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FROM FARM TO FORK: SMART SUPPLY CHAIN MANAGEMENT OF PERISHABLES

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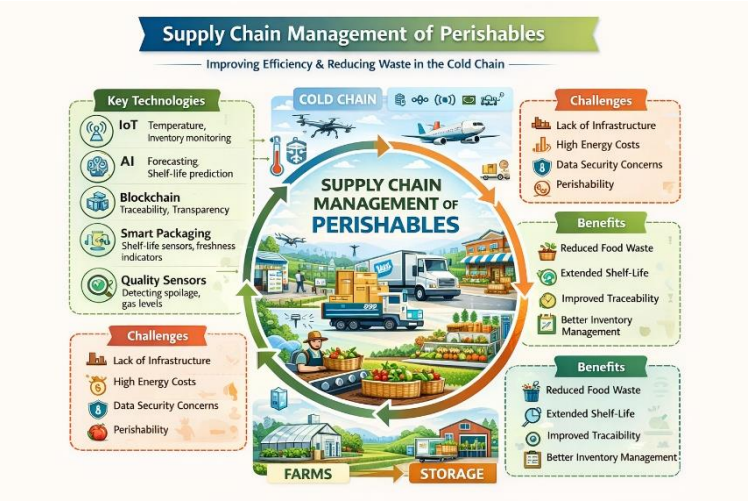
Abstract

Perishable commodities such as fruits, vegetables, flowers, dairy, meat, and seafood are highly sensitive to time, temperature, humidity, and handling conditions. Inefficient supply chain management (SCM) of perishables leads to significant quantitative and qualitative losses, threatening food security, farmer incomes, and sustainability. Modern supply chain management of perishables integrates traditional handling practices with advanced technologies such as cold-chain logistics, Internet of Things (IoT), artificial intelligence (AI), blockchain, and intelligent packaging to ensure quality preservation, traceability, and timely delivery. This article discusses the concept, components, technological interventions, benefits, challenges, and future prospects of perishable supply chain management, with emphasis on recent advancements and sustainable approaches.



Keywords: Perishables; Supply chain management; Cold chain; Postharvest losses; Traceability; Smart logistics.

1. Introduction

Perishable agricultural commodities form the backbone of nutritional security and agri-based economies, particularly in developing countries. However, their short shelf life and susceptibility to

spoilage make them vulnerable to losses during harvesting, handling, storage, transportation, and marketing. Globally, nearly one-third of perishable food is lost or wasted annually, primarily due to inefficient supply chain infrastructure and poor postharvest management practices (Anusha et al. 2024; Satheeshkumar et al. 2025).

In India, postharvest losses of fruits and vegetables alone account for substantial economic losses, highlighting the urgent need for efficient supply chain systems. Supply chain management of perishables aims to maintain product quality and safety from farm to fork by integrating coordinated logistics, cold-chain infrastructure, information flow, and technological innovations (Ministry of Agriculture, 2025).

2. Concept of Supply Chain Management of Perishables

Supply chain management of perishables refers to the integrated management of material flow, information flow, and financial flow involved in the production, postharvest handling, storage, transportation, processing, distribution, and retailing of perishable commodities. The primary objective is to minimize quality deterioration, microbial spoilage, and losses while ensuring timely delivery to markets and consumers (Ghosh et al.2025).

Unlike non-perishable goods, perishable supply chains are time- and temperature-sensitive, requiring strict control over environmental conditions and rapid decision-making across all supply chain nodes.

3. Key Components of Perishable Supply Chain

3.1 Harvesting and On-Farm Handling

Proper harvesting at optimum maturity, use of clean harvesting tools, field sorting, and pre-cooling are critical first steps in maintaining quality. Traditional knowledge of harvest indices combined with scientific maturity assessment ensures better shelf life and marketability (Satheeshkumar et al. 2025).

3.2 Pre-Cooling and Cold Storage

Pre-cooling methods such as forced-air cooling, hydro-cooling, vacuum cooling, and icing remove field heat and slow down respiration. Cold storage facilities maintain optimal temperature and relative humidity, significantly extending shelf life and reducing physiological losses (Chang et al. 2025).

3.3 Cold Chain Logistics

Cold chain logistics involves temperature-controlled transportation and storage throughout the supply chain. Refrigerated vehicles, cold rooms, ripening chambers, and reefer containers are essential for preserving quality and preventing microbial growth during transit (Revathi et al. 2025).

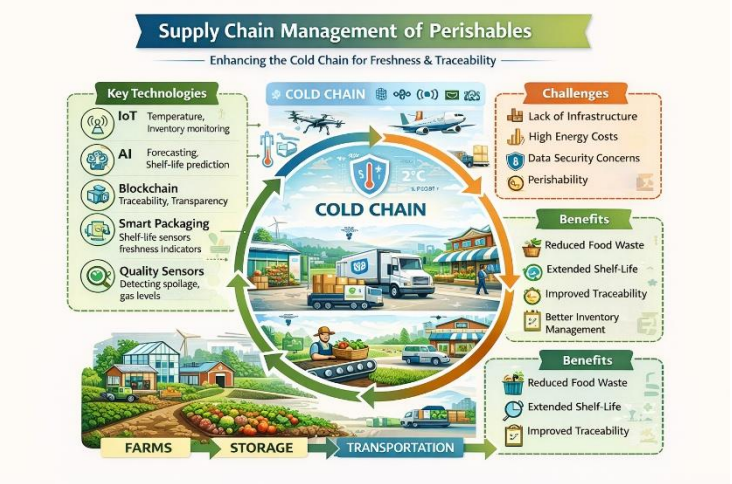


Fig.2. Cold chain logistics

3.4 Transportation and Distribution

Efficient transportation systems with proper packaging, cushioning, and stacking reduce mechanical damage. Route optimization and real-time monitoring ensure timely delivery and reduce transit losses (Ghosh et al. 2025).

3.5 Packaging and Handling

Advanced packaging systems, including modified atmosphere packaging (MAP), active packaging, and intelligent packaging, help regulate gas composition, control moisture loss, and inhibit microbial growth, thereby extending shelf life (Ashaq et al. 2025).

4. Role of Advanced Technologies in Perishable SCM

4.1 Internet of Things (IoT)

IoT-enabled sensors continuously monitor temperature, humidity, and gas composition during storage and transportation. Real-time alerts help prevent temperature abuse and quality deterioration (Kumar et al. 2025).

4.2 Artificial Intelligence and Big Data Analytics

AI-based predictive models analyze historical and real-time data to forecast demand, optimize inventory, predict shelf life, and reduce food waste. Machine learning algorithms support decision-making across logistics and distribution networks (Rajan, 2025).

4.3 Blockchain and Traceability Systems

Blockchain technology ensures transparent and tamper-proof traceability of perishable products across the supply chain. It enhances food safety, quality assurance, and consumer trust by enabling rapid recall and origin verification (Ghosh et al. 2025).

4.4 Smart Packaging and Nanosensors

Smart packaging integrated with nanosensors provides real-time information on freshness, spoilage, and microbial activity. These systems improve quality monitoring and reduce unnecessary food disposal (Ashaq et al. 2025).

5. Benefits of Efficient Perishable Supply Chain Management

- Reduction in postharvest losses and food waste
- Improved shelf life, quality, and safety of produce
- Enhanced market access and price realization for farmers
- Increased consumer confidence through traceability
- Lower environmental footprint and greenhouse gas emissions
- Improved overall efficiency and profitability (Satheeshkumar et al.2025; Ghosh et al. 2025)

6. Challenges and Constraints

Despite technological advancements, several challenges hinder efficient perishable supply chain management:

- Inadequate cold-chain infrastructure
- High capital investment and operational costs
- Fragmented supply chains and poor coordination
- Limited technical knowledge and skilled manpower
- Energy-intensive cold storage systems
- Regulatory and standardization issues (Ministry of Agriculture, 2025)

7. Future Prospects and Sustainable Approaches

The future of perishable supply chain management lies in intelligent, sustainable, and resilient systems. Integration of renewable energy-powered cold storage, AI-driven logistics optimization, digital twins, and smart packaging will enhance efficiency while reducing environmental impact. Community-based cold-chain models, mobile cold storage units, and inclusive digital platforms will support smallholder farmers and reduce losses at the grassroots level (Rajan, 2025; Satheeshkumar et al. 2025).

8. Conclusion

Efficient supply chain management of perishables is essential for reducing postharvest losses, improving food security, and enhancing farmer incomes. By integrating traditional handling practices with advanced technologies such as cold-chain logistics, IoT, AI, blockchain, and intelligent packaging, perishable supply chains can become more resilient, transparent, and sustainable. Strategic investments, supportive policies, and capacity building are critical for the successful transformation of perishable supply chains worldwide.

References

Anusha R, Kumar P and Singh D. 2024. Post-harvest losses in agriculture: Challenges and mitigation strategies. *Int J Food Sci Technol.* 59(4):1123–1135.

Ashaq M, Dar BN and Gani A. 2025. Green synthesis and applications of nanomaterials in food packaging and preservation: A review. *Food Packag Shelf Life.* 35:101020.

Chang L, Kumar S and Sharma R. 2025. Advances in cold-chain technologies for post-harvest preservation of perishables. *J Food Eng.* 358:111678.

Ghosh A, Mehta R and Reddy P. 2025. Smart and intelligent supply chain systems for perishable foods. *J Food Sci Technol.* 62(1):55–69.

Kumar R, Meena NK and Sharma S. 2025. IoT-enabled monitoring systems for cold-chain logistics of perishable commodities. *J Exp Agric Int.* 47(2):389–416.

Ministry of Agriculture & Farmers Welfare, Government of India. 2025. National strategy for reduction of post-harvest losses in horticultural crops. Government of India.

Rajan S. 2025. Artificial intelligence and digital transformation in agri-food supply chains. *Indian Horticulture.* 69(6):73–76.

Satheeshkumar N, Kumar KR, Bhuvaneswari P, Sridharan S and Alagendran S. 2025. Cold-chain interventions for reducing post-harvest losses of perishable produce. *J Food Sci Technol.* 62(3):245–260.