

"A Study On Challenges Faced By The Cold Chain Service Providers With Reference To Frozen Food Products"

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Abstract

Cold chain logistics play a pivotal role in ensuring the safety and quality of temperature-sensitive products. This study investigates the challenges faced by cold chain service providers and evaluates their impact on operational efficiency and performance. Using descriptive statistics and respondent feedback, the research identifies critical gaps and priorities within cold chain logistics, providing actionable insights for stakeholders. Limited handling practices and insufficient facility resources are noted as strengths, while poor tracking capabilities and environmental efficiency emerge as areas needing improvement. The findings emphasize the significance of infrastructure, safety, and response mechanisms in enhancing the cold chain's overall efficacy.

Keywords: Cold chain logistics, environmental efficiency, tracking capabilities, facility resources, handling practices and supply chain performance

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I. Introduction

Cold chain logistics is essential to today's supply chains, ensuring perishable goods like food and medicines are kept at the right temperatures from production to delivery. This system involves temperature-controlled storage, transportation, and distribution to maintain the quality of these products. Globally, the cold chain market is valued at \$253.3 billion, showing its importance in trade and commerce.

A cold chain includes several key components: pre-cooling facilities, cold storage units, refrigerated transport, processing centres, and retail display units. These parts work together to keep products within specific temperature ranges, such as deep freeze (-28°C to -30°C) or cool storage (13°C to 18°C), depending on the product. The challenge lies in maintaining these temperatures across different climates, regions, and handling stages.

Cold Chain Logistics in India

In India, cold chain logistics has significant potential but also faces unique challenges. The Indian cold chain market, worth ₹1,121 billion in 2022, is expected to grow to ₹2,862 billion by 2027. This growth is driven by urbanization, demand for processed foods, organized retail expansion, and the rising need for pharmaceuticals. India, being the largest producer of milk and the second-largest producer of fruits and vegetables, highlights the importance of a strong cold chain infrastructure.

India's current cold chain infrastructure includes 8,186 cold storage facilities with a capacity of 37.4 million metric tonnes, along with 876 refrigerated vehicles, 692 ripening chambers, and 353 pack houses. However, only about 4% of fresh produce is transported through cold chain systems. Most of the storage is used for potatoes (65%), with the rest divided among dairy (10%), seafood and meat (10%), and other uses.

Cold chain facilities are concentrated in northern and western India, especially in areas like Delhi-NCR, Mumbai, Bangalore, and Chennai. These regions are major hubs due to their proximity to agricultural and industrial centres and high urban demand.

Despite its growth, the Indian cold chain sector faces several issues. There is a shortage of infrastructure, including storage, transport, and last-mile delivery. High energy costs, unreliable electricity, and a lack of skilled workers further add to the problems. Financial challenges such as high setup costs, limited credit access, and slow returns on investment also hinder development.

Government Supportive schemes to enhance cold chain logistics

The Indian government is working to improve the sector through initiatives like the Pradhan Mantri Kisan SAMPADA Yojana (PMKSY), with a budget of ₹6,000 crores, to modernize food processing and cold chain infrastructure. The National Centre for Cold Chain Development (NCCD) is also helping by setting standards and promoting training and new technologies.

The future of cold chain logistics in India looks bright, with opportunities in technology like IoT sensors, renewable energy, and data analytics to monitor and optimize operations. Automation and digital tools can increase efficiency and lower costs. Adopting hub-and-spoke models and better transport networks will further improve distribution.

II. Review Of Literature

The study examines the link between service quality and customer loyalty in Shunfeng cold chain logistics, using a model that includes customer satisfaction as an intervening variable. It emphasizes key dimensions of the SERVQUAL model and offers solutions to improve service weaknesses, thereby enhancing customer satisfaction and loyalty.(J.-X. Zhang & Zhang, 2019).This study investigates consumer awareness of transporting frozen foods and how it impacts the cold chain, revealing that many do not use insulated bags, which can lead to quality issues. It suggests that regulations on insulated bag use or improved packaging by manufacturers are needed to maintain proper temperatures during transport, especially in summer.(Góral-Kowalczyk et al., 2023).Cold-chain logistics firms aim to reduce costs and carbon emissions through a model cold-chain logistic distribution system (CC-LDS), optimized using a Virtual Annealing algorithm. The study highlights how collaborative distribution and carbon tax policies effectively lower expenses and environmental impact.(Yin & Tian, 2022).

This study reviews cold chain logistics and joint distribution, focusing on fresh food logistics to analyse their operational modes, benefits, challenges, and future trends. It highlights the role of joint distribution in improving efficiency, reducing costs, and minimizing environmental impacts while offering insights into industry development.(Shi et al., 2024).The COVID-19 pandemic has exposed challenges in China's cold chain logistics, highlighting vulnerabilities in managing temperature-sensitive food transportation. This study analyzes these challenges and proposes strategies to improve the sector's security and efficiency in the post-pandemic era.(Peng et al., 2023).This study evaluates logistics service quality (LSQ) in fresh product e-commerce, identifying reliability, convenience, freshness, and personnel contact as key factors. The findings provide insights for e-commerce managers to enhance LSQ and improve customer satisfaction.(Wang et al., 2024).This study examines consumer satisfaction with cold chain distribution services for fresh agricultural products, identifying key issues and factors affecting satisfaction.

Based on a survey in Nanchang, it proposes optimization strategies to improve service quality.(Wu & Phakdeephrot, n.d.).This study reviews sustainability challenges in perishable food cold chain logistics (PFCCL), highlighting issues like infrastructure, energy use, and workforce skills. It emphasizes the need for smart technologies, sustainable strategies, and advanced decision-making tools to address these challenges.(B. Zhang & Mohammad, 2024).This study maps energy flows in cold chains for perishable goods, identifying key energy-consuming stages and evaluating overall energy performance. It emphasizes a holistic approach to enhance energy efficiency across the food and beverage sector.(Marchi & Zaroni, 2022)

III. Research Methodolgy

This research is descriptive by nature. The Sample technique adopted was convenient sampling and sample size was 278. The respondents selected were cold chain service providers namely frozen food company representatives, Logistics providers, Distributors and retailers. To collect the primary data questionnaire was used as research instrument. Appropriate statistical tools were applied to analyse the data. The Major objective of this study to investigate the existing challenges within the cold chain management of frozen food products.

IV. Analysis And Interpretation

The collected data were edited, coded, tabulated, and interrupted as below

Table 1.0 The Table showing the challenges of cold chain service providers

Challenges of Cold Chain Service Providers	Mean	Standard Deviation
Limited Environmental efficiency	10.41	4.27

Deficient safety measures	14.68	3.87
Poor Tracking Capabilities	9.69	2.58
Insufficient facility resources	19.01	3.24
Limited Handling Practices	20.26	3.00
Inefficient Response Mechanism	11.01	3.172

Interpretation:

The descriptive statistics provide insights into the critical dimensions of cold chain logistics. Limited Handling Practices (mean: 20.26, SD: 3.00) and Insufficient facility resources (mean: 19.01, SD: 3.24) emerge as the most robust areas, indicating these are well-established and

prioritized within the cold chain framework. However, Poor Tracking Capabilities (mean: 9.69, SD: 2.58) and Limited Environmental efficiency (mean: 10.41, SD: 4.27) stand out as key areas requiring significant attention. The low mean score for traceability highlights a gap in monitoring and transparency across the logistics chain, while the high variability (SD: 4.27) for sustainability indicates inconsistent implementation and diverse perceptions among stakeholders. Cold Chain Effectiveness (mean: 11.97, SD: 1.616) shows the most consistent responses, reflecting a relatively stable perception of the overall system's reliability. However, the moderate scores of Inefficient Response Mechanism (mean: 11.01, SD: 3.17) suggest opportunities to enhance collaboration across the supply chain and improve agility in addressing operational challenges.

The primary data was collected from the respondents through questioner and the Likert scale was utilized for the purpose. The measurement scale values are as follows (5 - most important; 4 - important; 3 - neutral; 2 - less important; and 1 – least important. Accordingly, for effect, the scale used is from 5 - most effect; 4 - more effect; 3 - neutral; 2 - less effect; 1 - least effect. Tables 4.6 and 4.7 summarize the responses regarding the importance and impact of various issues. The results highlight the significant relevance of these issues in terms of both their importance and their effect on cold chain performance.

Table 2.0 Table shows the Issues of Cold Chain Performance

Issue	Least Important		Less Important		Neutral		Important		Most Important		Total number
Limited Environmental efficiency	0	0.0%	28	10%	59	21%	66	23%	125	45%	278
Deficient safety measures	0	0.0%	0	0.0%	5	2%	110	39.5%	163	59%	278
Poor Tracking Capabilities	4	1%	26	9%	99	36%	90	32%	59	21%	278
Insufficient facility resources	0	0.0%	0	0.0%	16	6%	65	23%	197	71%	278
Limited Handling Practices	0	0.0%	1	0.1%	32	11.5%	106	38%	139	50%	278
Inefficient Response Mechanism	0	0.0%	0	0.0%	29	10%	99	36%	150	54%	278

Table 3.0 Table showing the respondents opinion on the Effect of issues on cold chain performance

Issue	Least Effect		Less Effect		Neutral		More Effect		Most Effect		Total number
Limited Environmental efficiency	0	0.0%	27	10%	93	33%	81	29%	75	27%	278
Deficient safety measures	0	0.0%	0	0.0%	27	9%	100	36%	151	54%	278
Poor Tracking Capabilities	0	0%	25	8%	67	24%	70	25%	116	42%	278
Insufficient facility resources	0	0.0%	0	0.0%	29	10%	51	18%	198	71%	278
Limited Handling Practices	0	0.0%	3	1%	24	9%	74	27%	177	64%	278
Inefficient Response Mechanism	0	0.0%	0	0.0%	31	11%	117	42%	130	47%	278

Interpretation:

Based on the data presented in Tables 2.0 and 3.0 it can be observed that 71% of respondents believe that infrastructure plays a crucial role and can significantly impact the performance of the cold chain. Therefore, the majority of respondents agree that the factors mentioned above are important and can have a substantial effect on the cold chain's overall performance.

V. Findings

- The open-ended questions was asked as” could you mention the major challenges faced by you in cold chain performance?”. The responses is been represented in the below mentioned pictorial representation.



Fig1.0 Visual depiction of the key challenges Identified in the cold chain

- Insufficient facility resources were considered as the biggest challenge continued by limited handling practices and then deficient safety measures these factors were followed by inefficient response mechanism, Poor tracking capabilities, and environmental efficiency.
- According to the respondent’s insufficient facility resources was the major challenge that created a significant impact on the cold chain performance followed by deficient safety measures these respondents were the frozen food company representatives and logistics providers. Distributors & retailers.

VI. Suggestions

- Cold chain service providers should strengthen handling practices to maintain high standards, as this area is already well-established and prioritized according to the data.
- Addressing insufficient facility resources should be a top priority, as 71% of respondents identified this issue as significantly impacting cold chain performance.
- Poor tracking capabilities should be improved by implementing modern technologies such as IoT-enabled sensors and real-time monitoring systems.

- Efforts should be directed toward improving environmental efficiency by adopting green technologies, energy-efficient cooling systems, and sustainable practices to address inconsistencies.
- Safety measures within cold chains should be enhanced by reviewing existing protocols and conducting regular training sessions for staff.
- Response mechanisms need to be streamlined through agile and collaborative approaches, such as implementing AI-driven systems for better crisis management.
- Stakeholder awareness programs should be conducted regularly to ensure a uniform understanding of cold chain processes and improve the consistency of their implementation.
- Policy and regulatory compliance should be enforced rigorously to standardize handling practices and improve operational effectiveness across the cold chain.
- Advanced technologies such as AI, blockchain, and predictive analytics should be integrated into cold chain operations to address challenges related to tracking, environmental efficiency, and response mechanisms.
- Periodic evaluations should be conducted through audits and stakeholder feedback to identify bottlenecks and ensure continuous improvements in cold chain processes.

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