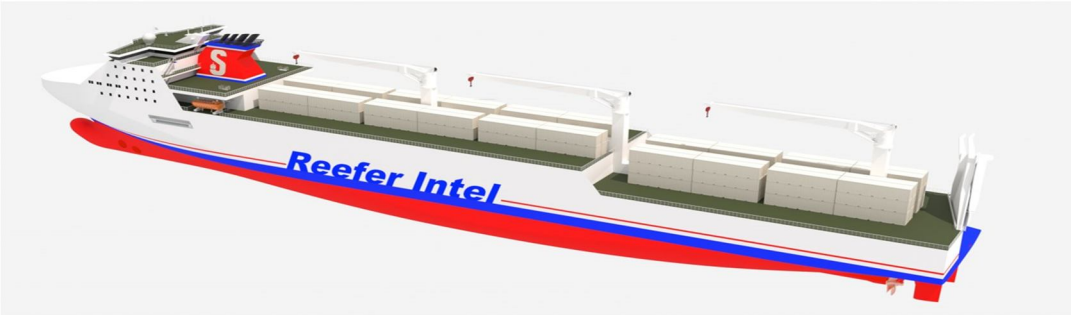

Figure 8: Reefer Ships
Source: safety4sea.com

VII. DESIGN OF COLD STORAGE

A. *Types Of Cold Storage*

Cold Stores are buildings or chambers that maintain controlled storage environment using appropriate thermal insulation and an efficient refrigeration system. Its objective is to properly handle and store fresh produce under appropriate temperature and humidity conditions for maintaining quality and extending shelf life and keeping the produce away from sources of contamination. Fresh produce cold stores are designed to control respiration and prevent discoloration, sprouting, dehydration and decay. The cold stores/warehouses can be classified as follows:

1) *Bulk Cold Stores:* Environment controlled storage space intended for the bulk storage of perishable produce are known as bulk cold stores. It is designed for long duration storage of produce hence these are used to store bulk of produce.
2) *Multipurpose Cold Stores:* Storage space with multiple temperature zones for functioning as a distribution hub. It is used for the purpose of distribution scale hence requires less time and small amount of produce to be stored for the entire year.
3) *Small Cold Stores:* It has precooling facilities available for the commodity that desires this facility the major concentration of these units is in Maharashtra but the trend is now picking up in other states like Karnataka, Andhra, and Gujarat etc.

4) *Frozen food stores:* The processed food products of the dairy industry are stored in these units that provide the desired requirements of the product
5) *Controlled Atmosphere (CA) Stores:* These are cold store fitted with technology that can alter the atmospheric gaseous contents, in addition to controlling the temperature.
6) *Mini units / Walk-in Cold Stores:* These units are generally located at hotels, restaurants, malls etc.

B. Specific Consideration For Design Of Cold Store

There are certain criterion which must be kept in mind while designing a cold storage the considerations are as follows:

1) Uniform temperatures
2) Length of air blow and impingement on stored products
3) Effect of relative humidity
4) Effect of air movement
5) Controlling ventilation systems, if necessary.
6) Product entering temperature
7) Expected duration of storage
8) Required product outdoor temperature
9) Transportation in and storage area

These considerations are of essential because they provide necessary monitoring of the product as well as the required environmental parameters for the product as well as the desired quality of the product can be easily achieved via these considerations.

C. Design Of Cold Storage

The parameters for designing a cold storage unit are as follows:

1) Selection of Site: The store must have a well-connected network of roadways and the location must be not too far from the manufacturing plant to ensure low fuel costing as well as the site must have power supply at all the times.
2) *Size:* The size of the store must be ensured by considering the volume of product to be stored, the average volume required per container as well as ample amount of space for manual and mechanical operations.
3) *Space Requirement:* Storage space 3.4 m^3 /ton suitable for stacking and circulation of cold air (EIRI 2003) Chamber height -3 to 10 m For loading and unloading distance between Rack & rack - should not < 75cm Rack & wall - least 20-25 cm Ceiling & product shelf top - 30 cm.

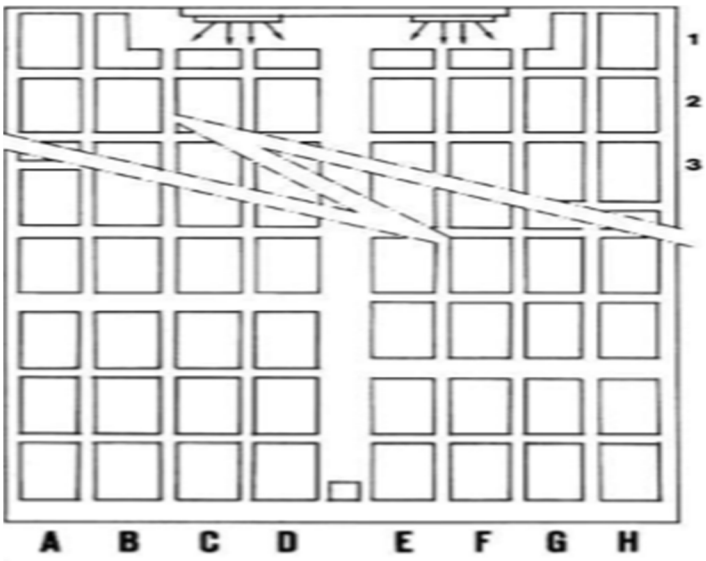

Figure 9: Space Requirement for Cold Storage
Source: Design of cold storage by PRAGATI SINGHAM

4) *Design of Building:* The design of the building have considerations of the roof, ceilings, walls, doors, floor, shelves etc. These considerations must be built up as per the requirement of the product stored as well the assurance of simple and easy working of the cold storage.

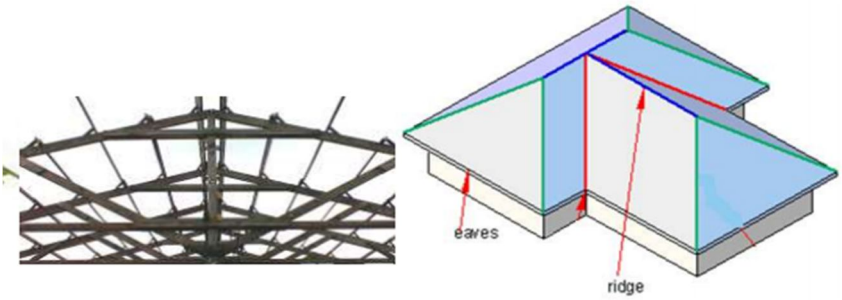

Figure 10: Roof design of Cold Storage
Source: Design of cold storage by PRAGATI SINGHAM

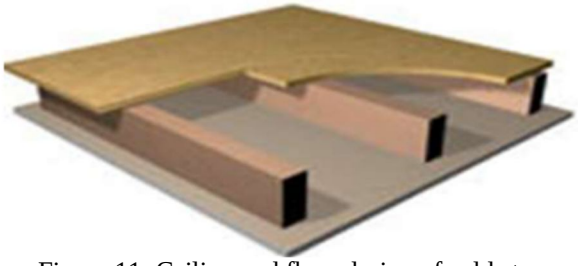

Figure 11: Ceiling and floor design of cold storage
Source:Design of cold storage by PRAGATI SINGHAM

5) *Thermal Insulation:* The cold room walls will affect the refrigeration efficiency of the refrigeration system hence ideally, a wall with thick insulation is ideal for regular and deep freezing applications.

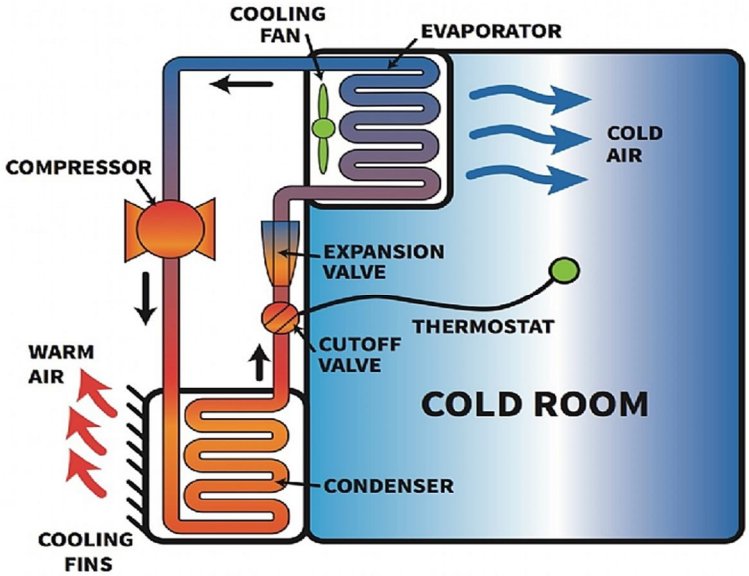

Figure 12: Thermal Insulation of cold storage
Source: Design of cold storage by PRAGATI SINGHAM

6) *Refrigeration System for Cold Store:* Cold rooms are serviced by an evaporator which draws heat from the inner compartment and a condenser which releases the heat. However, different refrigeration systems are derived from this basic concept hence depending on the product to be stored in cold storage refrigeration system with respect to the products efficiency must be attained.

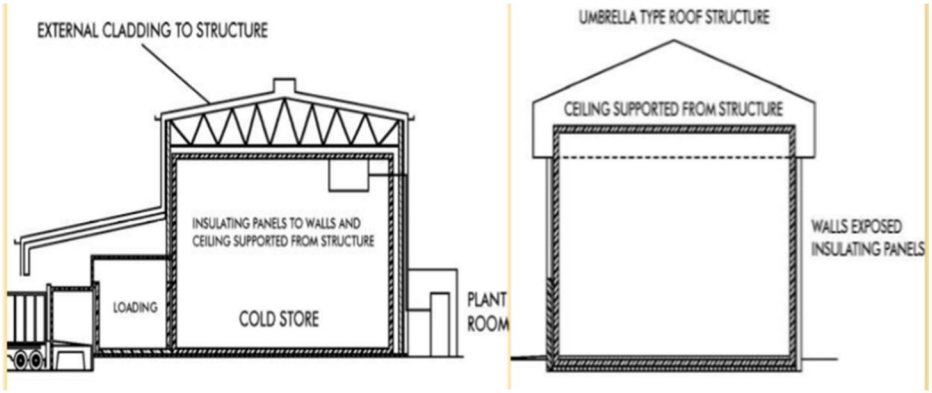

Figure 13: Refrigeration System for Cold Storage
Source:postharvest.net.au

VIII. GOVERNMENT INITIATIVES AND POLICIES

A. Encourage investment: Agri food is identified as priority sector.
B. Encourage organised sector: ECB route opened, import duty relaxed
C. Rationalize tax laws
D. Liberalize marketing norms: focus on increased retail, improved supply chain
E. Provide grant and subsidies
F. Excised waves on F &V, meat preparation, ice-creams and other RTE food mixes.
G. Duties reduced from import: zero service tax on installation
H. National highway development program
I. Partnering with Indian railways to establish cold chain infrastructure
J. Development of National Centre of Cold Chain Development (NCCD)

1) R & D
2) Training and capacity building
3) Development of cold chain infrastructure etc.

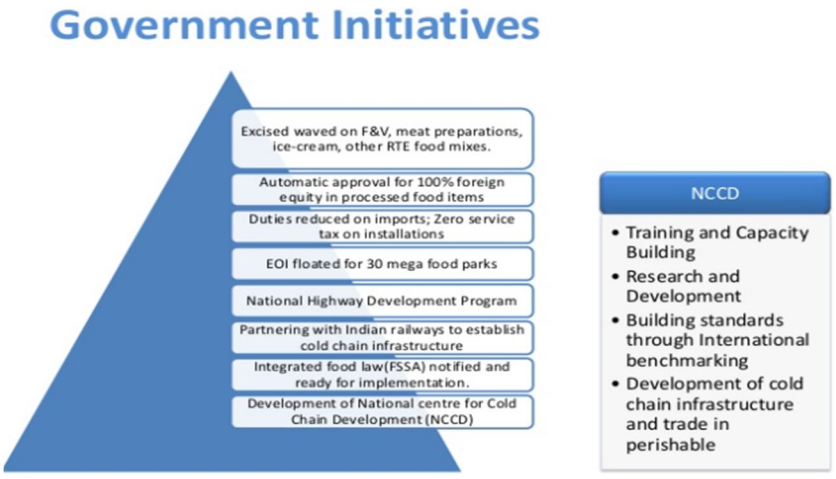

Figure 14: Government Initiatives
Source: Slideshare.net

IX. COLD CHAIN PRACTICES FOR DAIRY PRODUCTS

1) *Complete A Food Hazard Analysis:* The easiest and most often food hazard to dairy is temperature. Some temperatures may be enough to prevent bacteria from growing but aren't low enough to protect the product's quality. Milk is a good example. Bacteria won't grow as long as milk stays below 45 degrees Fahrenheit, but then milk needs to be stored below 40 degrees to preserve its quality as well and as well as minimise its spoilage. All these risks should be listed and taken into consideration at every step of the cold chain possibly through software specifically designed for the purpose–and accompanying controls should be implemented to prevent issues. Temperature monitoring and logging are two of the most obvious controls used to manage risk in the cold chain.
2) *Establish A Stringent Cleaning Schedule:* Cross contamination also is a risk factor responsible for the spoilage of the milk hence the stepwise cleaning throughout the cold chain is essential hence there must be a stringent cleaning schedule. Cleaning reduces the risk of the spoilage hence preserves the quality of the product and extends the shelf life of the product.
3) *Develop A Tracking And Monitoring Program:* If anything goes wrong its necessary to find the fault and remedy it at the earliest hence a simple tracking and monitoring program to have an easy and well-structured analysis system for the smooth movement of the cold chain supply throughout.

X. COLD CHAIN SUPPLY OF VARIOUS DAIRY PRODUCTS

A. *Cold Chain Supply Of Butter*

As per the Butter Cold Storages guidelines, most butter companies advice to keep butter refrigerated in an refrigerate container like a crock as it makes butter last at room temperature longer, but when room temperature rises above 50° F, all butter should be cold .Salted and unsalted butter are not the same, however: Salt in salted butter makes it less susceptible to bacterial growth, so it should be fine out on the counter.

The cold storage container specifications of butter are as follows:

Available butter storage container in three sizes – 10ft, 20ft and 40ft (2.5m x 2.5m x 5.5m or 11m). Most of the refrigerated containers require a high power supply and must be positioned in a space clear of overhead cables and obstructions for delivery with a lorry. There are some 21ft fridges containers that can be run from a 240V power supply.

B. *Cold Chain Supply Of Ice Cream*

The essential low temperature of -22degree C or lower is also required to be maintained while the product is being transported from one place to the other. The long distance transportation of ice cream is presently being done in India, by Refrigerated Trucks on road. Therefore the life and nature of the commodity while in transit are dependent on the quality of the equipment of the refrigerated truck and its operational productivity.

Along with the refrigeration equipment there is a power generating unit joined to the cooling unit in a refrigerated vehicle, to guarantee the quality and protection of products/

C. *Cold Chain Supply Of Cheese*

Cold chain is 34°F to 41°F with 38°F being the ideal temperature for storing cheese. Packaging that allows the cheese to breathe is ideal packaging, Breathable packaging includes paper, wax paper, cheese paper such as Formaticum, cardboard, wood and semi-permeable plastic. Best methods for storage during transportation include: air ship with proper packing and ice packs; delivery by refrigerated trucks and/or coolers; include retailer mandates for receiving cheese; know government regulations Storage at distributor facilities: FIFO, rotation of stock; cold chain storage between 34 and 38°F; comply with all local standards cheese must be kept cool and away from fans, which will dry it out; maintain proper inventory control for optimum health of the cheese.

XI. CONCLUSION

Milk supply chains are more concerned with controlling of milk quality and supply fluctuations which are unique to this sector. Perishable goods like milk and its value added products require a time efficient supply chain. This perishable factor can affect the milk supply chain.

Supply chain management has gain quick importance as it ensures zero wastage and preserves the shelf life and quality of the product hence the application of cold chain are increasing an unfolding in the coming years.

Cold chain supply provides the idea of the sector it has been used in like it provides the idea about the dairy sector in this study.

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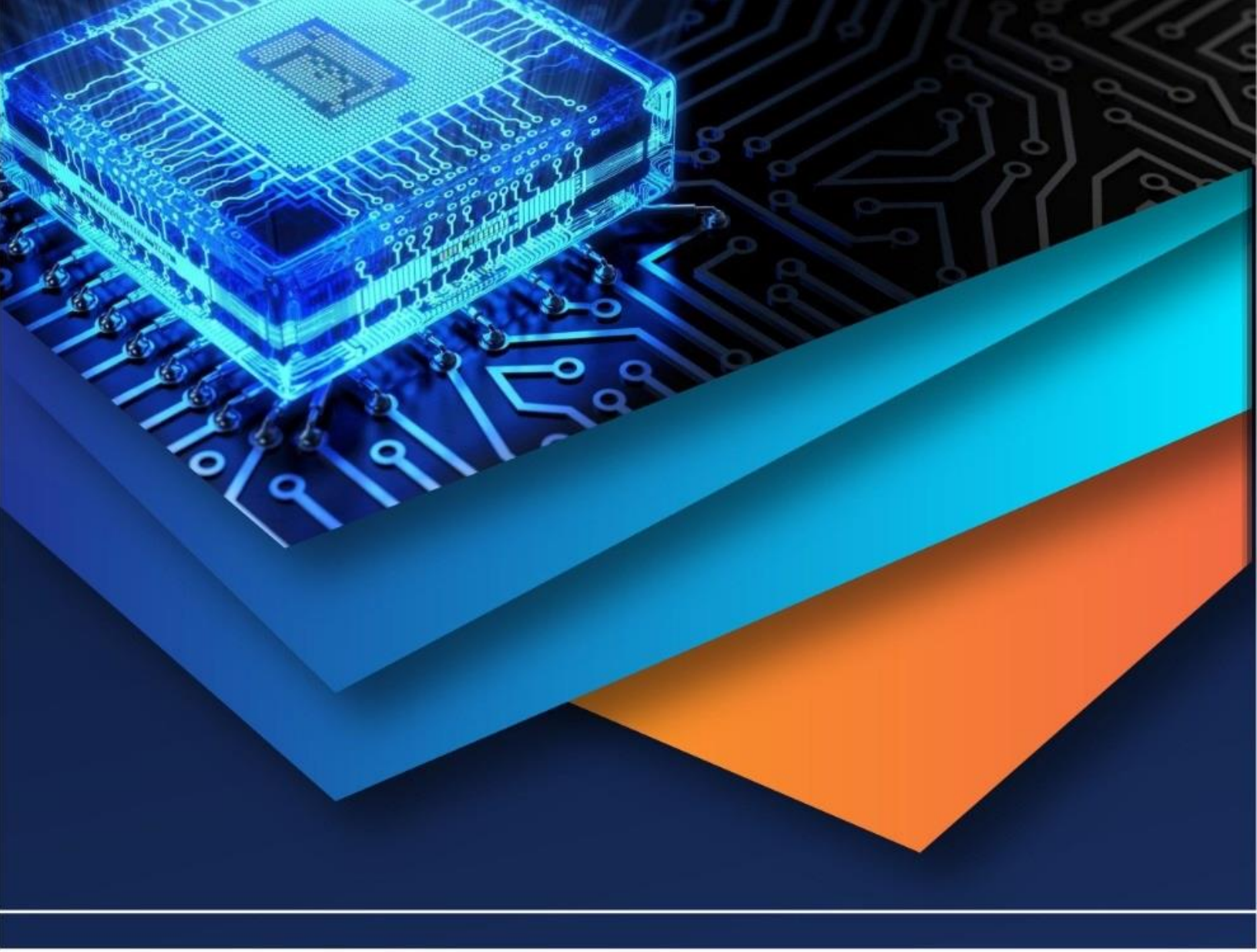

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