

**STUDY OF SELECT ISSUES IN SUPPLY CHAIN MANAGEMENT
OF PERISHABLES IN INDIA**

by

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CERTIFICATE

This is to certify that the thesis titled "**Study of Select Issues in Supply Chain Management of Perishable in India**" being submitted by Rohit Joshi to the Indian Institute of Technology, Delhi for the award of the degree of **Doctor of Philosophy** is a bona fide record of original research work carried out by him. He has worked under our guidance and supervision, and has fulfilled the requirements for the submission of the thesis, which has reached the requisite standard.

The results contained in this thesis have not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

A "Cold Chain" is a series of equipment and processes used to protect the perishables, by keeping them chilled and frozen, starting from the source of origin to the destination of consumption. Cold chain management is not easy even in developed economies like the US and the UK and it only gets more challenging in a developing economy like India. Infrastructure support in most developed countries is fairly robust and there are few uncertainties in business processes related to logistics. However, cold chains in developing countries tend to pose several challenges resulting from weaker infrastructure, unpredictable environment and uncertainty in availability of basic necessities like water, power etc.

As all perishables fall in 'fragile' category and have limited lives, their handling is far more complex and prone to much higher risks compared to handling of non-perishable products. And, with perishable food products forming one of the fastest growing items of Indian grocery sector, cold chain management is assuming greater importance and drawing the attention of practitioners and researchers.

India is world's largest producer of milk with a total projected production of about 108 Million Tonnes (MT) for 2009 and the country produces about 170 million MT of fruits and vegetables accounting for a share of 11 percent and 15 percent respectively of the global production. India is also the fifth largest producer of eggs and sixth largest producer of fish. Although India has been the world's largest producer of milk right from 1995, unfortunately not a single Indian dairy company has featured in the list of global top 20. Moreover, around 30 to 40 percent of total production of fresh fruits and vegetables in India, amounting to the annual production of these items in the United Kingdom, is wasted every year. Further, at current level of production, farm produce valued at Rs 70,000 million (USD 1,400 million) is wasted every year because of poor road connectivity; lack of adequate storage, transportation; inadequate cold chain facilities and other infrastructure supports. In fact, short shelf-life of perishables and poor post-harvest handling of the produce completely nullify the production advantages.

The food chain in India is very complex. Lack of organized distribution system and numerous stakeholders like small farmers, wholesalers, processor/manufacturer and retailers

make the multi-layered system of marketing channel very intricate and lead to operational and informational complexities. Each partner works in isolation and is not sufficiently connected with the system via a proper information network. This together with inadequate preservation considerably increases the end product costs. This offers an opportunity for continuous improvement in cold chain management and calls for technology and research within the domain.

Keeping in view the literature gaps identified, this research is aimed at examining the current Cold Chain Management (CCM) practices followed by the perishable food sector in India. The select CCM issues focused are: pre-cooling at farm level, cold storages, refrigerated transportation, retail display, traceability, cold chain practices of consumers, structure and characterization in cold chain management of fresh produce sector. Hypotheses were framed and a set of three questionnaire based survey instrument was developed. A survey was conducted to gain the insight about the current Cold Chain Management practices followed by the perishable food sector in India. Using a hierarchical Fuzzy Interpretive Structural Model the relationship among frontier characteristics of a robust cold chain are identified with their dependence and driving powers. Two case studies of leading co-operatives in India have been carried out to understand current status of cold chain practices and their initiatives taken to integrate their cold chain for wastage reduction and retaining value of perishables up till reaching the final consumer. A separate study is conducted to examine the awareness, behaviour and practices among Indian consumers with regard to maintenance of cold chain at homes within the framework of food safety. And finally, for measuring the cold chain, performance of a company, a novel consistent measurement scale is developed. This scale helped in developing performance frameworks that can facilitate managers in identifying the weaknesses in processes and improving upon them. Major contributions made by this research are as follows:

- It provides a comprehensive review of the literature and identifies contemporary research issues related to CCM.
- It brings out similarities and dissimilarities in the perception of companies that are in business of perishables and among different sectors of Indian cooperatives, towards

various issues related to cold chain management, through a structured questionnaire survey.

- The influence of farmers' practices on post harvest losses is studied through a separate questionnaire. The study divulges that farmers are mostly ignorant of the right stage for harvesting, pre-cooling, proper cleaning, grading and packing of the produce, which results in post harvest losses and low price for their produce.
- The study evaluates awareness, behaviour and practices among Indian consumers, regarding maintenance of cold chain from retailer's place to home and in home within the framework of food safety. The study reveals that the Indian consumer is not very familiar with the term "cold chain". Consumers do not have adequate awareness about refrigeration practices and they do not consider themselves responsible for maintaining cold chain and food safety.
- Fuzzy Interpretive Structural Modelling (FISM) reveals the dependence of critical factors (enablers and inhibitors) and their driving powers or respective dominance in implementation of an efficient CCM.
- The two case studies capture the cold chain practices adopted by Indian cooperatives dealing with perishables.
- Delphi-Analytical Hierarchical Process— Technique for Order Preference by Similarity to Ideal Solution (Delphi-AHP-TOPSIS) based framework critically analyses and benchmarks the performance of CCM on a consistent measuring scale for evaluation reference. This acknowledges the company's strengths and weaknesses and the market leader among the competitors. The framework also facilitates better understanding of the complex relationships among relevant cold chain performance factors for improved decision—making towards improvement.
- A novel Twin Graph Theory methodology is developed for cold chain performance improvement, which quantifies the cold chain performance index and alternative improvement index and suggests improvement measures by implementing the best practices learnt from the market leader.

Keywords: Supply Chain, Cold Chain, Perishables, Food, Questionnaire based survey, Fuzzy interpretative structure modelling, Analytical hierarchical process, Cold chain performance.

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